Advances in Intelligent Systems and Computing 610

Mark Hoffman *Editor*

Advances in Cross-Cultural Decision Making

Proceedings of the AHFE 2017 International Conference on Cross-Cultural Decision Making, July 17–21, 2017, The Westin Bonaventure Hotel, Los Angeles, California, USA

Springer

Advances in Intelligent Systems and Computing

Volume 610

Series editor

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Springer

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ISSN 2194-5357 ISSN 2194-5365 (electronic)
Advances in Intelligent Systems and Computing
ISBN 978-3-319-60746-7 ISBN 978-3-319-60747-4 (eBook)
DOI 10.1007/978-3-319-60747-4

Library of Congress Control Number: 2017943067

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

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Preface

The Cross-Cultural Decision Making (CCDM) research focuses on decision making across a variety of cultural constructs, including geographical, historical, sociological, organizational, team, and technology interactions. This includes the research of experts and industry practitioners from multidisciplinary backgrounds, including sociology, linguistics, human–computer interaction, human factors engineering, systems engineering, military science, psychology, neuroscience, instructional design, and education, who showcase the latest advances in our understanding of the role of culture on decision making in numerous settings. Improved decision making among members of diverse teams and within organizational systems, and innovative ways to measure and assess that process, comprise the foundation for many projects discussed in these volumes. The influence of culture on decision making is pervasive, as reflected in the diverse disciplines represented by those individuals and entities involved in sociocultural research and engineering. This book features papers that discuss emerging concepts, theories, and applications of cross-cultural decision making knowledge. The work described in these chapters reflects dedicated research by a wide range of expert academics and practitioners from around the world. A total of six sections presented in this book:

I. Social Media and Social Change
II. Cross-Cultural Design and Team Decision Making
III. Causal Analysis in Complex Environments
IV. Gray Zone Challenges
V. Intelligent Systems and Applications
VI. Human-Machine Interactions and Tools

Each of the chapters of this book was either reviewed or contributed by the members of Editorial Board. For this, our sincere thanks and appreciation go to the Board members listed below:

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We hope that this book, which is the international state of the art in CCDM, will be a valuable source of theoretical and applied knowledge enabling human-centered design of variety of products, services, and systems.

July 2017 Mark Hoffman

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Social Media and Social Change

A Cross-Cultural Comparison of the Accuracy of Personality Judgements Made Through Social Media

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Abstract. The growth of social media has seen a change in the way people meet and communicate. Previous studies have provided mixed evidence for the accuracy of judgments based on social media profiles alone, and relatively little is known about cross-cultural interpretations of online profiles. In the present study, the accuracy of first impressions formed from social media profile pictures was examined for people from similar or different cultural backgrounds. Results showed strong consensus between raters regarding the consistency with which attributes were rated, but poor agreement between raters and profile owners' own ratings of their personality, regardless of cultural background. Some relationships were found between raters' own personality and the ratings they assigned to others suggesting that one's own personality has an impact when making judgments of others. This will become increasingly important as social media expands the possibility of cross-cultural interaction globally.

Keywords: First impressions · Personality · Social media · Cross-cultural judgements

1 Introduction

It has been suggested a glance as quick as 3 s is all it takes for someone to evaluate another person on first meeting [1]. First impressions are usually formed on factors such as appearance, body language, clothing, and mannerisms. This tendency for humans to make automatic judgments is common across cultures although the circumstances under which such first impressions are formed may be changing. Recently, online social networks have gained popularity and are now a core means of communication in modern society [2]. Social Network Site (SNS) users may spend a large amount of time creating profiles in order to convey aspects of their personality, status or image towards others. It has also become increasingly common to meet people first online rather than face-to-face. Knowledge of how impressions are formed online is, therefore, important to understand how such media can influence the judgments we make of others. The current research asks whether the first impressions formed of others based on their online image are accurate, and how are these impressions influenced by the cultural background of the observer and the profile owner being judged?

M. Hoffman (ed.), *Advances in Cross-Cultural Decision Making*,
Advances in Intelligent Systems and Computing 610, DOI 10.1007/978-3-319-60747-4_1

According to Zhao and Jiang [3], self-presentation is strongly influenced by culture. Assumed collectivist cultures are thought primarily to view themselves as part of a whole (i.e. family, tribe, a nation) while more individualist western societies prioritize their own needs rather than group goals [4]. Some early cross-cultural research pointed to differences in the primary motivations for using the Internet. For example, in Hong Kong the internet was perceived as a medium for social interaction, while in America, using the Internet to seek and gain information was more commonly reported [5]. Kim, Sohn and Choi [6] found that SNS are used by Korean students more to gain social support from existing relationships rather than meeting new people, whereas American students used SNS more as a means of entertainment. Given that different cultures seem to have different core motivations for using SNS, then it is also relevant to consider how self-presentation online may also differ in different cultures.

Cultural differences have an impact on how people choose to present themselves to others because the concept of "self" is known to differ by culture [3]. Some studies have shown that Americans and Japanese perceive facial expressions of emotions, in particular smiles, differently [7]. A smile is a rather complex expression of emotion as it can convey genuine positive feelings as well as negative feelings. Moreover, the judgement of smiles differs across different cultures due to differences in cultural display rules [7]. For instance in Japan, people may smile more frequently for social appropriateness rather than true feelings of joy, which may lead the Japanese to perceive fewer emotions in smiles compared to other cultures. Moreover, in the US smiling faces may be associated with positive traits such as friendliness and sincerity whereas in Japan non-smiling faces may be associated with these more positive traits.

When meeting new people, Uleman [8] has proposed that we tend to evaluate their personalities based on our own experience. In other words, we need little new information to form first impression of others. It follows that first impressions formed online may therefore be influenced by past experience of online profiles. Carney, Calvin, and Hall [9] argue that such initial impressions may be based on impoverished information, nevertheless accurate personality judgments can be formed quickly when judging facial images from similar cultural backgrounds. In one study, Naumann, Vazire, Rentfrow and Gosling [10] compared interpretations of participants' in a standard, constrained pose (looking directly at the camera) with participants who posed spontaneously as they wished, finding that judgements of personality were more accurate for spontaneous poses. Whilst some studies have suggested that accurate first impressions may be formed from condensed profile information found online [11], it has also been noted that in some cultures, different display rules for online self-presentation may also exist. For example, Malaysian students adapt information such social connections to construct a desired online identity [12]. Male users were also found to be more comfortable than female users in using their own pictures as their profile pictures. Profile pictures are often carefully selected by profile owners and are one of the first aspects examined by observers of profiles, which has led some others to suggest that a different and evolving set of implied norms exists with respect to online self-presentation [13].

The Internet is now a global technology that has made it easier and more common for people from different countries and cultural backgrounds to interact. Cross-cultural judgments based on online profile are therefore, also becoming increasingly common. Whilst a standard format, that of a profile picture with limited written detail is common

to most SNS platforms, what is less known is how such public displays may be interpreted by people from different cultural backgrounds.

The focus of this present study is to explore how accurate impressions are formed online from personal images with particular reference to cultural differences. Whilst several studies have explored how first impressions are formed, little is known about how exposure or isolation to people from a different cultural background may impact on judgments of online profiles.

In this study, personality ratings judged from Western (UK) SNS profile owners' pictures are examined and compared to observers' ratings from three cultural groups. It was hypothesized that judges who were drawn from the same cultural background as the profile owners would form more accurate first impressions than judges from different cultural backgrounds.

2 Method

2.1 Design and Participants

The accuracy of first impressions was explored within three groups: UK based Western university students (n = 40), UK based Asian university students (n = 29), and overseas based Asian students (n = 27) attending university in Malaysia who had never visited the UK. The ages of participants ranged from 18 to 30 years old (Mean age, 20.8; SD = 2.1).

All participants were briefly presented with 52 social media profile pictures and were asked to evaluate 10 personality attributes of the profile owner after seeing each picture. Consistent with display durations used in other thin-slice judgment studies [9], pictures were serially presented on separate slides for a set time of 10 s. Pictures were shown abstracted from any other social media information about the profile owner.

The 52 female social media profile owners were of similar age to the participant group (Mean age, 19.4; SD, 1.6) and completed a self-evaluation of the same 10 personality attributes. All were Western (UK based) female students, who were not known to the participants in the study, and had given prior consent to their Facebook profile picture being viewed by others [14]. All participants rated the personality characteristics of each profile owner using an adapted version of Bond's dimensions used in perceiving peers scale [15]. This involved the rating of 10 bipolar objectives (e.g., Nervous – Calm) on a 7-point scale where a higher score was associated with the more positive attribute. Personality judgments were compared by using each profile owners' self-evaluation and observer evaluations to create an accuracy score.

2.2 Procedure

UK-Based Western Group. Trials were conducted under laboratory conditions. The pictures were serially presented on separate slides for a set time of 10 s with a blank slide being shown between pictures during which personality judgments were made. Where pictures contained more than one person, the position of the target individual

was stated below the picture. The presentation duration of each picture was controlled by a computer with a researcher present to ensure the task was completed correctly. No discussion of the photographic content of pictures was permitted between the researcher and observers. Observers were allowed as much time as they required to complete the personality evaluation for each picture, before moving on to the next picture. Trials took approximately 40 to 50 min for participants to complete all 520 separate evaluations (52 targets × 10 ratings).

UK-Based Asian and Overseas Group. The procedures followed for these two groups were essentially the same as the UK based Western group. However, participants from these groups were given a hardcopy of rating scales, rather entering these directly into a separate computer, whilst viewing the 52 profile images. Participants took approximately 30 min to complete all ratings in these conditions.

3 Results

3.1 Self-other Agreement Between Each Groups of Raters

To examine whether observers from the three cultural groups shared the same level of agreement when judging the personality of the target females, interclass correlations (ICC) were conducted to calculate observer agreement (consensus) for each personality attribute. Cronbach's alpha values for each attribute scored by observers from each group were calculated (Table 1).

Table 1. Intraclass correlations for averaged (ICC 2,k) measures of observer agreement (consensus) and Pearson (r) correlation coefficients between self-ratings and averaged observer ratings for 10 personality attributes * $p < .05$; ** $p < .01$.

Attribute	Consensus (Cronbach's α)			Self-other agreement (r)		
	UK Western	Malaysian	UK Asian	UK Western	Malaysian	UK Asian
Nervous-Calm	.69**	.74**	.76**	.21	.07	.19
Insecure-Confident	.92**	.83**	.80**	−.16	−.17	−.19
Shy-Outgoing	.94**	.85**	.87**	.11	.08	.08
Unattractive-Attractive	.94**	.92**	.89**	−.06	−.04	.01
Unfriendly-Friendly	.93**	.89**	.91**	.22	.39**	.28*
Insensitive-Sensitive	.90**	.31**	.30**	.39**	−.03	.03
Careless-Perfectionist	.90**	.81**	.82**	.06	.02	.05
Quiet-Loud	.94**	.90**	.89**	.21	.02	.23
Unreliable-Reliable	.93**	.86**	.85**	−.13	.09	−.07
Unintelligent-Intelligent	.92**	.79**	.83**	−.19	−.19	−.21

The overall findings suggest the level of consensus for averaged raters ICC (2,k) to be best in the UK rater group (alpha range .69 to .94) and poorer for the Malaysian raters (alpha range .31 to .92) and UK based Asian group (alpha range .30 to .91).

Interestingly, observer agreement for nervousness was the weakest in the UK group, but observer agreement was the lowest for the Malaysian and UK Asian group when judging sensitivity.

Whilst raters in each cultural group generally showed good consensus, accuracy as indicated by self-other agreement based on Pearson correlations of profile owner's ratings of their own personality with averaged ratings of all raters within each cultural group were generally low. In the UK group, only one significant relationship was found out of the 10 attributes; ratings of sensitivity ($r = .39$) was positively correlated between the owners' and raters' ratings, suggesting that raters managed to judge sensitivity with a degree of accuracy. However, no significant relationships were found for the remaining nine attributes, implying that raters' judgments did not agree with the profile owners' evaluations of themselves.

A similar pattern was seen in the Malaysian and UK Asian group where only one significant self-other correlation was found. Both in the Malaysian group ($r = .39$) and UK Asian group ($r = .28$), agreement between own ratings and other rater were found with respect to friendliness. This suggests that observers from different cultural backgrounds were better at judging friendliness in Westerners than other Western raters. The findings appear inconsistent with the hypotheses that raters from a similar cultural background would be better at judging the personalities of profile owners, from their profile pictures.

3.2 Judgment Differences Between UK, UK Asian and Malaysian Groups

The scores on the 10 personality attributes drawn from each cultural group were analyzed using a one-way MANOVA to determine the differences between three different cultures on how they generally perceived others. The multivariate effect produced from this analysis was significant ($F(2, 93) = 2.54$, $p < .01$, Wilks' $\lambda = .23$). Consideration of the univariate statistics, following MANOVA produced six significant univariate effects out of the ten personality attributes. Of the six effects, ratings of confidence ($p < .01$), calmness ($p = .02$), outgoingness and quietness ($p = .03$), friendliness and being a perfectionist ($p = .05$) were found to differ as a function of cultural background.

Figure 1 shows mean scores of each attribute in each of the three cultural groups. Results suggested a general trend whereby Malaysian based students tended to rate profile owners more conservatively than UK or UK based Asian students. UK based Asian students perceived profile owners as generally being calmer, more confident, more of a perfectionist, and quieter than rates in the other two cultural groups. UK raters considered profile owners to be friendlier than students in the other two groups.

3.3 Relationship of Profile Owners' Personalities with Raters' Own Personality

In order to examine the impact of observers' own personalities when judging others, Pearson correlation coefficients were calculated separately for the UK group, Malaysian

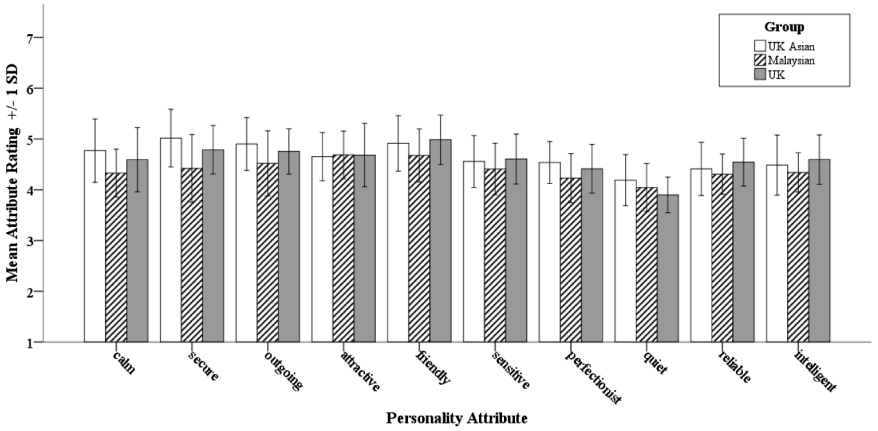

Fig. 1. Mean ratings (±1SD) of each personality attribute among the three cultural groups.

group and UK Asian group with averaged personality assessments of the profile owners' attributes (Table 2).

In the UK group, significant correlations were found for judgments of friendliness (r = .39), perfectionist (r = .43) and reliability (r = .37). In other words, UK raters who rated themselves higher on these traits, tended to rate others who showed those traits higher as well.

In the Malaysian group, a different pattern of relationships emerged. Significant correlations were found between observers' and owners' ratings of calmness (r = .45), outgoingness (r = .44) and friendliness (r = .38). This suggests that Malaysian students who had never been to the UK who considered themselves to be more calm, outgoing and friendly were more likely to assume these traits in others. In contrast, no relationships were found between UK-based Asian students' personality and the averaged ratings of others' personality.

Table 2. Pearson correlations between raters' own personalities and averaged ratings of profile owners * p < .05; ** p < .01.

Attribute	UK Western	Malaysian	UK Asian
Nervous-Calm	.13	.45*	.04
Insecure-Confident	.04	.15	.06
Shy-Outgoing	−.09	.44*	.01
Unattractive-Attractive	−.18	−.02	.02
Unfriendly-Friendly	.39*	.38*	.30
Insensitive-Sensitive	.27	.26	.34
Careless-Perfectionist	.43**	−.10	−.02
Quiet-Loud	−.11	.03	.20
Unreliable-Reliable	.37*	.21	.18
Unintelligent-Intelligent	.25	.12	.07

Collectively, these findings suggest that there may be a limited impact of one's own personality on the judgment of others, but that this effect is different across cultural backgrounds. Where significant correlations existed, it suggests that when one rates themselves higher on a trait, they will subsequently rate others higher on that particular trait as well. In other words, when people are unsure of making judgments of others, they may tend to judge others based on their own personality traits.

4 Discussion

The current study demonstrates that when making judgments of others' personality at zero-acquaintance, first impressions are not necessarily accurate even when judged from the same cultural background. Among the three groups of observers, individuals were only able to judge approximately one out of ten personality traits accurately regardless of their culture origin; sensitivity was most accurately judged by the UK group while friendliness was most accurately judged by the Malaysian and UK Asian groups. The hypothesis that people from similar cultural backgrounds would form more accurate first impressions was therefore not supported. This finding appears inconsistent with previous studies [12] that have suggested accurate impressions can be formed after brief initial exposure to strangers via social media. However, their studies included more detailed tasks such as browsing full profiles that might enable one to gain more information on which to form impressions, rather than just being exposed briefly to profile pictures. This might suggest that social media profile pictures alone do not necessarily provide sufficient information for making accurate judgments of non-visible personality attributes.

Past studies [9] have suggested that accuracy of judgments can be achieved after approximately 60 s of exposure for face-to-face situations, which is longer than the exposure duration used in the current study. It is important to note that the selected exposure was implemented to better understand if accuracy *could be achieved* more promptly via social media, given the short dwell time typically spent by users of SNS when first viewing online information about others. It should be taken into account that increasing exposure time could have led to better accuracy overall.

Despite this, whilst there was some variation between cultural groups, a consistent finding in the present study was that there tended to be good agreement between raters (consensus) regarding the opinions they formed of others. For example, good consensus between raters was found for attractiveness in the UK group as well as the Malaysian group. This could suggest that standards of attractiveness to a certain extent are consistent between these two cultures. However, low agreement for attractiveness was found in the UK Asian group who it could be argued may have had greater exposure to Western culture. This may suggest that although one is exposed to a culture, it cannot be assumed that traits will be judged consistently to natives of that culture, or that interaction with individuals in a foreign culture may affect people's perception of traits such as attractiveness differently. Alternatively, it could be that the UK Asian group used in the present study did not represent one homogeneous group but contained individuals drawn from a variety of countries, which may hold different values of attractiveness. Although observer consensus was relatively strong overall

within each cultural group, self-other agreement ratings were low, reflecting that consensus does not appear to always be an index of accuracy when forming impressions [16].

Previous research has suggested that people from eastern cultures may perceive smiles differently, due to different display rules [7]. Despite this, findings from the current study suggested that both Malaysian and Asian groups were more accurate in judging friendliness and tended to rate Western profile owners as more friendly, when assessed from profile pictures in which the majority of profile owners (67%) were smiling. Undoubtedly, the Malaysian and UK Asian groups may show different cultural expectations compared to Japanese. This perhaps implies that it is possible to judge friendliness in other cultures even where different social display rules may exist. Alternatively, since 'true' levels of friendliness were based only on the profile owners own view as to how friendly they were, it is possible that self-other agreement was artificially inflated by profile owners' tendency to overestimate their own level of friendliness.

An unexpected finding was that people from different cultural backgrounds differed with respect to the absolute levels with which they rated personality attributes. Since all participants rated the same set of target stimuli, it can be assumed that there may be consistent cultural differences in how they see others on several personality attributes. In the present study, such stereotypical differences between cultures were found with respect to the attributes of confidence, calmness, outgoingness, quietness, friendliness and being a perfectionist. Our results also suggested that an individual's own personality exerts an impact when making judgments of others as shown by the UK and Malaysian group. This may be partially explained by Human and Biesanz [17] who demonstrated that although well-adjusted individuals may not able to judge unique characteristics accurately; they tend to judge others based on assumed attributes of others or similarity to one's self. It is therefore possible that both normative accuracy (perceiving others as similar to the average person) and assumed similarity (perceiving others as similar to the self) may have limited the overall level of agreement between profile owners and raters in the present study.

That accuracy ratings did not differ between UK based Asians and those overseas is noteworthy. A possible explanation for this could be that UK Asian students currently residing in the UK are more likely to remain in their own cultural groups rather than integrating with the locals. Studies have shown that Chinese students studying abroad find it difficult to integrate with British students due to the differences in lifestyles and values [18]. It is therefore logical to assume when students do not integrate, they may be no more accurate at judging individuals in their new culture than individuals who have never been exposed to that culture.

In conclusion, the present study suggests that whilst consensus may be relatively high when it comes to making personality judgements about others about whom we have little information, overall accuracy when compared to the person's evaluation of their own personality tends to be low, regardless of cultural background. Taken together our findings suggest that people from all cultural backgrounds may rely more

on their own personality and beliefs about the 'typical' personality of others when forming first impressions and that greater cultural similarity does not necessarily lead to more accurate perceptions of others based on brief initial exposures.

Acknowledgements. With kind thanks to Help University, Wilayah Persekutuan, Kuala Lumpur, Malaysia for their assistance with the conduct of this project.

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Autochthonous Materials and Traditional Manufacturing Methods: Analysis Based on Cultural and Historical Features

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Abstract. In Brazil, there is an abundance of materials resource. Immensely, natural resources, native materials and traditional manufacturing techniques form them. However, the lack of articulation among producer community, companies, development policies in association with a poor projectual speech implies reduced use of local resources and, consequently, results in losses of opportunity to add value to local resources and developing local economy. Discuss and propose strategies for adding value to territories is very important for practitioners and researchers that work in the area of product design. Starting by the question – could a material or manufacturing method enable recognition of places and empathy by users? – We made use of a survey based upon questionnaires, answered by 60 people to find evidences of aspects involved in this relationship. They indicated products or brands made by materials or manufacturing methods they judge related to a place. This paper presents the result of analysis by historical and cultural perspective view based on documental review.

Keywords: Design and materials selection · Intangible meanings of materials · Design and promotion of local resources · Cork · Golden Grass

1 Introduction

Over the last decades production systems have acted globally: A product can be designed at some place and be built in other country with abroad materials or foreign technologies; this same product still can be sold everywhere. However this situation is critical to emergent places. According to [1], this reality is devastating because large companies have no responsibilities with social or environment aspects; they just obtain profits until it attends.

Beyond economic and social injuries, [1] defends that the concentration of economic supremacy and massive production had been also injuring environment.

M. Hoffman (ed.), *Advances in Cross-Cultural Decision Making*,
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[2] advert that large industrial systems discharge amount toxic waste on air, soil and water; causes intoxication to people and natural systems; produce dangerous materials; produces unless waste; buries materials. These production systems can improve and develop several aspects of places: environmental, social and economical.

The productive capacity from places can boost several benefits to them. It is possible to say some materials or some manufacturing methods are linked to history and tradition of territories. The way things are made can say something about its people and its place. In the meantime, some natural matters (what gives origin to a material) grows up exclusively in specific regions, they are singularly transformed in material in specific regions.

Moreover, traditional manufacturing methods or ancestry techniques used to build objects are current in the cultural history of societies. According to [3] crafts can be used as example: some territories can be represented by iconic elements from crafts skills developed by societies; some places still have their names associated to one of these crafts activities.

Brazil is an immense country and owns vast natural resources. Moreover, ancestry communities developed a lot of traditional manufacture methods. However, traditional manufacturing methods are not registered, and it exists a serious risk of they disappear. Rarely, large companies use traditional manufacturing methods and natural materials. Frequently, traditional manufacturing methods and natural resources are exploited by craft and usually results in low quality products. Emotional aspects of materials and manufacturing methods are not employed. Profits generated by massive production do not stay in territories of the materials or manufacturing processes. Design education almost ignores this type of source.

In 1986, the book "The material of invention" [4] presented materials and manufacturing processes as a "horizon of possibilities" for designers. Author explained technical features should not be principal criterion to select a material against an increasing number of new materials. Then, he realized reflections about cultural aspects of materials and it effects at users perception of products.

From then on, lots researches investigate the role of sensorial, emotional and perception aspects of material in user-interaction relations. These aspects are called by experts "intangible meanings" since they are subjective [5–11].

Starting by "materials evoke meanings and elicit emotions" [11], some material or manufacturing method employed in local products can evoke emotions in users. Among others, intangible aspects of materials are relevant to this research because it is concerned with factor of local recognition.

Recognition of territory is an essential factor for adds value to its resources. Then, as [12] arguments local qualities should be presented and exploited when gives value to local resources is expected. For author, local products can do this quality recognition. Beyond the history and culture of some place influence original design of products.

The purpose of this paper is to present a study about cultural and historic aspects of materials appointed by users as representative for places. It is important for designers and practitioners from local design field understand relevant aspects for users and their products appreciation, once recognition of local values is crucial for success of local products. The main objective of this study is to evaluate and list what kind of relationship materials have with history and culture of associated place.

2 Methodology and Methods

To realize this study it was needed new information about users and their appreciation of local products. Then, it was chosen Survey as method for this data gathering. Following, based on responses it was realized a Documental Analyzes to find the role of them in history and culture of places they were associated by inquired individuals. Next, analysis grids of finds have been built to classifies and compares them. Based on analysis grid a list of relevant indicators was shape.

3 The Survey: Materials and Manufacturing Techniques and Local Recognition

The survey firstly aimed to verify if users can recognize places by constructive aspects of products. It was based upon questionnaires, answered by sixty undergraduate students (thirty from Brazil and thirty from Portugal). This study was not boarded to a specific user, then the sample was chosen by convenience. Questionnaire had only one question that asked if the inquired people could cite any product or brand which uses native materials or local manufacturing techniques.

Most of Brazilian inquired individuals indicated at least one industrial product, brand or craft artifact which uses a material or a technique that make them realize associations to a place. Only two inquired individuals answered they could not remember any product or brand. Citations were extremely varied. Some responses were cited more than one time. Most cited products were art crafts from northeast of Brazil made by bobbin lace, indigenous pottery from Brazil, products made by cork from Portugal, objects made by golden grass from Jalapão and products made by murano glass from Italy. Figure 1 generated by Wordle System shows the proportion of responses.

Most of Portuguese inquired individuals indicated at least one industrial product, brand or craft artifact which uses a material or a technique that make them realize associations to a place. Only three inquired individuals answered they could not remember any product or brand. Citations were very similar to each other, mainly Portuguese products were cited. The majority of responses were cited more than one time. Most cited objects were cork from Portugal, pottery from Caldas da Rainha,

Fig. 1. Answers by Brazilian inquired individuals

Fig. 2. Answers by Portuguese inquired individuals

Filigree from Gondomar and carpet from Arraiolos. Figure 2 generated by Wordle System shows the proportion of responses.

Once verified both Brazilian and Portuguese users remember places through materials used in products it was drove some questions: why these products and brands were cited? What their role in history and culture from territory they were connected? Then, it was chosen two most cited materials: Golden Grass and Cork. Throughout relevant bibliography it was examined the indications of these materials in history and culture from territories they are associated with.

4 Documental Analysis by Cultural and Historic Aspects

4.1 Golden Grass and Jalapão

Golden Grass (Syngonanthus nitens Ruthland) is a specie of plant from Brazilian veredas region. This plant grows up without chemical products or pesticides, it is a natural, renewable and sustainable resource. Because of its bright quality, Golden Grass twigs after dry are used to create various crafts products [13].

Golden Grass crafts started with Xerente indigenous tribe. After 1930, Mumbuca community from Jalapão locality learned with Xerentes how to make Golden Grass crafts. But, only in 1990 Golden Grass products became known because of touristic points from Jalapão next the Mumbuca community.

On account of success of Golden Grass products with visitors, the Tocantins government began to support artisans on dissemination strategies. At the time, Golden Grass is specially known and related to Mumbuca community and Jalapão place. Eleven associations of workers, on Jalapão region, provision the production and market of Golden Grass products. In addition, SEBRAE (Brazilian Service Supporter for Micro and Small Business) promotes actions to improve artisan skills, to save crafts culture, to improve sells and exportation [14].

Nowadays, the Golden Grass craft is the most important economic activity in region. It is the unique monetary activity of many families. Tocantins government protects Golden Grass craft as historic and cultural patrimony by laws. Stimulated by

this reality, many artisans from other Brazilian regions moved out to Tocantins to learn and work [13].

Several types of products are made by Golden Grass: purses, jewelry cases, rings, necklaces, bracelets, bowls, decoration utilities, baskets and others (Fig. 3). Originally, products were stitched with Buriti thread, other natural material from Brazil. Actually, most of products are stitched with metals or other synthetic material because of high prices of Buriti. The formal and finishing qualities are low in many cases.

Fig. 3. Golden Grass products

4.2 Cork and Alentejo

Cork is a suberous parenchyma which involves the Cork Oak three. Cork Oak three mainly grows up at Mediterranean European and North of Africa, however, Portugal has the most extensive Cork Oak three forest of the world. Law in Portugal saves Cork Oak since Medieval Age because of its social, environmental and economical importance for the country [15].

Cork Oak forest is called in Portugal "Montado". The Montado is the main characteristic of Alentejo landscape. The abundance of Cork Oak reflects on the abundance of Cork. Portugal produces 60% of Cork global production. In Portugal, there are 637 businesses, which employ 8591 workers in this field [15].

The Cork Oak can live 350 years and permits, in average, 18 Cork extractions. Material is natural and renewable. It is necessary specialized work force to make the extraction. After, Cork is used to build various products: stop for bottles, furniture, coating plates, utilities for house, toys, clothing, shoes and others. Cork arts crafts are found among all Portugal territory [16] (Fig. 4).

Fig. 4. Cork products

Some parts of historical monuments are made by Cork and other monuments picture the use of Cork over the Portugal history. In 2010, the Portugal Pavilion at International Exposition of Xangai was completely coated by cork with the goal of demonstrate national politics for sustainability [16].

Although they are few, there are some initiatives on design field exploring Cork and its potential for contemporary and innovative products. New technologies for novel applications and monetization have been regularly investigated. These experiments resulted in viable Cork products such as synthetic composites, expanded plates, Cork skin, Cork paper and Cork textile.

5 Results

Grounded on documental review, it was specified themes, categories and relation indicators for content analyze. Themes were divided in Golden Grass in Jalapão and Cork in Alentejo, the object of analyze. Categories were divided in kinds of material transformation, which are interesting for product design. Relational indicators were established based on historical timeline and the anthropological definition of culture. According to [17] the term culture is used to summarize: knowledge, belief, art, law, behavior and other capacities or habits acquired by individuals members of a society. In anthropological view, these capacities or habits define the concept of otherness that means the difference in relation to the other [18]. All of those capacities and habits together define the identity of a place and generate the place's identity [18]. Then, it was assembled an analyze grid to be possible to analyze the role of material in culture and history (Tables 1 and 2).

Table 1. Golden Grass in historical and cultural aspects of place.

Category	Relation indicators				
	History	Everyday habits	Arts	Behaviors	Capacities
Material on natural landscape	Golden Grass is an autochthonous specie	Preservation of landscape is practiced	Poetry, music, photography and paint	Golden Grass is harvested only from September 20th to October 10th	Local techniques for preservation of Golden Glass plant
Gross material	No information	Harvest was initially taught for next generations. Now it is documented	Poetry and music	Party one day before Golden Grass harvest	Special skills to harvest the twigs
Craftwork	Before 1920, Xerentes indigenous tribe made it for them. After 1920, disseminated by Mumbuca community Since 1999, it is made buy other communities from Tocantins	Before 1999, only women crafted Nowadays, men and woman do it daily Initially, manufacturing techniques was taught by parents for children, nowadays there are limited courses for interested artisans On Mumubuca community people craft together	Art crafts and photography	Before 1920, use of Golden Grass products in domestic activities. After 1920, use of Golden Grass products a means of subsistence and later as a profession. There are points of sale of handicrafts throughout the region	Special skills to build pieces
Mass production	After 1999	Associations organize craftwork. Even handcrafted, pieces are made in series for exportation	Art crafts and photography	Professional activities	Special skills to build pieces for mass production, to manage production and exportation
High technology transformation	No information	No information	No information	No information	No information
Other alternatives	After 2000	Associations organize craftwork. Even handcrafted, pieces are made in series for exportation	Art crafts and photography	Professional activities	Use of metals, golden-plate, precious stones and other crafts techniques to improve production

Table 2. Cork in historical and cultural aspects of place.

Category	Relation indicators				
	History	Everyday habits	Arts	Behaviors	Capacities
Material on natural landscape	Cork Oak is autochthonous specie	Cork extraction; Livestock activities	Painted Montado landscape Sculptures about Montado landscape	Pastoral activities and hunting	Local techniques for: Cattle breeding; Preserve the Cork Oak
Gross material	Since Medieval Age (registered)	Products used in rural places. Use of cork gross products in domestic activities	Sculptures from XVIII; Archtecture elements of building from XV, XVI	Pastors used Cork trough and Cork jug to drink water in the Montado	Local techniques for initial phase of Cork getting: extraction and preparation
Craftwork	Since Medieval Age	Crafts workers crafts daily. There are pieces of various types of complexity, applications and quality of finishing	Various types of handicraft products	There are points of sale of handicrafts throughout the country. They are mainly sold for tourists	Special skills to build pieces
Mass production	Since 1920	There are 637 employments that generate more than 8000 jobs. Cork products are present in Portuguese daily live: cover plates, utilities and stop bottoms and others	Sculptures of stop bottoms	Cork for heat or cold insulation in public places. Cork for posting messages. Cork in kitchen objects	Specialized workers
High technology transformation	Since 2000	High technology crossing traditional manufacturing methods with Cork is used in daily life, for example expanded Cork and synthetic composites are applied in several viable products. New technologies have been regularly tested	No information	Expanded Cork blocks are widely used to insulate cultural events in open areas	Specialized workers
Other alternatives		Paper and Cork skin	Art with Cork paper	Clothes, shoes, fashion accessories and cork stationery are increasingly in use	Specialized workers

6 Final Considerations: Opportunities

This paper presented the results of an exploratory documental analyze about the relation of materials to their origin places. Considering the losses of identity and territories prejudices generated by actual production systems, the understanding of these relations is fundamental to design activity and creation of original and innovative local products.

Some considerations relevant to design of local products can be pointed out:

- Materials are relevant components on user-product interaction.
- According to survey's results people can associate materials and manufacturing methods to places. They cited several cases of products, brands, materials and manufacturing techniques related to territories.
- Artisanal and semi-industrial products were easier to remember, since they were the most cited.
- Portuguese individuals cited more products and brands from Portugal than Brazilian individuals cited Brazilian product or brands. Strategies to Brazilian recognize the value of local products and policies to Brazilian local product improvement are needed.
- Natural and autochthonous materials also were easier to associate to places than industrial materials.
- The evident relationship of Golden Grass and Cork and local history and culture were decisive to their recognition as local materials.
- Both materials help to tell the place history and are present in daily life of local individuals.
- Both materials support their territories economically.
- Both materials enabled the development of management techniques, production and organization, recognized as the "culture of doing" of each one of them.

Acknowledgments. This research would not have been possible without the support of the CAPES (Coordination for the Improvement of Higher Level Personnel) and the Federal University of Uberlândia.

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Cross-Cultural Reactions to Crisis Events via Language and Emoticon Use

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Abstract. We analyze language and emoticon use on a social media platform to describe large-scale human reaction to a crisis event. We focus on a targeted corpus of 2 million tweets defined by a set of hashtags and posted on the social media platform Twitter. We analyze these data under the framework of Construal Level Theory and compute lexical diversity and concreteness values of words across subsets of the data that differ with respect to geographical distance from the event. We find that word count and lexical variation among concrete words (but not average concreteness) decreased with increasing geographical distance. In addition, we investigate the use of non-verbal signals through the use of emoticons and emojis in these subsets. Overall, our findings make significant contributions in quantifying and contrasting cross-cultural communication with respect to large-scale human response to a crisis event, specifically a terrorist attack. The results presented here are novel in that they demonstrate what we learn from large-scale nonverbal as well as verbal communication analyzed in the framework of the Construal Level Theory.

Keywords: Human factors · Social media · Natural language · Construal

1 Introduction

Social media permits a sense of immediacy whose impact cannot be overestimated [1] and many have argued that it changes our concepts of time and space and how we experience them [2]. Construal Level Theory (CLT) [3] posits that people experience psychologically distal events by forming more abstract mental construals of such events than they do for events that are psychologically proximal. These mental construals manifest themselves in the language people use to describe the events, specifically in concreteness values (defined as the degree to which a concept denoted by the word refers to a perceptible entity). For instance, people may experience geographically distant, and hence psychologically distal, events by forming mental construals of such events at higher levels of abstraction than events that are geographically proximal [4]. As an example, the word *heart* has a high concreteness value and may be used to describe a geographically proximal event, whereas the word *love,* which has a low

M. Hoffman (ed.), *Advances in Cross-Cultural Decision Making*,
Advances in Intelligent Systems and Computing 610, DOI 10.1007/978-3-319-60747-4_3

concreteness (and hence high abstractness) value, may be used to describe a geographically distant event.

In this article, we test our hypotheses that people will use different vocabulary to describe the same crisis event, depending upon their own geographical distance from that event. We focus on natural language productions on social media platforms immediately following a terrorist attack. We use our analyses to challenge the claim that the sense of immediacy engendered by social media compresses our experience of time and space in ways that are evident in our spontaneous written language production.

2 Data Collection and Method

We focus on a targeted corpus gathered using a specific set of hashtags, composed of 2 million tweets posted on the social media platform Twitter. The tweets were posted in a 24-hour period following the terrorist attacks in Paris, France in November 2015. The unique hashtags across the corpus are listed in Table 1.

Table 1. List of unique hashtags in our tweet collection

Hashtags			
#ParisShooting	#ParisShootings	#parisattack	#parisattacks

In order to test our hypotheses on a large corpus of linguistic constructions, we created two subsets of tweets from the original set of 2 million—each subset containing 54744 tweets in English. One subset contained tweets that were posted from within France (determined using metadata associated with each tweet, specifically the geotags and geolocations). We call this subset *within-France*. We created a second subset of 54744 English tweets chosen randomly from those tweets out of the original 2 million that were posted outside of France (we call this subset *outside-France*).

For each subset, we determined the number tweets that contain non-verbal symbols, *viz*. emoticons and emojis (11% in the *within-France* subset and 7% in the *outside-France* subset). These proportions are shown in Table 2.

Table 2. Proportion of Tweets containing emoticons and/or emojis in each subset

Within-France		Outside-France (randomly chosen)	
Total Tweets	54744	Total Tweets	54744
% of Tweets with Emoticons and/or emojis	11%	% of Tweets with Emoticons and/or emojis	7%

For each subset, we also identified the top 10 most frequently occurring emoticons/emojis. We show these in Table 3 below.

Table 3. Top 10 most frequently occurring emoticons/emojis in both subsets

Rank	Within-France	Outside-France
1	red circle	☹
2	☹	man kissing woman
3	folded hands	folded hands
4	man kissing woman	broken heart
5	:/	pensive face
6	=(	red circle
7	camera	:/
8	pensive face	=(
9	broken heart	crying face
10	france flag	disappointed face

We note that some emoticons and emojis are common within the top ten most frequent symbols in the *within-France* and *outside-France* subsets. Interestingly, the French flag appears in the within-France set (at rank 10) suggesting patriotic feelings emergent in the tweets posted within France after the crisis tweet.

3 Analysis of Data

Our hypothesis is that *within-France* tweets will contain more linguistic expressions with higher concreteness (lower abstractness) ratings than those that originate elsewhere, since these expressions describe events with closer geographical distance.

We use an existing concreteness lexicon [5] to identify words in tweets that have extreme concreteness scores (≥ 4, on a scale of 1–5) and extreme abstractness scores (≤ 2). We compute the following measures of extreme concreteness and abstractness: (1) means of each tweet (2) counts of extremely scored words in tweets and (3) vocabulary richness/lexical variation measured by entropy of word choice. We shall describe the lexical variation analysis in detail next.

We computed lexical diversity from information entropy [6] of the frequency distribution of individual words and used it as a measure of vocabulary richness words (defined as unique character sequences delimited by spaces or punctuation; not including the emoticons themselves). For each word, we computed its frequency and then converted that to a percent of the total word frequency (relative frequency). We expressed each value in log base 2 and computed the negative product of the log times the relative frequency and summed those values. Higher values calculated using this

measure indicate greater uncertainty and greater lexical diversity. Low values indicate a more redundant word choice. We conducted separate analyses for the most extremely rated (top 25%) concrete and the most extremely rated (top 25%) of abstract words.

4 Results and Discussion

4.1 Analysis of Lexical Variation

For concrete words, lexical variation was found to be greater inside France than out (15.23 vs. 15.02), while lexical variation for abstract words across tweets was less *within-France* than *outside-France* (15.19 and 15.34). This suggests that *outside-France* tweeters tended to use and reuse a small set of very concrete words compared to their use of abstract words (Table 4).

Table 4. Lexical Diversity of words with extreme concreteness values (high and low) in within-France and outside-France subsets

	High concreteness	High abstractness
Within-France	15.23	15.19
Outside-France	15.02	15.34

However, means (SD) revealed that tweets in France were more abstract (1.44 (.08)) than those out-side (1.50 (.04)), which suggests that tweeters from *outside-France* selected a larger, more varied but less abstract set of words. Figure 1 shows the mean concreteness of tweets posted *within-France* and *outside-France*.

Here we find that variability and means for concreteness and abstractness worked systematically in complementary directions. Our results are consistent with the Construal Level Theory in that lexical variation among concrete words (but not average

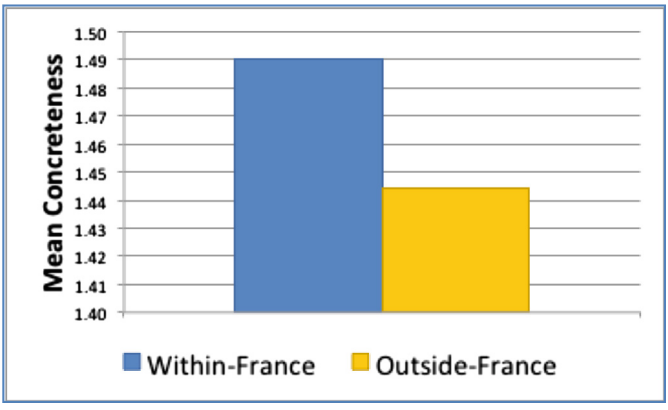

Fig. 1. Mean concreteness of words in tweets posted within and outside France

concreteness) decreased with increasing physical distance from the event. Similarly, with respect to extremely abstract words, within France tweets were less abstract and less lexically diverse.

4.2 Analysis of Lexical Variation with Emoticons/Emojis

Following Feldman et al. [7] who argue that emoticons in text function like gestures or paralinguistic elements in language, we compared tweets with and without emoticons with respect to lexical variation.

Of tweets *within-France*, 11% included emoticons and/or emojis, compared to 7% of *outside-France* tweets. The emoticons : (, :/ and = (constituted 82% of emoticons in *within-France* tweets but only 65% of *outside-France* tweets. Entropy analysis of emoticon use in tweets revealed that there is less variation in the distribution of emoticons in tweets that originate in France compared to those that originated elsewhere (2.35 vs. 3.05 resp.). These findings are summarized in Fig. 2.

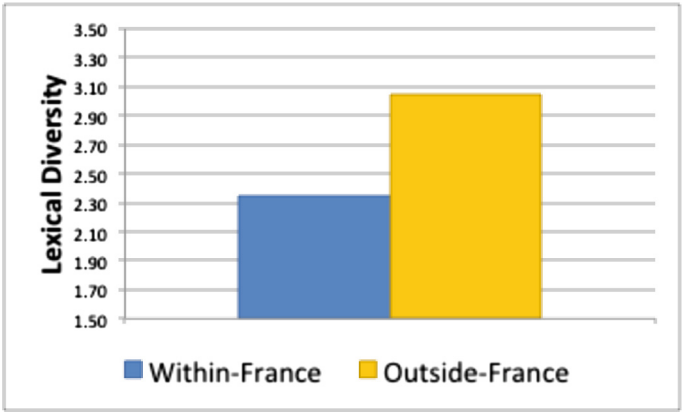

Fig. 2. Mean entropy of words in tweets with emoticons/emojis posted within and outside France

We also analyzed the words that co-occur with the most frequent emoticons under the assumption those words reveal what the user is experiencing in response to our target crisis event (see also [8]). In the context of a ☹, *within-France* tweets were less likely to mention the words 'prayers', 'thought' and 'thanks' and more likely to mention 'crazy' and 'crying' than *outside-France* tweets. Mention of 'thoughts' and 'prayers' were also more characteristic of *outside-France* than of *within-France* tweets that accompany a ☹.

5 Summary and Future Work

Social psychologists have always been interested in the behavior of groups and insights from contagion behavior show that the behavior of an individual is influenced not only by the people he/she knows but also by the behavior of the people that person knows. With the increasing popularity of social media platforms such as twitter, geographically distant individuals are now able to connect and respond to crises events such as terrorist attacks, as was the case in our work.

We analyze natural language productions on social media posted immediately (within 24-hours) of a crisis event that occurred in France in November 2015. We compute measures of lexical diversity to test our hypotheses that tweets posted from places that are geographically distant relative to the event will reflect the use of more abstract language when compared to tweets posted geographically closer to the event (i.e. within France). We find that our results are consistent with the Construal Level Theory and that lexical variation among concrete words decreased with increasing physical distance from the event.

Interestingly, geographic distance to the focal event plays a role in tweeting styles. Potentially this difference could be attributed to the development of in-group and out-group, such as the within-France tweeters and outside-France tweeters, with former as the in-group and the latter as the out-group.

In future work, we wish to extend our analyses to other facets of psychological distance, including social and temporal distance. We also aim to replicate our analyses on other large corpora, which may or may not be centered around a crisis event.

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Geo-Tagged Social Media Data as a Proxy for Urban Mobility

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Abstract. We evaluate the utility of geo-tagged Twitter data for inferring a network of human mobility in the New York City through a quantitative and qualitative comparison of the Twitter-based mobility network during business hours versus the ground-truth network based on official statistics. The analysis includes a comparison of the structure of the city inferred through community detection in both networks, comparison of the models of human mobility fitted to both networks, as well as the comparison of the dynamic population distribution across the city presented by the networks. Once the utility of the Twitter data is verified, the availability of an additional temporal component in it can be seen as bringing additional value to numerous urban applications. The data visualization web application is constructed to illustrate one of the examples of such applications.

Keywords: Urban Science · Human mobility · Social media · Twitter · LEHD · Gravity model · Community detection

1 Introduction

Multiple urban applications require a reliable but ideally low-cost dataset reflecting human mobility. Data from the cell phones [1–8], GPS devices [9], credit cards [10–12], 311 service requests [13] as well as various sensors [14–16] could provide rich information about the city and its residents, however such data availability is limited largely due to the privacy concerns [17–19]. Wide spread of social media and relative accessibility of the data creates an opportunity for using geo-tagged social media transactions as a proxy [20–22]. However due to its limited representativeness and high heterogeneity, ground-truth validation is often needed before such data can be recommended for the practical applications.

In the present paper, we evaluate the utility of geo-tagged Twitter data versus the ground truth Longitudinal Employer-Household Dynamics (LEHD) data, collected by Census. The paper compares the patterns of human mobility inferred from Twitter during business hours versus the ground-truth on people commute. We start with

M. Hoffman (ed.), *Advances in Cross-Cultural Decision Making*,
Advances in Intelligent Systems and Computing 610, DOI 10.1007/978-3-319-60747-4_4

evaluating the shape and parameters of dynamic population distributions defined by the two datasets and further focus on more specific patterns, such as the network community structure and the parameters of the models describing the networks.

Our studies support a conclusion that the temporal component of Twitter data represents well the dynamics of urban population and provides solid ground to the study of urban mobility. To illustrate the idea, we constructed simple data visualization web application that by allowing to select location, time and area of interest estimates how many people can be found in the given area at the considered moment of time and where those people come from.

2 Datasets

2.1 Longitudinal Employer-Household Dynamics (LEHD)

LEHD is the research program managed by the US Bureau and provides a rich data on the characteristics of the population employment by region, industry, race, gender, etc. over the years from 2005 and till (as for now) 2014. One particular dataset, LODES (LEHD Origin Destination), gives information on the amount of people commuting for work from and to the area, detailed to the block level. As such, it represents the human mobility network with all locations being the nodes and the commute connections being the edges, this directed graph represents an origin-destination commute network within the country including New York City (NYC).

2.2 Twitter

Twitter is a popular micro-blogging service that allows people to post short messages and follow other people across the world. In the first quarter of 2016, number of its monthly active users worldwide exceeded 310 million. Due to its text size limitation (recently removed), users tend to generate posts on a fast pace, through multiple native and third-party applications. Due to platform popularity, any approach based on its data is a-priory applicable to the most urban areas across the globe. With its large collection of historical records, and detailed information about time, user, application, post geographical coordinates and the body of message, Twitter has a premise to be a source of abundant information on characteristic of urban landscape.

A feed of tweets with geolocations from 5 boroughs of New York City was collected for two years, namely 2015 and 2016, using official API. Data has been then aggregated to 2166 census tracts across the city; tweets considered as automated were removed for cleanliness. Our final database contains over 10 million tweets from about 1,300,000 unique users.

2.3 Data Granularity

For the purpose of the present study with the exception of the Sect. 3, we aggregate all census tract level data into zip code level data in order to avoid data sparsity in certain

areas, since New York City has more than 2,100 census tracts, but only around two hundred zip codes, while this was done based on the centroid locations of each census tract and their belonging to the zip code shape files. Although some census tract areas in fact intersect with more than one zip code, converting both datasets in the same way ensures consistency of the analysis.

3 Properties of the Networks

3.1 Mobility Network Construction

For LEHD we already have the network defined directly in the data. Each record contains the origin (home) and destination (workplace), as well as the number of people commuting between the two, which will serve as an edge weight. However, this dataset counts only people being officially employed. Thus, children, elderly people, students and unemployed are not counted. In total LEHD maps only 2.7 million people, while census reports the population of over 8 million within 5 boroughs.

For the Twitter dataset for each user we try to define his/her home location: following the previously established approach [22], for all census tract areas compute the number of evening/night-time activities (after 8 pm, before 8 am) of that user and time interval length between the first and the last activity in this census tract; if the census tract having the max number of night-time activities is the same as the census tract having the longest interval, provided that max number of activities and interval satisfy selected thresholds, then this census tract area can be selected as the anticipated home location of this particular user. If no home location can be selected, then discard the user from further consideration.

Then define an edge weight E between the locations A and B as the number of activities in B, produced by the users residing in A. The edges defined that way are directed. The origin is the home location, the destination is the place where the tweet is posted, and the weight of the edge is the number of tweets. The weight E could be computed separately per each time-interval (3-hour, for example) of the week, creating a temporal network.

Next, we extrapolate this network to represent the entire city population by adjusting the edges' weights with following steps. First, for each home location, we get its census population. Then, the weight of each edge between A and B is estimated as a fraction of the tweets from the origin A it represents within the given time period, times overall census population of A.

Finally, we also consider an overall work hours network by aggregating and averaging all edges of the temporal network within the time span of 9 am–6 pm.

3.2 Distribution of Attractiveness of Urban Locations

To ensure numerical consistency between LEHD and Twitter networks we added the part of census population which does not participate in LEHD as the sedentary population. Specifically, for each census tract the difference between the total census population and commuters was defined as "stayers", and added to the loop edge

(people who move within the census tract of their home location). Using this approach, the LEHD network was adjusted to represent the entire city population of 8 million, just like the Twitter network does.

The first question we ask is if the two networks – Twitter and LEHD – redistribute people across the city in a similar manner. For that purpose, we analyze the distribution of the dynamic urban population, i.e. the total incoming population for each census tract according to the original and adjusted LEHD networks as well as according to the business hours Twitter network.

Distributions of that kind often follow a lognormal law. To verify it we plot each distribution after taking a logarithm of the incoming populations. As we can see from the Fig. 1 the resulting distributions look similar to normal and the normal distributions fit them quite well. Parameters of each distribution on the logarithmic scale are presented in Table 1.

Table 1. Log mean and standard deviation of the dynamic population distribution.

Dataset	Census	Original LEHD	Adjusted LEHD	Twitter
Log mean	8.042934	5.684584	7.923880	7.893511
Log standard deviation	0.859963	1.567767	0.837810	0.802851

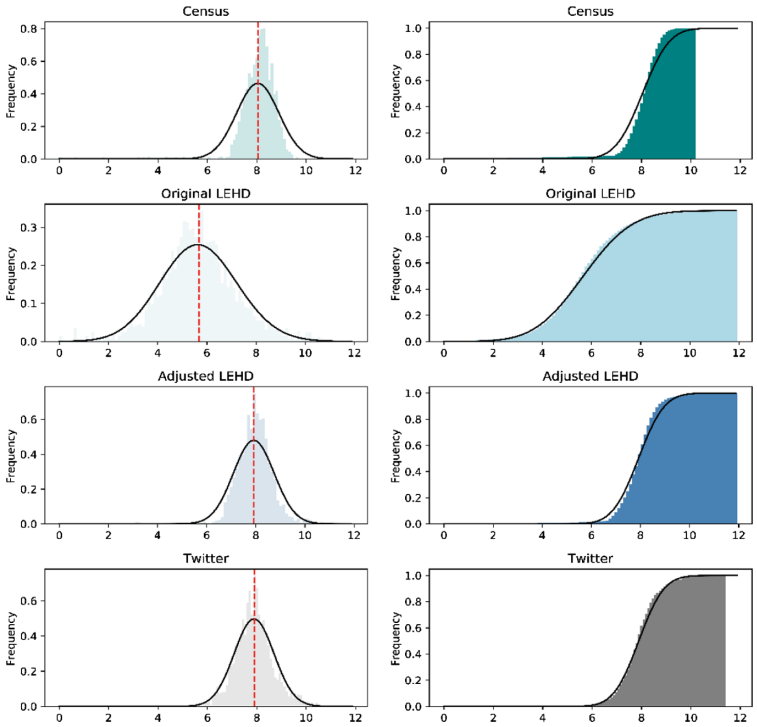

Fig. 1. The probability density function (left) and cumulative distribution function (right) of the logarithms of different types of dynamic population across the city, probability estimated with frequency.

While it is not surprising that means of the distributions are consistent (with the exception of the original LEHD network as the population participating in it is much smaller), the parameter to consider is the log standard deviation. It shows how narrowly or broadly the population is distributed across the city during business hours according to each dataset. And while parameters for adjusted LEHD and Twitter-based distributions are slightly different, they both highlight the same pattern – the dynamic business hour population of the city is more narrowly distributed compared to the original census population.

4 District Delineation

For the purpose of the further analysis of urban mobility networks, they were aggregated at the zip code level as described in the Sect. 2.3. Also, we only include the zip codes with at least 3 outgoing edges, meaning that isolated locations or locations lacking enough data to represent their connections will be dropped.

It was observed in the previous works that the networks of human mobility often reflect the geographic structure of the area on regional [4, 10] or even global scale [20]. This has been also validated on the city scale using cell phone and taxi data [23]. Here we are going to compare the district structure of the New York City as seen from LEHD and Twitter networks and evaluate its consistency.

With the help of the Combo partition algorithm [24], community detection can be performed for the above mobility networks. The optimal number of clusters for Twitter and LEHD are 13 and 5, respectively. The partition visualization can be viewed in Figs. 2 and 3. (From now on all LEHD refers to original unless stated otherwise.)

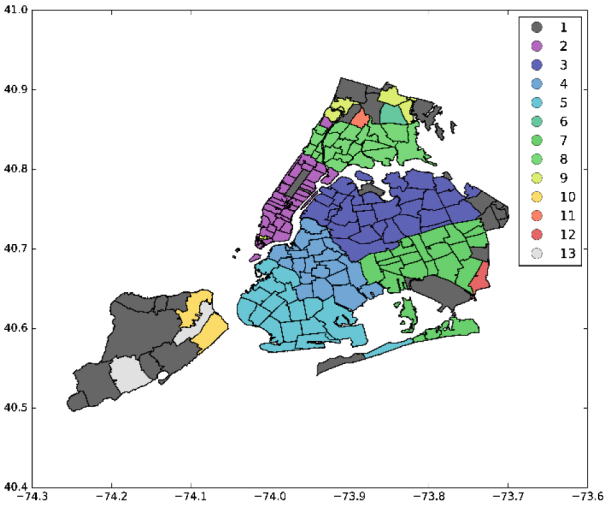

Fig. 2. Partition of NYC based on Twitter data

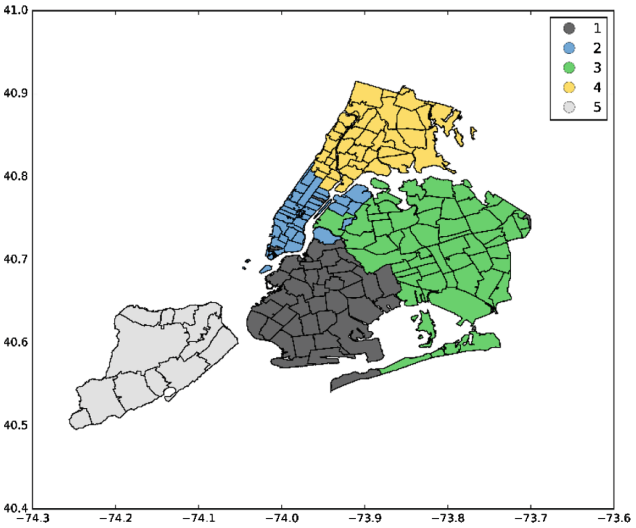

Fig. 3. Partition of NYC based on LEHD data

From the Figs. 2 and 3, we can see that LEHD data is generally more consistent and inherent, while Twitter data fluctuates more intensively creating a few outliers in the outer boroughs. This can be largely explained by the increasing sparseness of Twitter activities while going further from the city core. Also, LEHD-based optimal partition seems to present larger communities compared to Twitter, which can be attributed to the difference in relative strength in loop edges in both networks (following from the different ways the datasets represent the sedentary population, which is basically not included into LEHD). However, apart from the noise and the scale, the Twitter partition appears to be quite consistent with the one from LEHD – specifically being a subpartition of its LEHD counterpart, with only a small fraction of exceptions.

In order to evaluate this quantitatively we measure how much the Twitter partitioning is consistent with the LEHD's with respect to the fact that first one is more granular. Specifically, we count how many pairs of nodes within the same community on Twitter are also located in the same community on LEHD as well. And given the fact that different edges in the network have different degree of importance for the network represented by their weight, we shall weight the pairs of nodes according to the corresponding edge weight (although the "unweighted" estimation is also included for comparison). The results are summarized in Table 2.

Table 2. Consistency of Twitter and LEHD partitions.

The metric	In-community edges in Twitter	In-community edges in LEHD	In-community edges in both	Relative size of the intersection (same community in Twitter being the same community in LEHD)
Weighted	4758702	1191974	4493039	94.42%
Unweighted	3674	7466	3022	82.25%

This quantitative metric shows a high degree of consistency between the two partitions and once again confirms the possibility of extracting meaningful patterns from Twitter data, consistent with those extracted from the ground-truth official records.

5 Gravity Model for Human Mobility

Inspired by and derived from Newton's universal law of gravitation, which measures the attraction of two objects based on their mass and distance, gravity model is a commonly used method to estimate the amount of interaction or mobility between two locations [25]. We define the amount of interaction between two locations to be proportional to their relative weights and inversely proportional to their distance to a certain power. The weights of locations are usually taken in some relation to their size/population, however as we are more interested in a descriptive rather than predictive side of the model, we'll simply fit them from the data here. This way we need to fit both: the weight of each location (zip code) and the distance exponent showing how fast the mobility decays with distance. But since we are dealing with a directed graph, it could make sense to distinguish between the incoming and outgoing strength for each node, instead of one single weight. We believe the first can represent the activity of residents from the origin and the second - the attractiveness of the destination.

More specifically, let a typical edge in our directed graph be defined by an origin (zip code i), a destination (zip code j), and the edge weight $E_{i,j}$. Given the distance $D_{i,j}$ between these two zip codes i and j, the gravity model implies that the edge weight is proportional to the strength indicators of the two locations, as well as the distance between them, meaning

$$E_{i,j} \sim \frac{O_i I_j}{\left(D_{i,j}\right)^c} \tag{1}$$

where O_i and I_j represent the out-strength of origin zip code i and in-strength of destination zip code j, respectively.

Equivalently, the formula can be rewritten as

$$\log\left(E_{i,j}\right) \sim \log(O_i) + \log\left(I_j\right) - c\log(D_{i,j}) \tag{2}$$

and our job is to fit the parameters $\log(O_i)$, $\log(I_j)$ and c using a standard ordinary least squares regression. Once again, we only include the zip codes with at least 3 outgoing edges. Also, we do not consider loop edges as the edges with the zero distance obviously do not fit the scope of the model.

Comparing the models fit to the LEHD and Twitter data we will be focusing on the distance exponent. The results of this comparison together with the corresponding statistics are summarized in Table 3.

Table 3. Gravity model parameters for the Twitter and LEHD networks.

Network	Exponent (c)	Conf. int. (95%)	P-value	R-squared
Twitter	0.2957	(0.2802, 0.312)	0.000	0.458
LEHD	0.2806	(0.272, 0.289)	0.000	0.747

As one can see the influence of distance in the model is statistically significant as confirmed by the p-values, and the exponents we're getting from Twitter and LEHD are consistent as their confidence intervals overlap. So once again – Twitter provides a pattern of mobility decay with distance consistent with what one can get from official ground-truth LEHD data.

6 Temporal Dimension of Twitter Data

As we saw the patterns one could extract from Twitter network are generally consistent with those seen from LEHD, so despite its sparseness and limited representativeness, Twitter can be thought as a useful proxy for human mobility. However, its utility is not only in reproducing the patterns which one can get from the ground-truth statistics data such as LEHD. More importantly, unlike static LEHD data, Twitter provides a temporal dimension, allowing to track the mobility patterns as they evolve over time, bringing additional value this way.

In Sect. 3 we considered the parameters of the dynamic population distribution across the city during business hours. Now based on the Twitter data, we can see how those parameters change over the typical week during different 3-hour time spans. Figure 4 represents the dynamics of the corresponding log standard deviation.

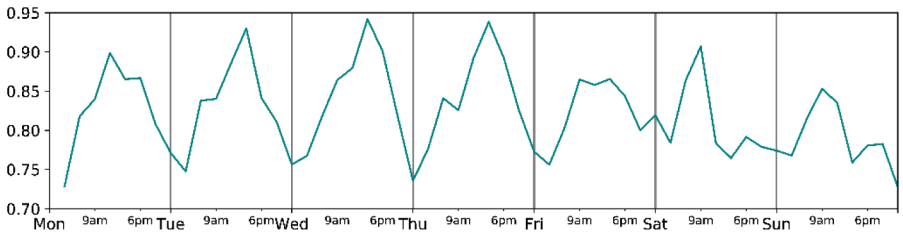

Fig. 4. Network standard deviation over typical week

As one can see dynamic population distribution across the city follows a pretty regular pattern during Monday–Thursday becoming considerably more narrow during business hours and more wide-spread during the rest of the day. The pattern is less evident on Fridays (as for many Friday might be a shorted business day) and changes during the weekend with the narrowest distributions being observed during the morning hours.

As far as the gravity model exponent is concerned, another regular weekly pattern can be seen on the Fig. 5.

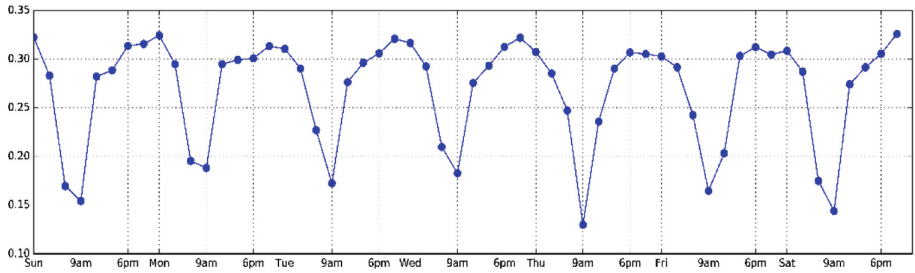

Fig. 5. Gravity exponent (c) changes over time on a 3-hour basis

From Fig. 5 we can see that the temporal pattern makes perfect sense–mobility is more local during the day and more far-reaching during typical commute time. Surprisingly enough, weekend pattern is not that different from the weekdays.

7 Discussion

As shown above, Twitter-based network turns capable of representing urban mobility, by providing an estimate of the number moving between locations, allowing to reproduce many patterns seen from the official LEHD data, such as the shape and characteristics of dynamic population distribution, characteristics of the network model and its community structure (despite the different partitioning granularity). Specifically, using community detection on the network, we were able to define areas of the city, largely self-consistent in terms of the daily commute. Twitter partition appears to be a more detailed sub-partition of its LEHD counterpart, but generally consistent with it with only a small fraction of exceptions.

With that, Twitter has some advantages over the LEHD as well. First of all, it is not bounded to the employees, thus, it gives better results for the recreational areas and transportation hubs - likely giving more realistic numbers at the airports and parks. Second, it is collected in real time, and can spot changes in pattern and abnormalities (thus, potentially, detect events) in nearly real time. Third, given its temporal properties, Twitter can estimate distribution of the population over any given period of time, reflecting any temporal patterns — time of the day, day of the week, and season of the year. The temporal pattern can be clearly seen on the plot of the standard deviation changes over the course of the typical week (Fig. 4), with concentration of people increasing during the work hours (empty suburbs and dense downtown), and decrease over the night. Another clear temporal pattern can be seen from the temporal variation of the gravity model exponent (Fig. 5) – mobility becomes more local during the day, and more far-reaching at night.

8 Application

As discussed above, Twitter-based model proves to provide a safe alternative compared both to Census and LEHD, while adding a temporal dimension to the research.

To illustrate that, the web-based tool, UVNets, was developed in collaboration between Center for Urban Science and Progress of New York University and Lockheed Martin Advanced Technology Labs. The project focuses on estimating impacts of various urban events and disruptions on metro city function using geo-tagged social-media data. The interface of UVNets allows selecting location, time, and area of interest to estimate how many people can be found in the given area at the considered moment of time and where those people come from. Such information provides valuable insights for multiple urban and transportation planning applications. The interface is illustrated on Fig. 6.

This type of tools would help urban and public safety stakeholders better plan for these contingencies and mitigating operations in megacities and other dense urban areas. The application allows identifying bottlenecks in the urban operation and its security, assessing different potential scenarios of impacts.

Fig. 6. UVNet web-based application interface

9 Conclusions

The present paper provides a qualitative comparison of the human mobility network in NYC based on the official LEHD and geo-tagged Twitter data. While the networks differ quantitatively, the qualitative patterns they provide, such as community structure, model shape and the shape and parameters of the dynamic distribution of urban population, are largely consistent. Those observations support the usability of Twitter as a proxy for urban mobility studies.

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Cross-Cultural Design and Team Decision Making

Veterans in STEM: Supporting the Transition from Military Culture to the Culture of College

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Abstract. Colleges have seen an increase in the number of military veterans returning to college or entering college for the first time. With this increase has been greater attention to ways colleges can be welcoming and supportive learning environments for veterans, who are in many cases non-traditional students. This paper presents the results of a recent think tank and follow-up study exploring the intersection of military and college cultures for veterans pursuing degrees in STEM (science, technology, engineering, and math).

Keywords: Veterans · Post-secondary education · STEM

1 Introduction

Veterans are STEM-ready students. Veterans leave the military having gained training and experience with sophisticated technology and/or field engineering that should – but typically do not – provide a strong foundation for becoming a STEM major (science, technology, engineering, and mathematics) at colleges and universities. With over 1 million veterans using their educational benefits in 2014 [1], higher education has an opportunity to support transition from military to civilian life through postsecondary education. What can colleges and universities do to better support student veterans to complete degrees in science and engineering and build careers in the STEM fields? As colleges and universities reach out to veterans, it is essential they understand veterans as adult learners with unique sets of prior experiences affecting their daily lives. Furthermore, when veterans have incurred a disability related to military experiences there are even more barriers to this transition [2–6].

Beginning 2009, the National Science Foundation invested funding in Kansas City-Building an Alliance for New Careers in STEM (KC-BANCS award #0929212) as a project designed to support military veterans with service-connected disabilities in their pursuit of a STEM degree leading to STEM employment. At that time, the disconnect between the needs and perspective of veterans with the college academic environment and available supports was apparent. To better understand the disconnection, as well as gaps and opportunities for improved systems and support, Transition STEM: A Wounded Warrior Think Tank was convened. The Transition STEM event was designed to elicit collective inquiry and response. Eighty individuals, representing 22 states, with both professional and personal expertise relevant to the issues, met for 2 days

M. Hoffman (ed.), *Advances in Cross-Cultural Decision Making*,
Advances in Intelligent Systems and Computing 610, DOI 10.1007/978-3-319-60747-4_5

to discuss the transition from military to college to careers in STEM. The results of Transition STEM highlighted the roles of higher education, veteran services, and STEM industry in reaching out to veterans as a valuable, STEM-ready workforce. The results also identified research gaps. While the conversations and perceptions were highly valuable, there remained a lack of research showing the effects and impact of supports and policies. Building on the work of KC-BANCS, the National Science Foundation awarded Veterans in STEM: Critical Analysis of the Factors Affecting Pathways to STEM Careers (award #1246221) as a research study investigating the critical factors affecting learning, participation, persistence, and graduation for veterans with disabilities pursuing undergraduate STEM degrees. Similarly, with national representation, the Veterans in STEM study resulted in a model for decision-making and design for improving the success of veterans in the pursuit of a STEM education leading into STEM employment. This paper describes the results of the Transition STEM event, how it led into the research design of Veterans in STEM, and the research findings from Veterans in STEM.

2 Background

Veterans often leave the military with an expectation that because their military service is valued, finding a job will be easy and assistance with navigating benefits and resources is ready and waiting for them. Many veterans are likely to discover finding a job can be difficult and often necessitates getting a college degree or certificate in order to launch a new career. Additionally, financial benefits, resources, and other supports are often a maze that is difficult to navigate and coordinate [3, 7–10].

For veterans with disabilities, the issues and challenges are more complex. Veterans who have experienced combat trauma may have acquired a physical or psychology condition. Thus, their transition to civilian life is further complicated by the need to self-discover how combat trauma affects daily life, memory, learning, employment, sleep patterns, and social relationships. Colleges have services and supports for students with disabilities and veterans with disabilities are eligible to receive them. However, veterans are not likely to pursue accommodations for various reasons [3, 6, 7]. Veterans with disabilities may not understand that their condition may be a disability and thus they are eligible for services and/or accommodations [3]. To further complicate the situation, campus disability support offices typically require Veterans Administration documentation of a disability in order to receive accommodations. Many veterans decide not to pursue a disability rating through the Veterans Administration because they want to return to service, and because of this, they are often ineligible to receive accommodations in their studies. Veterans with disabilities may not want to pursue services for students with disabilities because of the stigma or vulnerability of disability [2, 6].

2.1 Transition STEM

A total of eighty individuals representing a national cross-section of leaders and professionals participated. Participants represented 22 states and all had personal or professional expertise in supporting veterans in post-secondary education and transition to careers. The diverse group of participants shared the following representation: 38% had military experience; 18% were veterans with disabilities; 63% worked in higher education; 25% worked in veterans services; 8% worked in STEM business or industry.

Transition STEM Method. A World Café [11] approach was used to gather qualitative data. Built on the premises of appreciative inquiry [12], the structure of a World Café promotes a collective, multidimensional response to issues [13]. In reference to World Café founder Juanita Brown, Aldred [13] describes the approach as "gathering information through structured group discussions to produce positive organizational change."

Table 1. Transition STEM Think Tank Dialogue.

Transition	Questions
Combat to College	When are the critical transition junctures in which Wounded Warriors need resources and support? When are Wounded Warriors most receptive to these resources and supports?
	What are the resources reported to be effective for transition to civilian life and to beginning college?
	What improvements are needed in the systems to support transition to civilian life and to beginning college?
	How do you market STEM opportunities to people in the military before they transition to civilian life?
	How can STEM degrees and careers be more achievable?
Earning Degrees	What is "veteran friendly" and how do we make it real?
	How can public institutions increase recruitment and visibility in military communities
	What can higher education do to help veterans achieve STEM degrees? What types of supports, accommodations, or programs are needed?
	What do faculty need to know about engaging veterans in their courses?
	While understanding the restraints of funding and space, think outside the box. What can be done to help veterans with disabilities succeed in their STEM education
College to STEM Career	In what ways do military leadership and experiences translate into STEM careers? How do STEM fields benefit from veterans in their workforce? In what ways can STEM industry and higher education collaborate to ease the transition for veterans? What do STEM employers need to know about recruiting and employing veterans? What information and supports are needed to assist veterans in the transition from college to career? In what ways do military leadership and experiences translate into STEM careers?

This national group of experts engaged in dialogue focused on what is working and what is not working at key transition periods: combat to college, earning a degree, and college to career (Table 1).

Transition STEM Results. The results of the Transition STEM dialogue clustered into five themes: (a) relationships between higher education and veteran-focused organizations, (b) higher education policy changes, (c) veteran-ready campuses, (d) faculty effectiveness with student veterans, and (e) partnerships with STEM industry to promote hiring veterans who were STEM graduates. Higher education, especially public colleges and universities, need to reach out early to veterans to recruit for STEM degree/certificate programs. The process of being veteran-supportive does not end with recruitment or marketing, but includes evaluating and accepting (as appropriate) documented military training for college credit and taking other steps to ease the transition of veterans, e.g. college orientation for veterans and peer support programs. Because, for veteran stakeholders the systems are interdependent, taking steps to broaden participation of veterans in the STEM fields is not exclusive to higher education. Employers and community resources/services also have an important role to support veterans as they apply their skills, talents, and experience to the STEM fields. The think tank called upon employers and veterans services to provide STEM specific career counseling, to become prepared for discussing needs for accommodations of veterans experiencing combat trauma as workers, and to offer continued opportunities for peer support in the workplace. Transition STEM was the launch to future conversations continuing to share (a) ideas for improving services, resources, and systems; (b) research identifying effective strategies, (c) data systems for documenting effective systems change, and (d) first-person descriptions of lessons learned. This study was a direct and needed next step for supporting veterans with invisible disabilities in pursuit of STEM degrees and careers.

2.2 Veterans in STEM: Critical Analysis of the Factors Affecting Pathways to STEM Careers

The Veterans in STEM study focused on a primary research questions of, "*What are the critical factors reported by veterans with invisible disabilities influencing their decisions to enroll and persist in STEM post-secondary undergraduate programs?*" Prior to this study, little was known about how personal characteristics and interpersonal relationships affect persistence in education. Additionally, this study sought to describe, from the perspective of veterans, the lingering effects of combat trauma, which can pose ongoing and dramatic challenges for student veterans such as difficulty with memory, communication, attention, processing detailed information, and emotional stability [4, 14].

The target population of this study was post 9/11 veterans experiencing stress and challenges related to their time in service, which are often 'invisible' or unrecognized during the transition from military to civilian life. Sixty-nine individuals, representing military veterans as well as service men and women preparing to transition to civilian status participated in the study. Collectively, participants reported fifteen home states

representing East and West Coasts, Hawaii, Midwest, South, and New England regions of the country.

Veterans in STEM Method. Using a social ecological perspective, this study centered on veterans and their interactions with and the influences of the contextual variables directly and indirectly in their lives. As demonstrated in studies of human behavior and ecological systems, the benefit of a social ecological approach is the joint consideration for the influence of person-specific variables as well as the environment-specific variables and the interactions between levels of influence [15–17]. Fuzzy cognitive mapping (FCM) was determined to be the most appropriate approach to addressing the research question, maintain focus on veterans with consideration for the full array of contextual factors, and to yield results to inform decision-making and improve the design of services and supports.

Through FCM, researchers gather causal cognitive maps from participants, which are then mathematically integrated into a model [18, 19]. Causal cognitive maps are the mental models of key stakeholders–in this case veterans. Through an interview process, Veterans in STEM researchers gathered perspectives and insights, which concluded with each veteran creating a personal causal cognitive map. Maps consisted of the critical factors leading to their personal success in STEM. Each critical factor was labeled, defined, and connected to each other. Veterans indicated the relationship between factors (positive or negative) and the strength of that relationship (ranging from very strong to very weak). With all of these pieces of information (factors, relationships, and strength), an adjacency matrix for each map was formed. After an extensive process of data review, cleaning, and validation, final versions of individual maps (matrices) were integrated to form an overall model.

Veterans in STEM Results. After integrating the causal cognitive maps from 69 veterans, the final model contained 55 factors and 518 connections. Researchers examined the ways pre-transition maps (N = 23, from service men and women who had not formally left their military positions) compared to post-transition maps (N = 46, veterans enrolled at a university or college). The rationale for examining the maps at these two separate junctures was to identify the distinct qualities of the factors as well as the shared qualities between pre- and post-military transition.

In general, the study participants who were still in the military based their responses on their speculation of the types of services and supports that could be helpful. In contrast, the college student veterans had a range of post-transition experiences, and thus were more descriptive about the types and characteristics of services and supports that were either helpful or not. The student veterans were also likely influenced by their college peers' stories of their experiences with available services and supports. Given this difference in perspective, the full list of concepts are not present in both military and college veteran maps. In the pre-transition maps, three factors were not mentioned: peer connections, time management skills, and unauthentic education opportunities. In the post-transition maps, one factor was not mentioned: STEM career orientation.

Determining the factors with the most prominent contributions requires examining indegree, outdegree, and centrality. High centrality indicates a factor has great importance in the cognitive map [20]. Centrality is computed as the sum of indegree and outdegree. High indegree indicates that the concept is affected very much by other

concepts. High outdegree indicates that the concept affects other concepts very much. Indegree and outdegree are calculated by averaging the absolute value of the weight of inputs and outputs.

Pre-transition Maps. The following eleven concepts have greater than average indegree, outdegree, and thus centrality. Their importance to the overall model is due to veterans including these concepts in their maps and assigning strong values of connectedness to other concepts, all leading to Veteran Success.

- Personal Factors
- Military Provided Transition Training
- Education Funding (for veterans specifically)
- Internship
- Personal/Family Resources
- Financial Stability
- Job Search/Placement Support
- Convenient Course Options
- Comprehensive Academic Supports
- STEM Industry/College Collaboration
- College Veteran-Peer Connections

Post-transition Maps. In a parallel analysis of the post-transition college student maps, the following sixteen concepts have greater than average indegree, outdegree, and thus centrality.

- Education Funding (for veterans specifically)
- College Veteran-Peer Connections
- Personal Factors
- Job Search/Placement Support
- Centralized College Resources (for veterans specifically)
- Internship
- Personal/Family Resources
- Military Training Transfer Credits
- Job Preparation Resources
- Family/Friend/Community Support
- Financial Stability
- Community Veteran-Peer Connection
- VA Services
- Industry/Military Collaboration (for veterans specifically)
- Education Benefits Advising
- Health Services (for veterans specifically)

Figures 1 and 2 display the full integrated models for pre-transition veterans and post-transition veteran respectively. The size of the shape corresponds to the factor's indegree and outdegree.

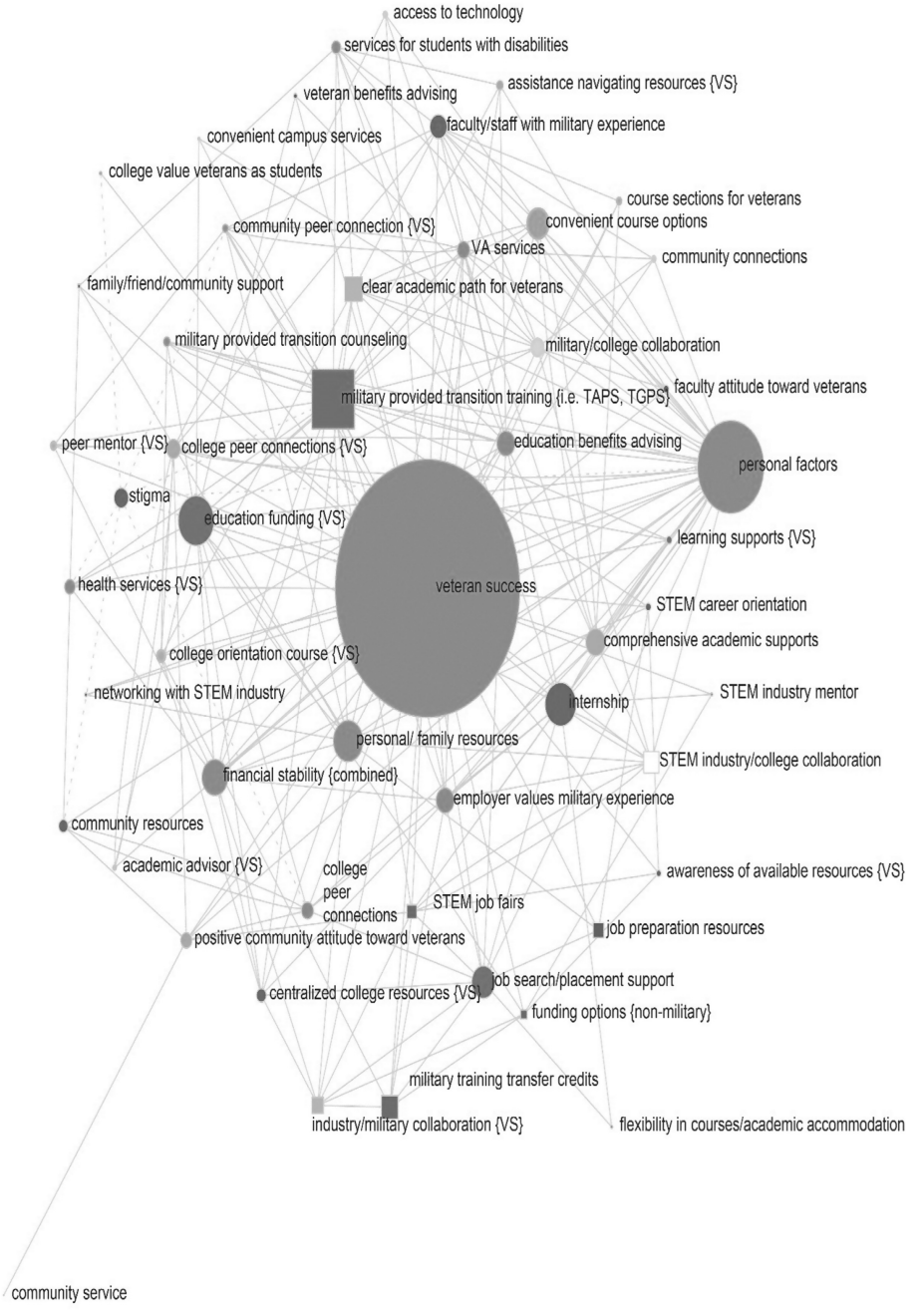

Fig. 1. This figure displays an integrated map of all causal maps from pre-transition participants. (VS) denotes veteran-specific.

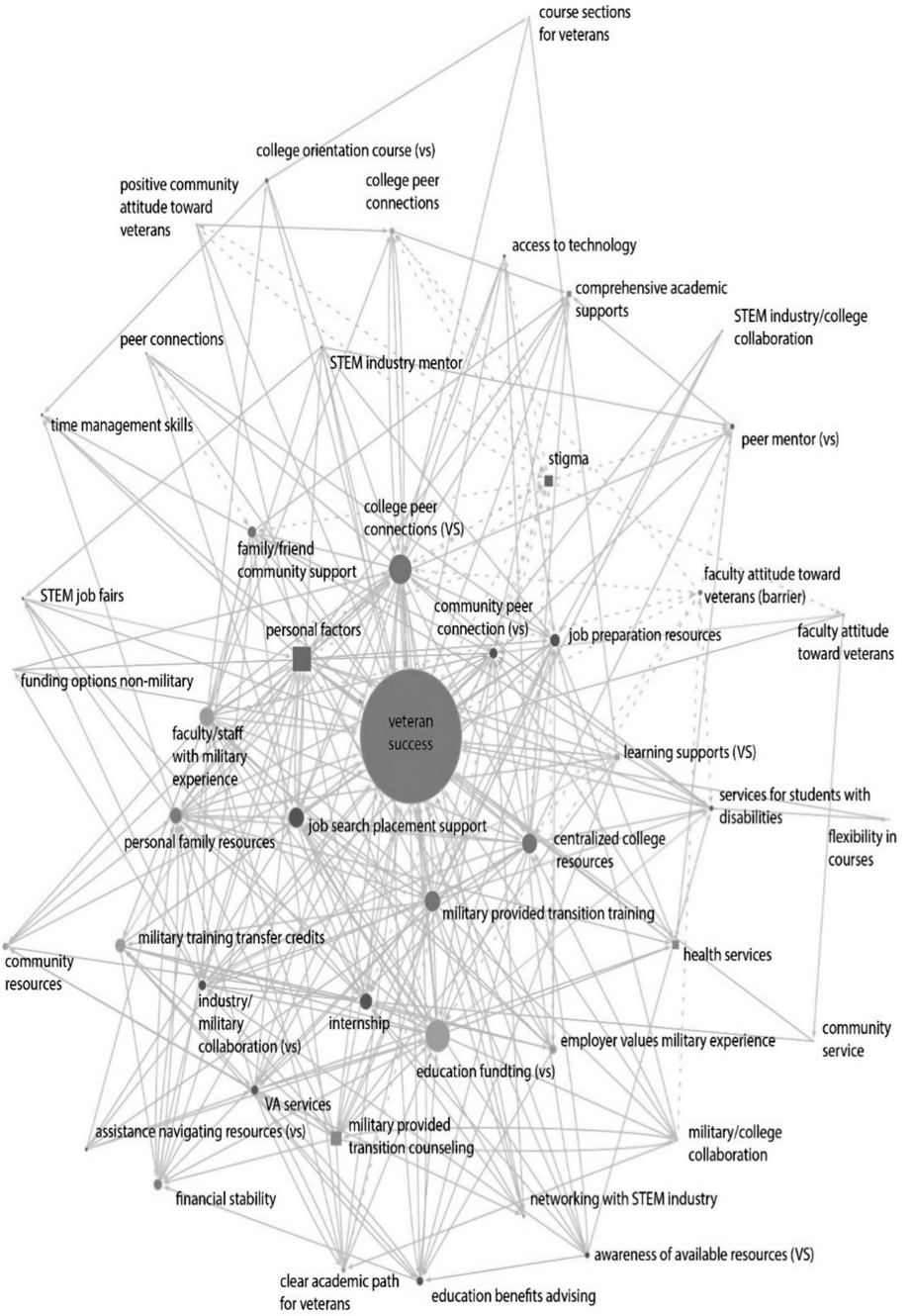

Fig. 2. This figure displays an integrated map of all causal maps from post-transition participants. (VS) denotes veteran-specific

There were a number of similarities between both groups; however, with each similarity there were nuanced differences. Funding and employment were important to both groups. Both groups identified social connections as important; in particular, the relationship with peer-veterans was reported as critical. The college students also identified family, friend, and community support as important. Both groups reported the high value of colleges having faculty/staff with military experience and military training transfer credits. The college students added that job preparation resources are also important. Collaboration across the continuum of military to college to STEM industry was raised within each group. Pre-transition maps showed the importance of military/college collaboration whereas the college student maps showed the importance of industry/military collaboration. Lastly, both groups reported on the personal factors and personal/family resources were significant to their success.

Differences were primarily due to pre-transition participants lacking experiences and exposure to college and post-transition veterans were more focused on factors leading to stability. Centralized college resources were more important to college students whereas the transitioning veterans wanted a clear academic path. Pre-transition veterans identified comprehensive academic supports and convenient course options as important, but neither of these were prioritized by college veterans. Both groups agreed on military provided transition training as important. However, the college students also reported military provided transition counseling as additionally important.

2.3 Conclusion and Implications

The Transition STEM Think Tank started a focused dialogue on the range of contextual factors affecting veteran success. The Veterans in STEM research study applied research methodologies to further examination of the context. The outcomes point to specific services and policies reported by veterans, pre- and post- transition, to be beneficial in supporting their success. However, uniquely present in these results is the way personal factors, social connections, and family supports emerge as critical. Personal factors include aspects of life affecting school/life balance, personal challenges experienced due to transition, and self-motivation or grit for persistence. Personal and family resources describe the needs of the veterans family such as day care, commissaries or community stores, and other general family services. Social connections, especially with other veterans or other veteran families, was often identified as highly important to success. Repeatedly, veterans shared that because the military experience is so unique, it is difficult for others to understand. Being able to talk to other veterans about day-to-day experiences and having faculty with military backgrounds is essential for navigating services and supports and being a supportive ear when faced with stigma. Nearly all veterans reported experiencing stigma from others expressing political viewpoints, lacking information, or lacking sensitivity to the trauma that can be associated with military work.

Given the investment the military has made in service-member STEM training, a smooth transition into degree programs and civilian careers seems natural. However, making the transition from military to college to the workplace can be laden with many hurdles [1, 5]. Overcoming these hurdles requires a higher education and industry

investment in veterans as non-traditional students with rich, field-based experiences, striving for stability and purpose in the workforce and for their families.

2.4 Limitations

There are a few limitations to be considered with interpreting and applying the results of Transition STEM and Veterans in STEM. The Transition STEM participants were invited; therefore, there was a risk of bias. The number of pre-transition maps was one-third of the overall sample; therefore, the sample sizes for comparison purposes was not equal. Having equal comparison groups is often considered a standard for credible analysis. The Veterans in STEM data collection sites were purposefully chosen to represent post-secondary locations as well as military installment. Hawaii was chosen as a location due to the college proximity to an army installation. However, because of Hawaii has a high cost of living, the Hawaii data included factors either not included or less prominent than other states.

Acknowledgements. This research was supported in full by the National Science Foundation under NSF Award #0929212 and #1246221. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect those of the National Science Foundation.

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New Approach to Decision Making (DM) - Evaluation of DM by not Choice but Preference of Alternatives

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Abstract. Traditionally, the DM process under uncertainty was explored using the DM paradigm to choose one from two or more alternatives, and human's irrational DM was modeled using a variety of cognitive biases such as certainty effect or common ratio effect. However, until now, no attempt has been made to generalize such a DM process. Moreover, there are many cases where it is difficult to choose one of the two alternatives. When the preference of each alternative is nearly equal, it is difficult to make decision on which alternative to take. This forces us to loose important information that is necessary for investigating more detailed characteristics of DM process. In such a case, it is recommended that the preference for each alternative should be expressed numerically. Such an evaluation of alternatives has not been tried until now. This study attempted to propose a new approach to decision making process to get more into the insight of the DM process.

Keywords: Behavioral economics · Decision making (DM) · Choice of alternative · Preference of alternative · Detailed process of DM

1 Introduction

Thaler [1–3] and Shiller [4] pointed out anomaly in economics, and showed that we do not always behave rationally as Econ does. We tend to behave irrationally in our daily decision making.

Generally, in the framework of behavioral economics, the following decision making (DM) problems are presented to participants, and an attempt has been made to explore human's decision making process and clarify the property of bounded rationality or irrationally biased decision [5–11]. The following examples of DM are considered.

- (DM Problem1)
  - Prospect A: ($4,000, 0.8)
  - Prospect B: ($3,000, 1)
- (DM Problem2)
  - Prospect C: ($4,000, 0.2)
  - Prospect D: ($3,000, 0.25)

M. Hoffman (ed.), *Advances in Cross-Cultural Decision Making*,
Advances in Intelligent Systems and Computing 610, DOI 10.1007/978-3-319-60747-4_6

In this case, the participants were required to choose one prospect for each DM problem. The participants tended to choose Prospect B (sure thing) in DM Problem1, while they tended to choose Prospect C (higher reward) in DM Problem2. This tendency of reversal of preference (choosing a higher reward with a smaller probability) is called certainty effect or common ratio effect in behavioral DM or economics. Such a tendency of DM is regarded to be distorted and irrational.

The DM process under uncertainty has been generally explored using the DM paradigm above to choose one from two or more alternatives, and human's irrational DM was modeled using a variety of cognitive biases. In this paradigm, the values of \$4,000 or 0.2 are usually fixed, and the effects of these values on DM have not been extensively investigated. In other words, no attempt has been made to generalize such a DM process. Moreover, there are many cases where it is difficult to choose one of the two alternatives. It is difficult to make decision on which alternative to take, for example, when the preference of each alternative is nearly equal. The forced choice under such a situation makes us loose important information that is necessary for investigating more detailed characteristics of DM process. In such a case, it is recommended that the preference for each alternative should be expressed numerically to get further insight into the DM process without losing important information on DM. Such an evaluation of alternatives has not been tried until now.

This study attempted to use an experimental paradigm that makes participants not choose from two or more alternatives but evaluate the preference to each alternative in order to preserve (hold) important information in DM and get further insights into DM processes under uncertainty.

2 Generalized Model of Decision Making

In this study, the DM Problems 1 and 2 were generalized as follows, and the effects of parameters X, p, and n were more systematically considered to get insight into human's DM process. In other words, the mechanism behind the reversal of choice (how the parameters X, Y, p, and n affected DM and the reversal of choice) was considered using the generalized DM problem below. The following generalized DM problem was used, and not the choice of alternative but the numerical evaluation of each alternative was used in our approach.

$$\begin{aligned} &(\text{Generalized DM problem}) \\ &\text{Prospect A}' : \ (\$\text{X}, \text{p}/\text{n}) \\ &\text{Prospect B}' : \ (\$\text{Y}, 1/\text{n}) \end{aligned} \tag{1}$$

It is assumed that X is larger than Y. To get new insight into human's decision process, the more generalized DM process was modeled using the following approach different from traditional behavioral economics. (i) not the choice but the evaluation of

preference of each alternative was used to clarify human's DM process, and (ii) the characteristics of DM process was investigated with the change of X, Y, p, and n. Few examples of such a generalized approach have been demonstrated.

3 Method

The generalized DM problem was further modified as follows.

$$\begin{array}{l}\text{Prospect A}' : \ (\$X, p_A) \\ \text{Prospect B}' : \ (\$Y, p_B)\end{array}. \tag{2}$$

where $X > Y$ and $p_A < p_B$.

The values of (X, Y) = ($60, $30), and ($31, $30) were used. The following values of (p_A, p_B) were used for each (X, Y).

$$p_B = 2.5\% : \ (p_A = 2\%, p_B = 2.5\%). \ (p_A = 1.5\%, p_B = 2.5\%). \tag{3}$$

$$p_B = 5\% : \ (p_A = 4\%, p_B = 5\%). \ (p_A = 3\%. p_B = 5\%). \tag{4}$$

$$p_B = 20\% : \ (p_A = 18\%, p_B = 20\%). \ (p_A = 16\%, p_B = 20\%.). \ (p_A = 14\%, p_B = 20\%). \tag{5}$$

$$p_B = 40\% : \ (p_A = 38\%, p_B = 40\%). \ (p_A = 35\%, p_B = 40\%). \ (p_A = 30\%, p_B = 40\%). \tag{6}$$

$$p_B = 60\% : \ (p_A = 55\%, p_B = 60\%). \ (p_A = 50\%, p_B = 60\%). \ (p_A = 45\%, p_B = 60\%). \tag{7}$$

$$p_B = 80\% : \ (p_A = 75\%, p_B = 80\%). \ (p_A = 60\%, p_B = 80\%). \ (p_A = 40\%, p_B = 80\%). \tag{8}$$

$$\begin{array}{ll} p_B = 90\% : & (p_A = 89\%, p_B = 90\%). \ (p_A = 85\%, p_B = 90\%). \ (p_A = 70\%, p_B = 90\%). \\ & (p_A = 50\%, p_B = 90\%). \end{array} \tag{9}$$

$$\begin{array}{ll} p_B = 100\% : & (p_A = 99\%, p_B = 100\%). \ (p_A = 95\%, p_B = 100\%). \ (p_A = 80\%, p_B = 100\%). \\ & (p_A = 60\%, p_B = 100\%). \end{array} \tag{10}$$

For the fixed values of p_B and (X, Y), the preference of A was evaluated using a numerical number from 0 to 100 for each value of p_A. The value 0 means that the participant completely prefers B to A. The value 100 represents that the participant completely prefers A to B. The order of p_A was randomized across the participants. The order of the combination of p_B and (X, Y) was also randomized across the participants.

4 Results

The results are summarized in Figs. 1, 2, 3, 4 and 5. The frequency distribution of preference to A for $p_A = 2\%$ and $p_B = 2.5\%$ is shown in Fig. 1. The frequency distribution of preference to A for $p_A = 80\%$ and $p_B = 100\%$ is shown in Fig. 2. Even if p_A (= 80%) and p_B (= 100%) were the same, the preference to A was greatly affected by (X, Y).

The frequency distribution of preference to A for $p_A = 99\%$ and $p_B = 100\%$ is shown in Fig. 3. The preference to A was affected by (p_A, pB). The preference to A was polarized when ($p_A = 99\%$ and $p_B = 100\%$) and (X, Y) = ($31, $30) as compared with ($p_A = 80\%$ and pB = 100%) and (X, Y) = ($31,$30). The preference to A was strengthened when ($p_A = 99\%$ and $p_B = 100\%$) and (X, Y) = ($60, $30) (Fig. 3) as compared with ($p_A = 80\%$ and $p_B = 100\%$) and (X, Y) = ($60, $30) (Fig. 2).

Figure 4 shows how the preference to A changes when p_A and p_B changes for each combination of (X, Y). For (X, Y) = ($31, $30), the preference to A weakened as p_A and

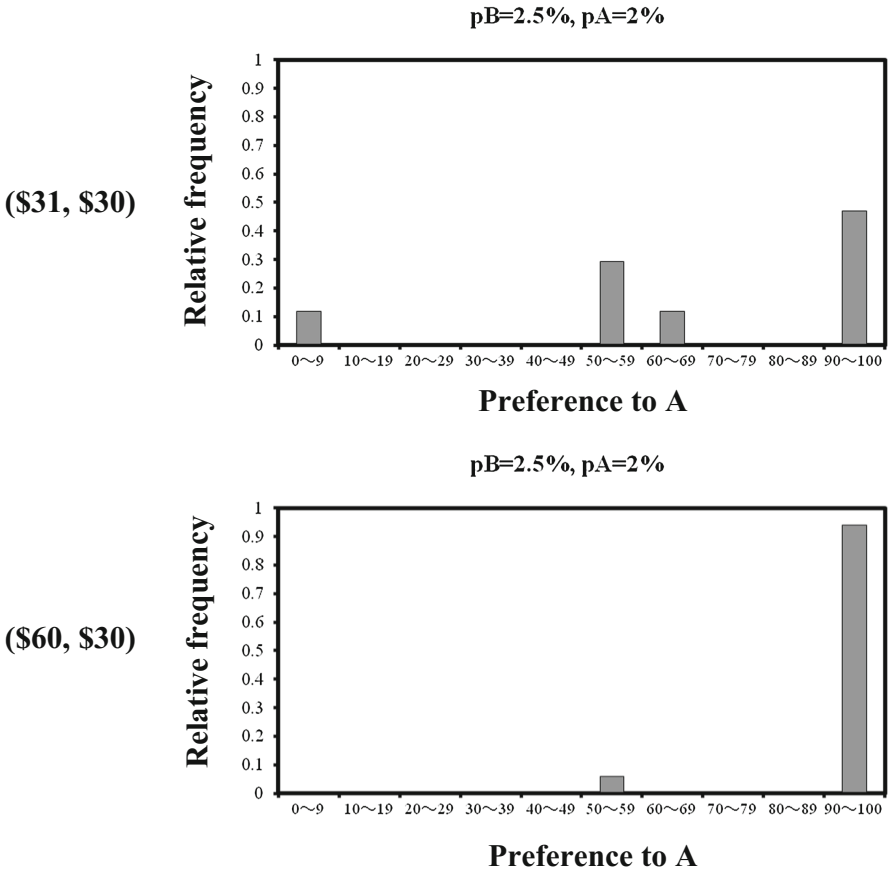

Fig. 1. Frequency distribution of preference to A for $p_A = 2\%$ and $p_B = 2.5\%$.

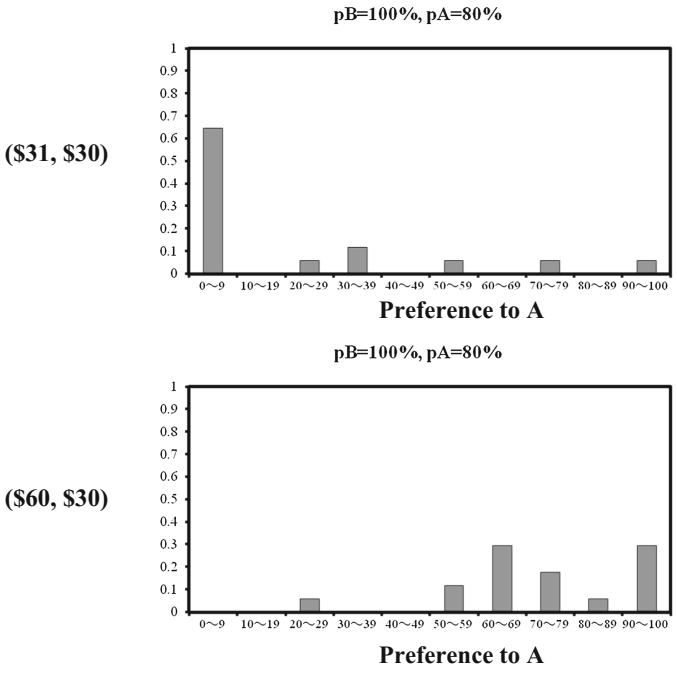

Fig. 2. Frequency distribution of preference to A for p_A = 80% and p_B = 100%.

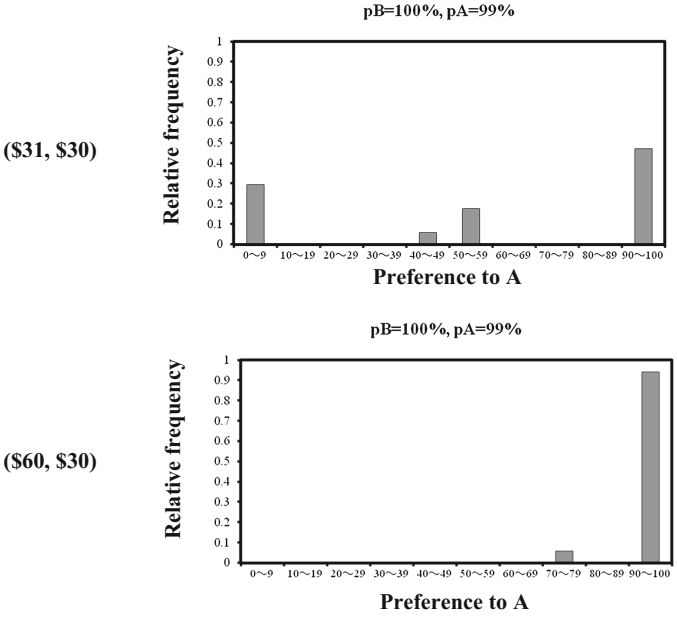

Fig. 3. Frequency distribution of preference to A for p_A = 90% and p_B = 100%.

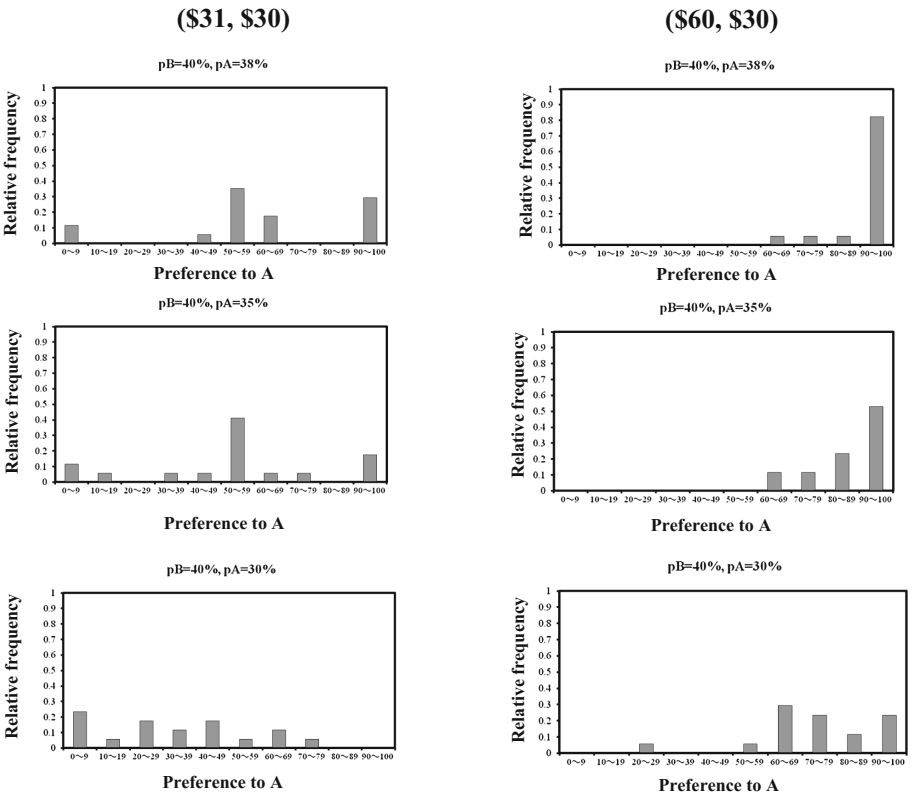

Fig. 4. Frequency distribution of preference to A as p_A and p_B changed from (p_A, p_B) = (38%, 40%) to (35%, 40%) to (30%, 40%).

pB changed from (p_A, p_B) = (38%, 40%) to (35%, 40%) to (30%, 40%). When X and Y were \$60 and \$30, respectively, the preference to A did not differ remarkably between (p_A, p_B) = (38%, 40%) and (p_A, p_B) = (35%, 40%). The preference to A was moderately weakened for (p_A, p_B) = (35%, 40%).

Figure 5 shows how the preference to A changes when p_A and p_B changes for each combination of (X, Y). For (X, Y) = (\$31, \$30), the preference to A was polarized when p_A and pB were 85% and 90%, respectively. The preference to A was weakened and the participants tended to prefer B to A as p_A and p_B changed from (70%, 90%) and to (50%, 90%). When X and Y were \$60 and \$30, respectively, the preference to A changed from (p_A, p_B) = (85%, 90%) to (70%, 90%) to (50%, 90%). The preference to A was completely weakened for (p_A, p_B) = (50%, 90%).

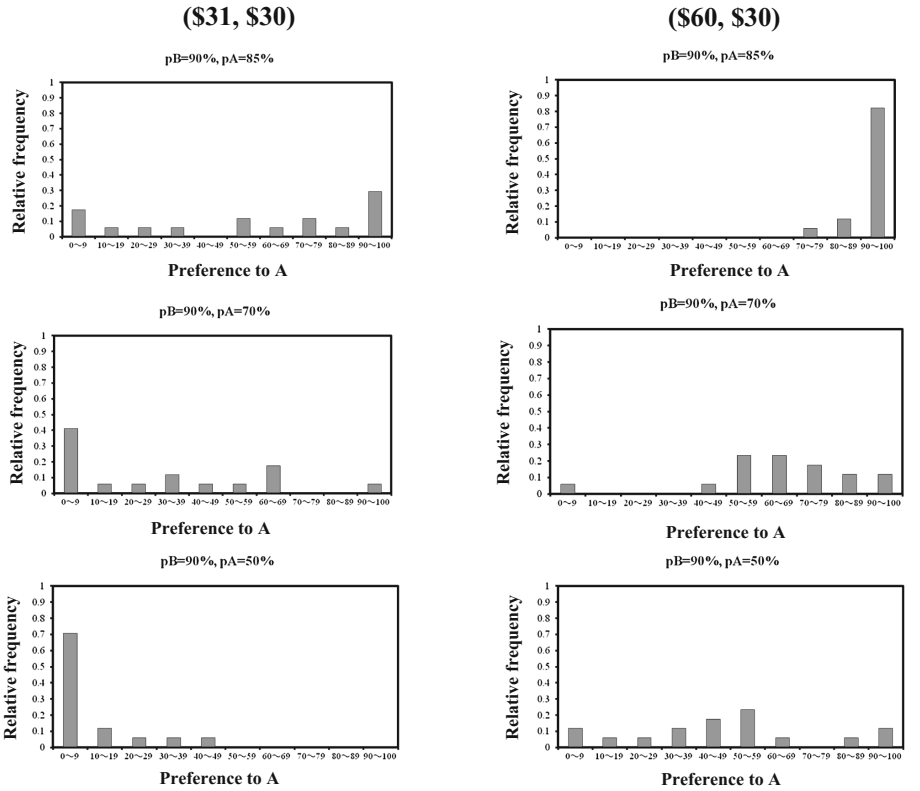

Fig. 5. Frequency distribution of preference to A as p_A and p_B changed from (p_A, p_B) = (85%, 90%) to (70%, 90%) to (50%, 90%).

5 Discussion

As shown in this experiment, it is clear that the common ratio effect or certainty effect holds under the limited condition of parameters (X, Y) and (p_A, p_B).

5.1 Effects of (X, Y) on Preference to A

As shown in Figs. 1 and 2, the preference to A was greatly affected by (X, Y) even if p_A and p_B are the same. For (X, Y) = ($31, $30), the mean preference to A of (p_A = 2% and p_B = 2.5%) and (p_A = 80% and p_B = 100%) were 69.6 and 18.9, respectively. As predicted by common ratio effect or certainty effect, the preference to B was stronger when p_A and pB were 80% and 100%, respectively. For (X, Y) = ($60, $30), the mean preference to A of (p_A = 2% and p_B = 2.5%) and (p_A = 80% and p_B = 100%) were 96.5 and 73.9, respectively. This means that the certainty effect or common ratio was not so strongly observed when (X, Y) shifted from ($31, $30) to ($60, $30), because the reversal of choice was not seen as in the case of (X, Y) = ($31, $30). Based on the

results (Figs. 1 and 2), it is doubtful whether the certainty effect or common ratio effect generally holds irrespective of the value of (X, Y). It seems that such an effect occurs under a limited condition.

5.2 Effects of (P_A, P_B) on Preference to A

As shown in Fig. 3, the preference to A was affected by (p_A, p_B). The preference to A was polarized when (p_A = 99% and p_B = 100%) and (X, Y) = (\$31, \$30) as compared with (p_A = 80% and p_B = 100%) and (X, Y) = (\$31, \$30). The preference to A was strengthened for (p_A = 99% and p_B = 100%) and (X, Y) = (\$60, \$30) as compared with (p_A = 80% and p_B = 100%) and (X, Y) = (\$60, \$30). Even from this result, it is doubtful whether certainty effect holds universally. When p_A and p_B were 99% and 100%, respectively, the mean preferences to A for (X, Y) = (\$31, \$30) and (\$60, \$30) were 58.3 and 98.2, respectively. When p_B is equal to 100%, the difference between p_A and p_B is small (1%), and (X, Y) corresponds to (\$31, \$30), the certainty effect was not necessarily observed like (X, Y) = (\$60, \$30). This condition (p_A = 99%, p_B = 100%) must have caused the strong preference to a higher reward (\$60) although it is not certain whether this reward can be obtained (getting a reward of \$60 fails at one out of 100 trials).

5.3 Multiple Effects of (X, Y) and (P_A, P_B) on Preference to A

Figures 4 and 5 show the change of preference to A as a function of (p_A, p_B) and (X, Y). The value of (p_A, p_B) in Figs. 4 and 5 changed from (38%, 40%) to (35%, 40%) to (30%, 40%), and from (85%, 90%) to (70%, 90%) to (50%, 90%), respectively.

As for (X, Y) = (\$31, \$30), the change of (p_A, p_B) from (38%, 40%) to (35%, 40%) to (30%, 40%) led to a stronger preference to B (see left in Fig. 4). As for (X, Y) = (\$60, \$30), the change of (p_A, p_B) from (38%, 40%) to (35%, 40%) to (30%, 40%) did not lead to a stronger preference to B (see right in Fig. 4). Under (X, Y) = (\$60, \$30), more larger difference between p_A and p_B is necessary to induce a stronger preference to B.

As shown in the left of Fig. 5, the polarization of preference (the preference to A and B were approximately equal) was observed when (p_A, p_B) = (85%, 90%). Although the data was not collected, this tendency would have been further enhanced if (p_A, p_B) is (39%, 40%). With the increase of the difference between p_A and p_B, the participants tended to prefer B to A (stronger preference to B). As shown in the right of Fig. 5, the preference to B for (X, Y) = (\$60, \$30) was not so strong even when the difference between p_A and p_B became larger (p_A = 30%, p_B = 40%). When the difference becomes by far larger, it is expected that the preference to B becomes stronger.

In this manner, we confirmed that X, the difference between X and Y, p_B, and the difference between p_A and p_B are the determinant of the preference to each alternative. Although this study selected two levels of (X, Y) and 24 levels of (p_A, p_B), this parameter setting was insufficient to further generalize the DM process. Future research should more systematically explore the effects of X, the difference between X and Y, p_B, and the difference between p_A and p_B on the preference to each alternative.

5.4 General Discussion

There are many cases where it is difficult to choose one of the two alternatives especially when the preference of each alternative is nearly equal. Once the decision was made under such a situation, important information that is necessary for investigating more detailed characteristics of DM process is lost. Even if the alternative A is chosen with its preference 90 or 55, this corresponds to one data that the alternative A was chosen in DM. In the traditional DM approach to choose one alternative from two or multiple alternatives, the information on preference to the alternative is not preserved. Therefore, the proposed approach would be more important to get further insight into human's DM process.

Interactive effects of (X, Y) and (p_A, p_B) on DM was investigated, which traditional DM theories have not investigated systematically.

6 Conclusions

Although DM process under uncertainty was explored using the DM paradigm to choose one from two or more alternatives and human's irrational DM was modeled using a variety of cognitive biases, no attempt has been made to generalize such a DM process without loosing important information that represent the preference to each alternative especially when the preference of each alternative is nearly equal and one cannot decide which alternative should be chosen. In this study, we showed that the preference to each alternative should be expressed numerically and get more into the insight of the DM process. Using a preference to each alternative, one can examine the effects of parameters (X, Y) and (p_A, p_B) and get further insight into DM process.

The results showed that the preference to alternative A or B is strongly affected by (X, Y) and (p_A, p_B). The parameters in this experiment are not sufficient to further generalize the DM process. Future research should further explore the effects of (X, Y) and (p_A, p_B) on the choice of alternatives A and B. In other words, it should be more systematically investigated how p_B itself, the difference between p_A and p_B, X itself, and the difference of X and Y affect the preference to each alternative.

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Nationalism, Patriotism and Multinational Decision-Making Competence: Evidence from a Situation Judgment Test

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Abstract. Multiple factors may influence Warfighters' ability to team effectively with personnel from other nations in joint military operations. The present study (N = 696) used a situation judgement test (SJT) to assess multinational decision-making competence. We hypothesized that both social identity and general decision-making competencies would be associated with SJT performance. Performance was associated with lower nationalism, and with decision-making competencies including application of decision rules and knowledge of social norms. Multivariate analyses suggested social identity and decision-making competence predicted performance independently, although nationalism and competence were negatively associated. These findings suggest that training strategies for Warfighters might identify the individual's strengths and weaknesses, and tailor explicit instruction and virtual learning scenarios accordingly.

Keywords: Decision-making · Teams · Culture · Military psychology · Social identity · Nationalism · Situation Judgment Test

1 Introduction

Successful multinational teaming is critical for many US military operations. However, Warfighters may find working with personnel from partner nations challenging because of cultural differences in beliefs and values. In the military context, teaming issues include managing cooperation, communication, conflict, and team performance [1]. Work-related norms may also differ across cultures, including those for structuring and implementing work, determining pace of work, and respect for hierarchy [2]. Beyond differing beliefs about how team members should work together, effective cooperation is also threatened by intergroup prejudices [2]. The pressures of intergroup teaming may be exacerbated in the military context, in which high-stakes decisions must be made under time pressure and stress. Furthermore, team members may have little time to become acquainted and practice working together.

There may be individual differences in the ability of people to rapidly adjust to the demands of multi-cultural teaming. The US military is a diverse population, and

M. Hoffman (ed.), *Advances in Cross-Cultural Decision Making*,
Advances in Intelligent Systems and Computing 610, DOI 10.1007/978-3-319-60747-4_7

demographic factors such as gender may play a role, although evidence is lacking. Personality and ability factors may also influence the influence the ability of individuals to adjust to the demands of working within culturally diverse teams. Decision-making processes are especially important as a foundational team process that occurs at all echelons. Decision-making is a core skill for teamwork [3]. It also supports additional social skills that may be especially important in multinational teams. For example, US commanders must decide how to adapt their styles of leadership, communication, and team coordination in order to maintain effectiveness and morale in personnel from allied nations.

Cultural values may be internalized as individual traits that influence decision-making. For example, individuals high in power distance [4] may be more prone to impose decisions on subordinates without consulting them. However, such a decision-making style may be especially likely to antagonize people from low power distance cultures who, on average, prefer a more collaborative approach to decision. Other relevant personality traits define typical cognitive and emotional reactions to ingroups and outgroups [5]. The present study focused on two types of factors that may impact decision-making in multinational teams: social identity and decision-making competence.

1.1 Social Identity and Multinational Teaming

Social identity is shaped by the ingroups with which the person identifies [6], including people of common nationality. A strong affiliation with a national or ethnic ingroup is considered ethnocentrism. Favoritism towards the ingroup does not necessarily imply derogation of outgroups [7]. However, there are several factors that may promote outgroup hostility, to different degrees in different individuals. People may have negative attitudes towards outgroups based on cultural values that foster prejudice, negative experiences, and interpersonal anxiety [5]. Conversely, there are also individual differences in positive perceptions. In addition, individuals who are strongly vested in a single group identity are motivated to maintain distinctiveness and boundaries between ingroup and outgroup members [7].

We examined the role of social identity by assessing individual differences in American identity with scales from Kosterman and Feshbach's [8] Patriotism-Nationalism Questionnaire (PNQ). These constructs distinguish feelings of attachment to America (patriotism) from the view that America is superior and should be dominant (nationalism). Patriotism may reflect simple positive attachment to America as a national ingroup, whereas nationalism is associated with chauvinistic arrogance, ethnocentrism and hostility towards outgroups [9]. Patriotism is commonly seen as benign, in that it provides a sense of security, belonging, and self-worth, as well as fostering group cohesion and constructive communal action [10]. Conversely, in the tradition of Adorno's account of the authoritarian personality, nationalism is linked to malignant outcomes such as belligerence towards foreign nations and intolerance of diversity [9].

The organizational literature on the effects of cultural diversity on team processes and performance identifies mixed effects [11]. On the positive side, more diverse teams

tend to possess a wider range of skills, and are more creative. On the negative side, diversity is associated with greater conflict and poorer communication, especially in larger teams. Negative outcomes may reflect both people's preferences for coworkers with similar beliefs, attitudes and values, and the tendency for diverse groups to fractionate into in- and out-groups [12]. Even in well-motivated teams, poor communication may lead to misunderstandings and failure to share information. Both factors may influence the social teamwork processes that are necessary for team cohesion including mutual performance monitoring, providing backup when needed, and sharing mental models [13]. "Deep-level" personal characteristics, including values or attitudes associated with culture, may especially impact teaming [11]. In the military context, cultural differences in the value attached to punctual work completion might impede multinational teaming, for example.

Studies of prejudice in multiple nations confirm that nationalism is reliably associated with negative attitudes towards people of different ethnicity [14]. Highly nationalistic US Soldiers may thus have unrealistic negative attitudes towards personnel from partner nations, especially non-Western nations. Such attitudes are likely to impair both allocation of tasks to individuals, and social processes to the extent that US Soldiers communicate poor evaluations of partners. Nationalistic individuals may be prone to define themselves as an in-group, and more likely to provoke opposing in-group behavior from foreign team members. The association between patriotism and outgroup derogation is more complex but of lesser likely impact [14].

1.2 Individual Differences in Decision-Making Competence

The social identity perspective focuses on how various social processes might either enhance or impair team performance. However, irrespective of social processes, individuals differ in decision-making competence. Military decision-making is a rational activity. Typically, missions have well-defined goals and there are explicit Rules of Engagement (ROEs) shaped by military history and experience to guide decision-making. Analysis of the competencies necessary for effective, real-life decision making identifies factors such as consistency in following rules, recognizing social norms, appropriate calibration of confidence, and avoiding common biases [15]. Competencies can be measured reliably and validly with Bruine de Bruin et al.'s Adult Decision-Making Competence (A-DMC) index [15].

Purely cognitive factors may influence decisions in the multinational context irrespective of social identity. However, there is also some scope for influence of identity on decision-making competencies. For example, highly nationalistic individuals might disregard the social norms of foreign partners and seek to impose their own cultural norms on others. Biases in beliefs and attitudes might also engender cognitive biases. For example, negative attitudes to foreign nationals might support confirmation bias [16], leading to under-estimation of their work capabilities.

1.3 Study Aims

This study aimed to identify factors associated with competence in military decision-making during multinational operations. Decision-making in this context was assessed using a Situation Judgment Test (SJT) developed by the authors [17]. Test items place the respondent in the role of a US commander who must rate the effectiveness of alternate options for dealing with challenging multinational teaming scenarios. The SJT is scored in relation to how closely the respondent's ratings correspond to those of two subject matter experts (SMEs), former US military personnel with extensive experience of overseas deployment. The SMEs also helped to develop and verify the 21 scenarios that comprise the SJT. Our previous study confirmed the reliability of the SJT in civilian and US military samples [17].

We hypothesized that nationalism [8] would be associated with lower scores on the SJT. We selected three decision-making measures available from the A-DMC [15]: decision rules, social norms and over/underconfidence. High scores on decision rules and social norms should be associated with higher scores on the SJT, and overconfidence with lower scores. We also tracked associations with demographic factors.

2 Method

2.1 Participants

242 individuals (55% female) were recruited via Amazon Mechanical Turk (AMT). All were US residents and fluent in English. Mean age was 38.1 (range: 22–69). 89% of respondents reported having at least some college education. The majority (80%) self-identified as Caucasian. Respondents met AMT criteria for being "expert" workers, i.e. previous successful completion of multiple assignments. They were paid for participation. An additional 454 participants (64% female) were recruited from a university psychology student pool. Mean age was 19.6 (range: 18–49), and 69% self-identified as Caucasian. They received course credit for participation.

2.2 Materials

SJT [17]. The SJT comprised 21 scenarios, developed in conjunction with two subject matter experts (SMEs). The SMEs were former US Soldiers, familiar with overseas deployment and command level decision making for "blue-on-blue" interactions (i.e., US with allies). Each one placed the participant in the role of a US commander working with personnel from a coalition partner nation. Scenarios were sampled to represent challenges associated with three constructs that may differ across cultures: trust, locus of control, and uncertainty avoidance. Each scenario had four options that varied in one of these constructs. For example, one scenario had the commander deciding how to deal with Soldiers from an allied nation who were not performing well. Poor response choices might reflect both over-trust (e.g., failure to monitor partner activities) and under-trust (e.g., harsh criticism of the commander of the partner nation). The respondent was required to rate the effectiveness of each option on a 1–7 scale.

The score for each scenario was calculated as the root mean square (RMS) of the deviations of the participants' four responses from those of the SMEs; i.e., a lower RMS indicates that the person responds similarly to the experts. In the present sample, internal consistency (coefficient alpha) was .83, which is satisfactory. The RMS scores were standardized, using the mean and SD for the whole sample, and multiplied by −1, so that higher scores represented better decision-making performance. The SJT also includes two "attention check" items that require response to a very simple question. Data from respondents who failed either item were discarded.

For civilian use, participants were instructed to answer the questions based on their understanding of how people from different backgrounds can best work together, as well as any other sources of insight they considered relevant.

PNQ [8]. The 11-item version of the scale [9] assesses patriotism (5 items: e.g., "I am proud to be an American") and nationalism (6 items: e.g., "Other countries should try to make their government as much like ours as possible").

A-DMC [15]. This decision-making test measures six facets of competence, such as resistance to common biases. Tests of special relevance to multinational decision-making were selected as follows:

Applying Decision-Rules. This 10-item test assesses the participant's ability to use different decision-rules when making a consumer purchase. Being able to use context-specific decision-rules appropriately may support effective decision across different cultural contexts.

Overconfidence. This test includes 34 "true-false" general knowledge questions; participants also rate their confidence in their answers on a 50–100% scale. Confidence measures may be scored in different ways. We scored the test so that higher scores indicate over-confidence and lower scores under-confidence. Over-confidence may lead commanders to make decisions which are inappropriate for other cultures.

Recognizing Social Norms. This 16-item test is in two parts, separated by other surveys. Part I requires the respondent to rate the acceptability of rating various socially disapproved behaviors. Part II requires ratings of the prevalence of each behavior. To score the test, the rank-order correlation between Part I and Part II ratings is calculated. The more positive the correlation, the more the respondent's judgements of acceptability follow perceived prevalence, implying recognition of social norms. This decision-making competency should assist commanders in assessing social norms in other cultures.

2.3 Procedure

All surveys were completed online through a web-based interface. Demographics were assessed first, followed by the SJT, followed by additional surveys. There were three samples of data collection (*N*s = 180, 242, 274) that differed in the additional surveys administered. All three samples completed the PNQ: only sample two completed the A-DMC. Other surveys included are beyond the scope of this report. For each sample, survey completion took approximately 1 h.

3 Results

3.1 Demographic Factors

Demographic factors were assessed in the whole sample ($N = 696$). Age and gender were unrelated to SJT score. Student and AMT samples also did not differ in mean score. For those participants who reported valid SAT scores, there was a weak positive association between SJT and SAT scores. SJT score correlated with self-reported total SAT score ($r = -.11$, $p < .05$, $N = 554$), reading score ($r = -.17$, $p < .01$, $N = 526$) and writing score ($r = -.10$, $p < .05$, $N = 469$). Math scores were unrelated to the SJT.

3.2 Social Identity

Table 1 shows that nationalism was consistently negatively correlated with SJT score, but patriotism showed a weaker tendency towards negative associations. Nationalism and patriotism were themselves positively correlated ($r = .56$, $p < .01$), and so partial correlations were calculated. Nationalism remained significantly correlated with the SJT with patriotism controlled ($r = -.27$, $p < .01$), in the total sample, but patriotism did not predict SJT score with nationalism controlled ($r = .08$).

Table 1. Correlations between SJT score and PNQ scales in three samples and total sample.

	Sample 1	Sample 2	Sample 3	Total
Nationalism	−.22**	−.30**	−.29**	−.28**
Patriotism	−.13	.02	−.14*	−.10*

* $p < .05$; ** $p < .01$.

3.3 Decision-Making

Several decision-making correlates of SJT score were found. High scorers on the SJT tended to score better on applying rules ($r = .33$, $p < .01$) and social norms ($r = .18$, $p < .01$) A-DMC subtests. On the over-confidence test, SJT score was correlated with general knowledge ($r = .24$, $p < .01$). The SJT did not correlate with mean confidence rating ($r = -.04$) or with absolute discrepancy between confidence and knowledge score, but it was associated with the raw confidence-knowledge discrepancy ($r = -.27$, $p < .01$). That is, high scorers on the SJT were not generally over-confident, or more accurate in their confidence ratings, but they tended to systematically underestimate their knowledge. By contrast, low scorers tended to be over-confident.

Analysis of the Sample 2 data ($N = 242$) showed that nationalism was associated with the weaknesses in decision making characteristic of low SJT scorers, including poorer application of rules ($r = -.39$, $p < .01$), lower social norms ($r = -.19$, $p < .01$), lower general knowledge ($r = -.23$, $p < .01$), and over-confidence ($r = -.20$, $p < .01$). By contrast, patriotism was positively correlated with social norms ($r = .24$, $p < .01$) and with general knowledge ($r = .24$, $p < .01$).

To disambiguate the various correlates of SJT score, a hierarchical multiple regression was run with SJT score as the criterion. At step 1, the two PNQ predictors were entered, followed by the four A-DMC measures that correlated with both SJT score and nationalism. The first step contributed 11% to the variance explained, and the second step an additional 7%. Both steps were significant ($p < .01$), as was the final regression equation ($R = .42$, $p < .01$). Predictors making significant independent contributions to the final equation were nationalism ($\beta = -.21$, $p < .01$), decision rules ($\beta = .22$, $p < .01$) and the discrepancy score representing over-confidence ($\beta = -.22$, $p < .05$). Thus, social identity and general decision-making competence were independently associated with multinational decision-making competence.

3.4 Qualitative Analyses of Individual Differences

We also examined the role of individual difference factors at the level of specific scenarios. The following analyses were performed in the Sample 2 data, which provided both social identity and decision-making competence data. Partial correlations were calculated to discriminate items that might be uniquely associated with the two strongest predictors of SJT performance, nationalism and applying decision rules. With decision rules score controlled, nationalism was significantly ($p < .05$) negatively correlated with 7/21 scenario scores. Conversely, with nationalism score controlled, decision rules was significantly ($p < .05$) positively correlated with 8/21 scenario scores. Examination of individual scenarios may thus illustrate the unique impacts of nationalism and decision rules qualitatively. We describe two analyses of this kind.

SJT score on scenario 16 was uniquely associated with nationalism (partial $r = -.20$, $p < .01$). This scenario focuses on trust issues when Soldiers from a partner nation are failing to following agreed security protocols. The four response options are as follows (in summary):

1. Have US troops take over guard posts until a new security plan is developed.
2. Send US troops to monitor guard posts from time to time.
3. Encourage the partner nation commander to do a better job.
4. Criticize the efforts of the partner nation commander.

In this scenario, options #1 and #4 may suggest insufficient trust in the partner, whereas #3 implies over-trust. Nationalism was correlated with a higher preference for options #1 ($r = .26$, $p < .01$) and #4 ($r = -.24$, $p < .01$), but it was not significantly associated with ratings of the other options.

Figure 1 shows mean ratings of the four response options for relevant groups. The experts preferred option #2, which addresses the situation without undermining the trust necessary for the partnership to flourish. The two "under-trust" options received the lowest ratings, reflecting the critical important of maintaining trust in this scenario. The "sample" means reflect the whole sample. Like the SMEs, the participants identified option #2 as the best and option #4 as the worst, on average, but they tended to over-estimate the acceptability of the alternatives, with the largest discrepancy for option #1. For options #1 and #4, the Figure also shows illustrative ratings for high and low nationalism individuals. The ratings were derived by finding the linear regression

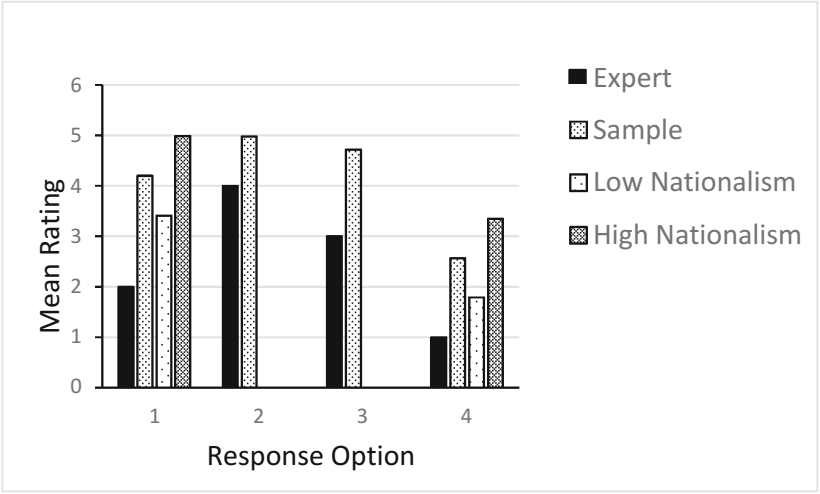

Fig. 1. Mean ratings for four response options on SJT scenario 16.

equation that predicts the rating from nationalism, and calculating predicted values of the rating for individuals 2 SD above and below the mean for nationalism. On this basis, highly nationalistic individuals over-favor the two response options, whereas those very low in nationalism are closer to expert judgement, but still over-estimate the quality of the response. The performance deficit associated with nationalism may derive from under-valuing the importance of maintaining trust in the partner nation relationship.

Turning to unique correlates of decision making competence, scenario 11 score correlated at .32 ($p < .01$) with applying decision rules, with nationalism controlled. The scenario places US troops together with foreign allies in a rural camp. A primary purpose of the exercise is to have Soldiers live together to improve cooperation. The challenge is that US Soldiers find the unhygienic conditions of the camp offensive, leading to friction between the two nations. Response options are:

1. Ask the foreign commander to improve living conditions.
2. Tell the US Soldiers to keep the camp clean so as to maintain good relations.
3. Arrange separate living facilities for US troops.
4. Tell the foreign commander forcefully to clean up the camp.

The theme for this scenario is locus of control. Option #2 represents internal locus, because the US Soldiers must take responsibility themselves for camp conditions, whereas Option #3 represents external locus, because the commander is capitulating to external pressures. In this case, applying decision rules was significantly positively correlated with option #2 rating ($r = .18$, $p < .01$), and negatively correlated with options #1 ($r = -.20$, $p < .01$), #3 ($r = -.25$, $p < .01$) and #4 ($r = -.35$, $p < .01$).

Figure 2 shows mean ratings for different groups. The SMEs favored option #2, with option #4 rated lowest. These ratings reflect the primary objective of the exercise, which was to have Soldiers live together, without alienating the foreign commander.

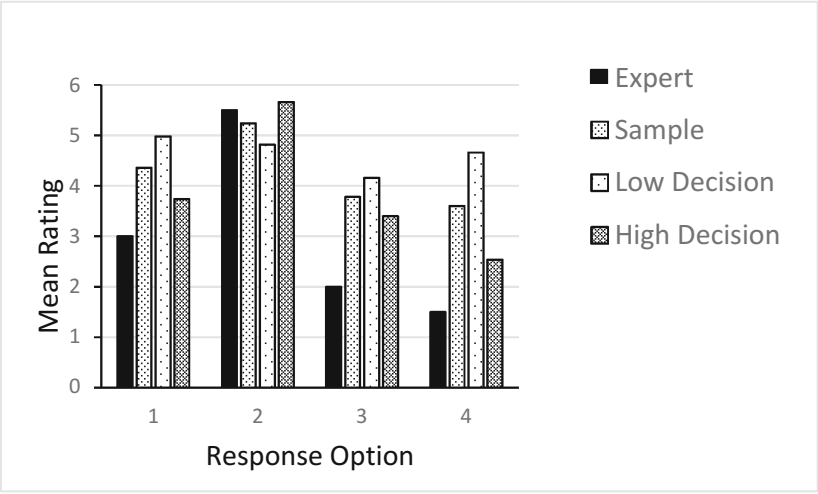

Fig. 2. Mean ratings for four response options on SJT scenario 11.

The civilian sample also rated option #2 most highly, but over-rated the acceptability of the alternatives. Individuals scoring highly in applying decision rules more closely than those low on the test, although they still tended to over-rate less favored options. Low scorers deviated strongly from SME recommendations. These findings suggest that competent decision-makers are better able to determine that common living is a primary objective and apply this rule in making their ratings.

4 Discussion

The current study identified several predictors of scores on an SJT for multinational decision-making competence, supporting its validity. Correlates of the SJT broadly matched expectation. The hypotheses that nationalism and general decision-making competence would be associated with SJT scores were supported. Across three separate samples, nationalism was moderately but significantly negatively correlated with the SJT. We also confirmed that several aspects of decision-making, including applying rules, understanding social norms, and avoiding over-confidence were associated with superior SJT performance. Multivariate analysis suggested that nationalism and decision-making competence were independently predictive. Successful multinational decision-making may thus depend on several distinct qualities whose relative impact varies across different contexts. In this section, we discuss these findings and suggest some practical implications for military training.

The negative role of nationalism is consistent with its association with negative attitudes towards foreigners [9, 14]. Broadly, it is unsurprising that biased perceptions of foreign team-mates would affect decision-making adversely. Studies of social identity suggest several more narrowly defined mechanisms that might be investigated further. For example, a simple preference for working with Americans might influence

teaming and decision-making, even if the person does not hold derogatory views of foreigners [7]. Such preferences might contribute to mixed-nationality teams fractionating into ingroups and outgroups. Countering such tendencies may require a positive orientation towards integration of personnel from different nations. The illustrative qualitative example suggested that individuals high in nationalism may not value such integration highly, impairing decision-making. However, nationalism was significantly negatively associated with performance on a subset of scenarios only, suggesting that the role of social identity varies across contexts. Future research might probe those contexts in which high nationalism is most damaging.

The positive associations between A-DMC test scores and the SJT confirm the relevance of general competencies, again depending on the scenario. Military operations require following rules such as ROEs to arrive at the best decision, so competency in applying rules should predict multinational decision making. Evaluation of social norms should facilitate understanding of what is appropriate behavior in foreign partner nations. The negative impact of over-confidence may reflect the need for Soldiers to be aware of the gaps in their knowledge of foreign cultures. The illustrative example scenario suggests that decision-making competence may be especially important where there are conflicting goals to be prioritized: maintaining both common living spaces and hygiene in the example.

Social attitudes tend to be stable over time [18]. In addition, high nationalism is linked to perceived combat readiness [19] and to morale [20], and so may be advantageous in the military context. Thus, solutions for the downside to nationalism in the multinational teaming context should focus primarily on training rather than on attitude change or personnel selection. Nationalism may be associated with specific vulnerabilities that only emerge in certain scenarios, e.g., when it is important to cede authority to foreign nationals or to work proactively to integrate individuals from different cultures. Identifying these scenarios through qualitative perspectives on data may allow targeted, effective training to enhance teaming effectiveness.

Similarly, while selecting for cognitive ability may enhance certain forms of decision-making [15], those competencies most important in the multinational context can be trained. Traditional decision-making theory suggests a focus on careful deliberation, with training methods emphasizing systematic evaluation of the various costs and benefits of different courses of action, prior to decision [21]. In the multinational context, the advantages of such training would be to highlight costs and benefits that might not have occurred to trainees. For example, the long-term benefits of building team cohesion might exceed short-term costs of reduced effectiveness in the initial stages of teaming. Training in self-regulation and metacognition also make a contribution, so that learners can acquire insight into their own reasoning processes [21]. Such training might counter the detrimental influence of over-confidence identified in the present study, specifically in relation to knowledge of foreign cultures.

The contrary perspective is that of naturalistic decision-making [22], based on observations that experienced decision-makers often do not evaluate all options systematically. Instead, they use pattern-recognition processes based on prior experience to rapidly categorize situations, and select the optimal action. This capacity is especially useful in complex, time-pressured, high-stakes situations, such as combat. Training can then be geared towards recognition and discrimination of situations,

followed by a brief period of conscious evaluation to catch any errors in the intuitive recognition process. In the multinational decision-making context, one strategy would then be to base training on virtual environments in which the Soldier is exposed to a range of challenging multinational teaming scenarios, and the consequences of different actions.

5 Conclusion

Multinational teaming may be challenging for the military because of cultural differences in beliefs, attitudes, social norms and values between Soldiers from the US and from partner nations. Findings of the current study suggest that several personal characteristics may contribute to the Soldier's ability to make effective decision in the multinational context. These include aspects of social and cultural identity, especially lower nationalism, as well as general decision-making competencies. However, the impact of personal factors may depend on the decision-making context. Training for multinational operations might benefit from profiling the Soldier's strengths and weaknesses allowing instruction to be tailored accordingly. Both traditional and naturalistic decision-making research may suggest training methods, including use of simulated teaming scenarios.

Acknowledgments. This research was sponsored by the U.S. Army RDECOM and was accomplished under Cooperative Agreement Number W911NF-15-2-0100. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the official policies, either expressed or implied, of RDECOM or the U.S. Government.

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Cultural and Social Determinants of Working Conditions in Europe

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Abstract. A continent wide perspective, based on a secondary analysis of data provided by European Union institutions is the point of departure of the study reported in this paper. National Dimensions of Culture proposed by Gert Hofstede are correlated with country by country results of the 7th European Social Survey (2014). This informs on cultural determinants of the European Social Dimensions reported on the ESS. Moreover, considering data from the 6th European Working Conditions Survey (2015), working conditions, on a country by country basis as well, are further considered and analyzed from the perspective of national cultural dimensions and from the perspective of social dimensions. This multiple pronged study of association unveils interesting associations between selected dimensions of culture and working conditions, as well as between selected dimensions of national culture and social dimensions, and also, between social dimensions and working conditions, taking the European country as a unit of analysis.

Keywords: Cultural ergonomics · Occupational health and safety · Cross-cultural analysis

1 Introduction

A territory populated by more than five hundred million people, the European continent boasts high levels of diversity in its geographical, climatic, political and cultural landscapes. The diversity of the continent has been studied and analyzed in several dimensions, cross-sectionally and longitudinally. Not only are there geographical axis (East-West and North-South) that have been emphasized as a means to understand the diversity, but there are also historical and other motivations underlying the obvious and multiple-faceted diversity. European Union institutions have been carrying out themselves, and, or, sponsoring academic institutions to do the analysis and monitoring of a great set of indicators across the continent, including social dimensions and working conditions. There is a generalized consensus that is underlying such studies and motivating them. This is that policy setting aiming at improving living and working conditions across the continent, may benefit from an understanding and consideration of cultural factors that may serve as deterrents to the widespread adoption of measures

M. Hoffman (ed.), *Advances in Cross-Cultural Decision Making*,
Advances in Intelligent Systems and Computing 610, DOI 10.1007/978-3-319-60747-4_8

that are conducive to improvements in these realms. The study reported in this paper aims providing a contribution to the understanding of the association of cultural and social factors with working conditions across Europe. In particular, the study's objective is to analyze the determinants of working conditions from a social and a cultural combined perspective, considering the level of analysis of the nation.

In this paper, the National Dimensions of Culture proposed by Gert Hofstede are first presented and then correlated (with the assistance of IBM SPSSS v.23) with selected country by country results of the 7th European Social Survey (2014 data). This informs on cultural determinants of selected European Social Dimensions reported on the 2014 ESS (Round 7). Additionally, considering data from the 6th European Working Conditions Survey (2015 data), selected aspects of working conditions, on a country by country basis as well, are further considered and analyzed from the perspective of national cultural dimensions and from the perspective of social dimensions, taking the European country as a unit of analysis. The findings shed light on the interconnectedness of the distinct domains under study, as well as informing policy development towards creating tailor made approaches suiting each particular country reality within the continent.

2 Hofstede's National Dimensions of Culture

The six measures of national cultures, initially identified by Hofstede [1–3], are numerically depicted in Table 1 and summarized as follows, according to Coelho [4–6] and to Barata and Coelho [7]:

1. Power Distance Index (pdi) - Power distance is the extent to which less powerful members of organizations expect power to be equally distributed [1]. In low power distance countries there is limited dependence of sub-ordinates on their bosses. Power is very decentralized as well as decision-making. In contrast, in high power distance countries, hierarchy is the fundamental principle on which all relationships are based. Power is centralized as well as decision-making, leading to more emphasis on formal methods for gathering and analyzing external information [8].
2. Individualism versus Collectivism (idv) - Individualism is the degree to which people are oriented towards acting as individuals as opposed to acting as a group [1]. In individualist countries people tend to value individual success and achievement. Members of individualist countries are autonomous and confident, tending to rely primarily on their own ideas [9]. In collectivist countries, people are bound in groups such as the extended family or the village and are more likely to rely on information provided by others in formulating their opinions [9].
3. Masculinity versus Femininity (mas) - Masculinity is the extent to which success and aggressiveness are valued [1]. In high masculinity countries, high earnings, advancement through opportunities and challenging work are mostly emphasized. The use of information to support decision-making is dependent on its expected effectiveness in gaining advantage over competitors [8]. In contrast, in high femininity countries, relationships, concern for the others, inclusiveness and society's best interest are valued. Co-operation is often a visible feature. The use of

Table 1. Hofstede's national dimensions of culture [14] for 31 European countries (source: http://www.geerthofstede.com/research—vsm, accessed February 2015), (legend of headings given in main text in the current section).

Country	pdi	idv	mas	uai	ltowvs	ivr
Austria	11	55	79	70	60	63
Belgium	65	75	54	94	82	57
Bulgaria	70	30	40	85	69	16
Croatia	73	33	40	80	58	33
Czech Rep	57	58	57	74	70	29
Denmark	18	74	16	23	35	70
Estonia	40	60	30	60	82	16
Finland	33	63	26	59	38	57
France	68	71	43	86	63	48
Germany	35	67	66	65	83	40
Great Britain	35	89	66	35	51	69
Greece	60	35	57	112	45	50
Hungary	46	80	88	82	58	31
Ireland	28	70	68	35	24	65
Italy	50	76	70	75	61	30
Latvia	44	70	9	63	69	13
Lithuania	42	60	19	65	82	16
Luxembourg	40	60	50	70	64	56
Malta	56	59	47	96	47	66
Netherlands	38	80	14	53	67	68
Norway	31	69	8	50	35	55
Poland	68	60	64	93	38	29
Portugal	63	27	31	104	28	33
Romania	90	30	42	90	52	20
Serbia	86	25	43	92	52	28
Slovak Rep	104	52	110	51	77	28
Slovenia	71	27	19	88	49	48
Spain	57	51	42	86	48	44
Sweden	31	71	5	29	53	78
Switzerland	34	68	70	58	74	66
Turkey	66	37	45	85	46	49

information to support decision-making is very typical of a feminine national culture [10].

4. Uncertainty Avoidance Index (uai) - Uncertainty avoidance is the degree to which people feel confident about the future [3]. National cultures that score high in uncertainty avoidance have an emotional need for rules. Vice versa, national cultures that score low in uncertainty avoidance dislike formal rules, setting them only when it is necessary [8].

5. Long Term Orientation versus Short Term Normative Orientation (ltowvs) – Long term orientation stands for the fostering of virtues oriented towards future rewards, in particular perseverance and thrift. It's opposite pole, short term orientation, stands for the fostering of virtues related to the past and present, in particular, respect for tradition, preservation of 'face' and fulfilling social obligations.
6. Indulgence versus Restraint (ivr) - Indulgence stands for a society that allows relatively free gratification of basic and natural human drives related to enjoying life and having fun. Restraint stands for a society that suppresses gratification of needs and regulates it by means of strict social norms.

Geert Hofstede conducted one of the most comprehensive studies of how values in the workplace are influenced by culture. He analyzed a large database of employee value scores collected within IBM between 1967 and 1973. The data covered more than 70 countries, from which Hofstede first used the 40 countries with the largest groups of respondents and afterwards extended the analysis to 50 countries and 3 regions. Subsequent studies validating the earlier results include such respondent groups as commercial airline pilots and students in 23 countries, civil service managers in 14 counties, 'up-market' consumers in 15 countries and 'elites' in 19 countries. In the 2010 edition of the book Cultures and Organizations: Software of the Mind, scores on the dimensions are listed for 76 countries, partly based on replications and extensions of the IBM study on different international populations and by different scholars.

In what concerns the current validity of Hofstede's cultural measures, criticisms addressed to the construct of national culture as a suitable variable for differentiation, apply directly to all measures [4]. Different corporate, organizational, industrial and/or sector specific cultures may co-exist within the same firm and might as well conflict and counterbalance the national one [11].

Furthermore, in many countries, different ethnic or national cultures co-exist (Au 2000), as result of people mobility around the globe. Within the same country, different sub-cultures might persist, standing apart on religious, language or ethnicity grounds. As a consequence, the four measures of national cultures could be far from being reliable proxies for cultural homogeneity for a given national culture [12].

The data extracted from Hofstede's measures of national culture, that was used in the correlation analyses is presented in Table 2. The data has been cross-validated in an empirical study by van Oudenhoven [13] for Belgium, Denmark, Germany, United Kingdom, Greece, Spain and the Netherlands. The country scores on the dimensions are relative - societies are compared to other societies. It is thought that these relative scores have been proven to be quite stable over decades. The forces that cause cultures to shift tend to be global or continent-wide - they affect many countries at the same time, so that if their cultures shift, they shift together, and their relative positions tend to remain the same.

Table 2. Variables of the ESS round 7 (2014) [15] core questionnaire selected for analysis.

Core section theme	Data/variables selected
Media and Social Trust	ppltrst: Most people can be trusted or you can't be too careful pplhlp: Most of the time people helpful or mostly looking out for themselves
Politics	trstlgl: Trust in the legal system stflife: How satisfied with life as a whole
Subjective well-being	sclmeet: How often socially meet with friends, relatives or colleagues health: Subjective general health
Gender and household	gndr: Gender agea: Age of respondent, calculated
Socio demographics	edulvlb: Highest level of education wrkctra: Employment contract unlimited or limited duration
Human values	ipeqopt: Important that people are treated equally and have equal opportunities ipshabt: Important to show abilities and be admired ipfrule: Important to do what is told and follow rules impfree: Important to make own decisions and be free ipadvnt: Important to seek adventures and have an exciting life imptrad: Important to follow traditions and customs

3 Selected Dimensions of the European Social Survey (2014)

The European Social Survey (ESS) [15] is an academically driven cross-national survey that has been conducted across Europe since its establishment in 2001. Every two years, face-to-face interviews are conducted with newly selected, cross-sectional samples. The survey measures the attitudes, beliefs and behavior patterns of diverse populations in more than thirty nations.

For the purpose of the analysis reported on this paper, a selection was made of 16 indicators extracted from the ESS round 7 (2014) data, using as criteria to extract no more than two questions from each of the core section themes (media and social trust, politics, subjective well-being, gender and household, socio demographics and human values), with the exception of human values, where more variables were extracted, in order to match them with the cultural dimensions presented in Sect. 2. Table 2 depicts the result of the selection. The selection was subjectively carried out by the researcher, based on the perception of the most impactful themes covered in the ESS7 regarding working conditions.

Selected average scores per country were obtained from the dataset (ESS round 7) and are shown in Tables 3 and 4. In this process, the response scale items were considered in a question by question approach (answer ranges shown to survey respondents are given in the Tables captions).

Table 3. Part 1 of 2 of selected average scores per country obtained from the dataset (ESS round 7) (legend of headings given in Table 2) (ppltrst scale: 0-You can't be too careful—10-Most People can be trusted; pplhlp scale: 0-People mostly look out for themselves – 10-People mostly try to be helpful; trstlgl scale: 0-no trust at all – 10-complete trust; stflife scale: 0-extremely dissatisfied – 10-extremely satisfied; sclmeet scale: 1-never – 7-every day; health scale: 1-very good – 5-very bad) [15].

Country	ppltrst	pplhlp	trstlgl	stflife	sclmeet	health
Austria	4.968	5.081	5.638	7.380	4.867	1.979
Belgium	5.016	4.632	5.020	7.452	5.131	2.053
Czech Republic	4.479	4.548	4.659	6.641	4.485	2.086
Denmark	6.903	6.070	7.404	8.356	5.320	1.928
Estonia	5.574	5.015	5.215	6.401	4.180	2.563
Finland	6.739	5.971	6.758	7.922	5.014	2.187
France	4.666	4.704	5.131	6.395	5.185	2.294
Germany	5.092	5.263	5.739	7.422	4.727	2.339
Hungary	4.175	4.359	4.623	5.834	3.476	2.464
Ireland	5.128	5.847	5.291	6.943	4.526	1.859
Israel	5.153	5.032	5.554	7.376	4.626	1.925
Lithuania	4.770	4.454	4.335	5.812	4.006	2.483
Netherlands	5.975	5.629	5.909	7.602	5.414	2.181
Norway	6.617	6.062	7.188	7.942	5.353	1.942
Poland	3.948	3.662	3.545	6.932	4.148	2.327
Portugal	3.667	3.991	3.708	5.800	5.691	2.587
Slovenia	4.069	4.933	3.131	6.573	4.564	2.386
Spain	4.828	4.351	4.018	6.965	5.222	2.314
Sweden	6.245	6.110	6.385	7.903	5.450	1.966
Switzerland	5.719	5.690	6.583	8.077	5.136	1.876
United Kingdom	5.376	5.920	5.548	7.163	4.808	2.140

Table 4. Part 2 of 2 of selected average scores per country obtained from the dataset (ESS round 7) (legend of headings given in Table 2) (scale: 1-Very much like me – 6-Not like me at all) [15].

Country	ipeqopt	ipshabt	ipfrule	impfree	ipadvnt	imptrad
Austria	1.952	2.967	3.141	1.933	3.903	2.565
Belgium	2.039	3.105	3.158	2.126	3.857	2.711
Czech Republic	2.497	3.301	2.695	2.354	3.740	2.621
Denmark	2.113	3.514	2.810	2.163	3.449	2.758
Estonia	2.364	3.573	3.328	2.266	4.106	2.926
Finland	1.947	3.836	3.018	2.142	3.890	3.031
France	1.851	3.503	3.845	2.581	4.215	3.349
Germany	1.887	3.590	3.563	1.921	4.288	2.973
Hungary	2.022	2.615	3.295	2.062	3.792	2.445
Ireland	2.075	2.884	3.122	2.212	3.666	2.581

(*continued*)

Table 4. (*continued*)

Country	ipeqopt	ipshabt	ipfrule	impfree	ipadvnt	imptrad
Israel	1.974	2.374	2.724	1.953	3.565	2.453
Lithuania	2.461	3.278	3.353	2.606	3.951	2.547
Netherlands	2.094	3.287	3.013	2.039	3.727	2.888
Norway	2.123	3.714	2.736	2.389	3.720	3.016
Poland	1.912	3.100	2.429	2.070	4.031	2.129
Portugal	2.140	3.213	3.451	2.314	4.350	2.884
Slovenia	1.715	2.447	3.031	1.813	3.708	2.392
Spain	1.622	3.451	3.264	2.104	4.026	2.703
Sweden	1.765	3.545	3.337	2.247	3.810	3.170
Switzerland	1.918	2.962	3.353	1.741	3.750	2.800
United Kingdom	2.022	3.228	3.350	2.136	3.837	2.874

4 Selection of Dimensions from the European Working Conditions Survey (2015)

Since its launch in 1990 the European Working Conditions Survey (EWCS) has provided an overview of working conditions in Europe [16]. Themes covered today include employment status, working time duration and organization, work organization, learning and training, physical and psychosocial risk factors, health and safety, work-life balance, worker participation, earnings and financial security, as well as work and health. For the purpose of the analysis reported on this paper, a selection was made of indicators extracted from the 6th EWCS 2015 data [17]. Tables 5 and 6 depict the

Table 5. Physical variables of the EWCS 2015 [16] selected for analysis.

Variable	[are you exposed at work to…? does your main job involve…?]
Q29a	Vibrations from hand tools, machinery etc.
Q29b	Noise so loud that you would have to raise your voice to talk to people
Q29c	High temperatures which make you perspire even when not working
Q29d	Low temperatures whether indoors or outdoors
Q29e	Breathing in smoke, fumes (such as welding or exhaust fumes), powder or dust (such as wood dust or mineral dust) etc.
Q29g	Handling or being in skin contact with chemical products or substances
Q29i	Handling or being in direct contact with materials which can be infectious, such as waste, bodily fluids, laboratory materials, etc.
Q30a	Tiring or painful positions
Q30b	Lifting or moving people
Q30c	Carrying or moving heavy loads
Q30e	Repetitive hand or arm movements
Q30g	Handling angry clients, customers, patients, pupils etc.
Q30h	Being in situations that are emotionally disturbing for you
Q30i	Working with computers, laptops, smartphones etc.

Table 6. Psychosocial variables of the EWCS 2015 [16] selected for analysis.

Variable	[to what extent do you agree with the following statements about your job…?]
Q89c	I receive the recognition I deserve for my work
Q89d	I generally get on well with my work colleagues
Q89e	The organization I work for motivates me to give my best job performance
Q89f	I get on better with my children because I have a job
Q89g	I might lose my job in the next 6 months
Q89h	If I were to lose or quit my current job, it would be easy for me to find a job of similar salary

result of the selection regarding physical and psychosocial exposures. The selection was subjectively carried out by the researcher, based on the perception of the most impactful themes covered in the 6th EWCS 2015 data. Selected average scores per country were obtained from the dataset. In this process, the response scale items were considered in a question by question approach (answer ranges shown to survey respondents are given in the Tables captions).

5 Results of Analysis of Association

Association between the national dimensions of culture presented in Sect. 2, and the selected social dimensions presented in Sect. 3 was made based on data from 20 countries that were matched across the two datasets. Table 7 depicts the pairs of variables where Pearson correlation factors above 0.5 were found. The dimensions of culture that are more salient in this analysis are power distance, uncertainty avoidance and indulgence versus restraint. The social dimensions that are more salient in this analysis are those of trust in other people and trust in the legal system.

Table 7. Strong Pearson correlations (above 0.5 in absolute value) resulting from associating the National Dimensions of Culture (NDC) with selected dimensions of the ESS7 (European Social Survey - round 7, 2014 data); variable names explained in Sect. 2 and Table 2; p-values shown in parentheses; n = 20.

ESS7/NDC	pdi	idv	uai	ltowvs	ivr
ppltrst	−0.696(0.001)	0.505(0.023)	−0.786(<0.001)	–	0.589(0.006)
pplhlp	−0.732(<0.001)	–	−0.879(<0.001)	–	0.756(<0.001)
trstlgl	−0.769(<0.001)	0.594(0.006)	−0.757(<0.001)	–	0.619(0.004)
stflife	−0.553(0.011)	–	−0.593(0.006)	–	0.771(<<0.001)
health	0.544 (0.013)	–	0.602(0.005)	–	−0.795(<0.001)
gndr	–	–	–	–	−0.593(0.006)
edulvlb	–	0.559(0.010)	−0.597(0.005)	–	–
wrkctra	–	–	–	−0.580(0.007)	–
ipadvnt	–	–	0.579(0.007)	–	−0.524(0.018)

Association between the national dimensions of culture presented in Sect. 2, and the selected working conditions dimensions presented in Sect. 4 was made based on data from 20 countries that were matched across the two datasets. Table 8 depicts the pairs of variables where Pearson correlation factors above 0.5 were found. The dimensions of culture that are more salient in this analysis are indulgence versus restraint and uncertainty avoidance. The physical working dimensions that are more salient in this analysis of association are those of 'Handling or being in direct contact with materials which can be infectious, such as waste, bodily fluids, laboratory materials, etc.' as well as 'Tiring or painful positions'. The psychosocial working dimensions that display a great number of associations with the cultural dimensions are those concerned with job insecurity, recognition for work, ease of working with colleagues and prospects of finding a new job if needed.

A third set of associations concerns the correlation between selected social and working conditions dimensions (Table 9). Most salient social dimensions in the analysis are peoples' perceived helpfulness, subjective general health, peoples' perceived trustworthiness, the trustworthiness of the legal system and the level of satisfaction with life as a whole. In what concerns physical working conditions, the variables most involved in the strong correlations are experiencing tiring or painful positions and working with electronic devices. Salient psychosocial factors are recognition for work, organization motivated performance, job insecurity and prospects of finding a new job if needed.

Table 8. Strong Pearson correlations (above 0.5 in absolute value) resulting from associating the National Dimensions of Culture (NDC) with selected dimensions of the 6th EWCS (European Working Conditions Survey, 2015 data); variable names explained in Sect. 2 and Tables 5 and 6; p-values shown in parentheses; n = 20.

EWCS/NDC	pdi	idv	mas	uai	ivr
Q29a	–	–	–	−0.522(0.018)	0.753(<0.001)
Q29e	–	–	–	–	0.507(0.022)
Q29i	–	−0.597(0.005)	–	0.630(0.003)	−0.503(0.024)
Q30a	−0.503(0.024)	0.578(0.008)	–	−0.660(0.002)	–
Q30b	–	–	–	–	−0.513(0.021)
Q30e	–	0.551(0.012)	–	–	–
Q30i	–	–	–	0.712(<0.001)	−0.765(<0.001)
Q89c	0.639(0.002)	–	–	0.506(0.023)	−0.543(0.013)
Q89d	–	–	0.619(0.004)	0.529(0.016)	−0.612(0.004)
Q89e	–	–	–	–	−0.631(0.003)
Q89g	−0.638(0.002)	0.535(0.015)	–	−0.629(0.003)	0.711(<0.001)
Q89h	0.553(0.011)	−0.651(0.002)	–	0.748(<0.001)	–

6 Discussion

The greatest absolute value of correlation found in the study was 0.879 between uncertainty avoidance and people's perceived helpfulness. Hence, people from countries with a low degree of uncertainty avoidance (e.g. Denmark, Sweden, Norway) are bound to perceive others as helpful, while people from countries with a high degree of uncertainty avoidance (e.g. Portugal, Belgium) are bound to perceive others around them as mostly looking out for themselves.

National dimensions of culture that were shown to be strongly associated to physical exposures were uncertainty avoidance and indulgence versus restraint. More tiring and painful positions on average were associated to higher uncertainty avoidance cultures, and relatively high indulgence cultures (e.g. Sweden, Denmark, Great Britain) were on average associated with lower exposure to vibrations from hand tools and machinery and more work with computers than high restraint cultures (e.g. Estonia, Czech Republic). Higher uncertainty avoidance cultures were associated to greater perceived difficulty in finding a new job, while relatively higher indulgent cultures associated to higher perception of work recognition, relationship with colleagues and organization motivated performance and lower prospects of job loss than restraining cultures.

Associations of physical exposures with self-perceived health were negative for vibrations, breathing in some and fumes, experiencing tiring or painful positions and performing repetitive hand or arm movements. Job security correlated very notably with trust in the legal system and recognition for work.

There are limitations in this study. First and foremost, given the breadth of the ESS and ECWS surveys, a selection of variables was made, which carries a level of

Table 9. Strong Pearson correlations (above 0.5 in absolute value) resulting from associating the selected the ESS7 (European Social Survey - round 7, 2014 data) with selected dimensions of the 6th EWCS (European Working Conditions Survey, 2015 data); variable names explained in Tables 2, 5 and 6; ** correlation is significant at the 0.01 level (2-tailed); * correlation is significant at the 0.05 level (2-tailed); n = 20.

ESS7/ 6EWCS	ppltrst	pplhlp	trstlgl	stflife	sclmeet	health	gndr	edu-lvlb	ip-eqopt	ipshabt	ip-advnt	imptrad
Q29a	–	.561*	–	.504*	–	−.676**	–	–	–	–	−.527*	–
Q29c	–	–	–	–	–	–	–	–	.638**	–	–	–
Q29e	–	–	–	–	.572**	−.512*	–	–	–	–	–	–
Q29g	–	–	–	–	.505*	–	–	–	–	–	–	–
Q29i	−.567**	−.573**	–	–	–	–	–	–	–	–	–	–
Q30a	.586**	.643**	.661**	–	–	−.583**	–	.546*	–	–	−.551*	–
Q30e	–	–	–	–	–	−.506*	–	–	–	–	–	–
Q30g	–	–	–	–	–	–	–	.670**	.520*	–	–	–
Q30i	−.779**	−.806**	−.686**	−.717**	–	.633**	–	−.522*	–	–	.618**	–
Q89c	−.761**	−.623**	−.841**	−.672**	−.579**	.619**	.509*	–	–	−.525*	–	–
Q89d	−.716**	−.737**	−.583**	−.580**	−.664**	–	–	–	–	–	–	–
Q89e	−.645**	−.646**	−.683**	−.694**	−.568**	.589**	.598**	–	–	–	–	–
Q89f	–	–	–	–	–	–	–	–	–	–	.626**	–
Q89g	.753**	.796**	.879**	.731**	–	−.701**	−.627**	.605**	–	–	–	.564**
Q89h	−.735**	−.663**	−.729**	−.642**	–	.571**	–	−.785**	–	–	–	–

subjectivity. Moreover, the size of the level of analysis in this study (country level) precludes fine grained differences which are inherently present in any big population group, such as a nation. This notwithstanding strong correlations were found between all the three datasets associated in this study. Moreover, the European countries included in each of the three datasets considered was not the same; the intersection of the three datasets yielded a sample of twenty European countries. Hence, the scope of analysis while continent wide is not completely encompassing.

7 Conclusion

The current study was aimed at providing a contribution to the understanding of the association of cultural and social factors with working conditions across Europe. The study shows very strong associations across the board, when combining selected variables of the three datasets in pairs.

When associating cultural dimensions with social dimensions, the more salient dimensions are power distance, uncertainty avoidance, indulgence versus restraint, trust in other people and trust in the legal system. Associating cultural dimensions with working conditions sheds light on the importance of indulgence versus restraint, uncertainty avoidance, 'Handling or being in direct contact with materials which can be infectious, such as waste, bodily fluids, laboratory materials, etc.', 'Tiring or painful positions', job insecurity, recognition for work, ease of working with colleagues and prospects of finding a new job if needed. The correlation analysis between social and occupational dimensions showed the salience of peoples' perceived helpfulness, subjective general health, peoples' perceived trustworthiness, the trustworthiness of the legal system, the level of satisfaction with life as a whole, experiencing tiring or painful positions, working with electronic devices, recognition for work, organization motivated performance, job insecurity and prospects of finding a new job if needed.

Overall, the cultural dimensions that are most important as determinants of working conditions are uncertainty avoidance and indulgence versus restraint. The social dimensions that are most noteworthy as determinants of working conditions are peoples' perceived helpfulness, subjective general health, peoples' perceived trustworthiness, the trustworthiness of the legal system, the level of satisfaction with life as a whole. Of these, perceived helpfulness, subjective general health and the level of satisfaction with life as a whole are those that are not strongly associated to cultural dimensions, and hence, those where it will be easier to set policy measures aiming for improvement that do not have to go against culture, and hence are more likely to succeed.

The cultural dimension of uncertainty avoidance is well-established as a predictor of predispositions to take risk or be risk averse [18]. If trust is the willingness to take risk in a relationship [19], the results of the current study shed light on how uncertainty avoidance as a dispositional quality affects the onset of trust. This notwithstanding, there is considerable work that needs to be done in fine-tuning what is known about the influence of culture on the propensity to trust. Future research should also focus on different levels of analysis, and exploring further implications for organizational theory of the findings of the current study. Moreover, given the existence of longitudinal data

for the working conditions and social surveys, it is feasible to explore the evolution of the associations, and as such ascertain their persistence over time, and provide a contribution to build macro models of the phenomena under study.

Acknowledgements. The current study was funded in part by Fundação para a Ciência e a Tecnologia Project UID/EMS/00151/2013 C-MAST.

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Organization & Cultural Impact of Microservices Architecture

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Abstract. Microservices Architecture encompasses more than the decomposition of applications. If the organization and cultural impact is not addressed initially, and continually, the output of a Microservices architecture will never match the desired goal. In this paper, we walk through the key concepts of Conway's Law, Bezo's Rule, and other foundational principles of culture and structure. Addressed are key factors in an effective Microservices culture including group size, motivation, relationships and how they impact the development and goals of Microservices.

Keywords: Human factors · Microservices · Digital transformation · DevOps · Conway's law · Bezo's rule · Culture · Architecture · Software development · Social loafing · Group size

1 Introduction

Culture has become a large topic within Microservices. Most acknowledge that culture has to change. Even advanced organization's typically incorporate some variation of Jeff Bezo's two pizza teams and/or Conway's law and consider their job done.

Within this context, we are only scratching the surface of the cultural impact and organizational considerations behind Microservices.

Scrum and Agile originated within software development and now countless books litter the pages of Amazon showing how to extend it to other parts of the organization or even into every day life. Today, software is dominating. Software Defined, Software Developed, Software Everything. The critical key is to not forget that this "software everything" still originates with a human. In the beginning, there was a human and he created all of the software (insert word here) you can imagine. So when you look at output from Microservices development, always remember the adage of garbage in, garbage out. The output is the direct reflection of the structure and culture that exists in the organization.

What we strive for in Microservices, as well as any process, service, or activity is efficiency and effectiveness.

Efficiency (ITILv3): [Continual Service Improvement] A measure of whether the right amount of resources have been used to deliver a Process, Service or Activity. An Efficient Process achieves its Objectives with the minimum amount of time, money, people or other resources.

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Advances in Intelligent Systems and Computing 610, DOI 10.1007/978-3-319-60747-4_9

Effectiveness (ITILv3): [Continual Service Improvement] A measure of whether the Objectives of a Process, Service or Activity have been achieved. An Effective Process or Activity is one that achieves agreed Objectives [1].

Simple. We are looking to have the right resources and achieve our objectives. And to do so, we must also implement cultural best practices before we can consider architectural best practices. Broadly speaking, the three major areas to address are: Structure, Size, and Evolution.

> 'Those who cannot remember the past are condemned to repeat it.' – George Santayana

First we must understand the fundamental principles and beliefs for optimal organizational structure. The success of Microservices architecture, more than providing a challenge, can also be mirrored in the success of more effective and efficient organizations.

2 Structure

2.1 Conway's Law

In 1967, Conway submitted a paper, "How Do Committees Invent?" to Harvard Business Review. It was rejected because he did not have the proof for his hypothesis. Since that time, this hypothesis has been proven repeatedly, even by Harvard itself. And not for just the original scope of software project management, but in much broader systems. Fred Brooks citation of the paper and the idea in "The Mythical Man-Month," permanently coined it "Conway's Law."

The most common form of this is:

> "Any organization that designs a system (defined broadly) will produce a design whose structure is a copy of the organization's communication structure." [2]

Understanding this, you can understand if the output you are trying to achieve doesn't reflect your organization's structure, you will inevitably have a problem.

If you can model the Microservices architecture first in the culture and organization, you are setting the stage to have the successful demonstration of success.

What are the basic tenants of Microservices?

- Organized around Business Capabilities: Teams no longer should be single capability teams. In Microservices, you can no longer have the DBA team, and the middleware team, and the design team. Just like Microservices, teams now need to be be organized around a full end to end business capability.
- Componentization/Containerization: Fowler defines component as a unit of software that is independently replaceable and upgradeable [3]. Translating this concept to human factors does not make the group easily replaceable. It makes it easily upgradeable. The group has the ability to upgrade both their component of the Microservices architecture to continuously innovate, but also is able to continuously innovate themselves.
- Smart endpoints and dumb pipes: The teams are innovative, upgradeable, and smart. I may at this point be giving them a complex. The point with dumb pipes is

that teams need to be decoupled. Their intelligence is within the team. The more dependencies that exist between teams, the more connections of failure you create.

- Automation: The old adage was always if you make your job replicate-able, you make yourself replaceable. This has changed. The more you can automate what you do, the greater the chance you will also find your own strategic niche. The people that implement the automation advancements are also the ones that create patents. They find the next better way. This is now the norm.
- Design for failure: What happens when a failure happens? Everyone gets onboard and spends sleepless nights throwing people at the problem and fixing it, right? Wrong. Failure should be designed and standard and a way to lead to further innovation instead of a point of extreme stress. One team should be able to fix failure without everyone else standing over them and screaming at them the entire time. Design for it so it can be fixed within a team without or only minimally affecting anyone else.
- Decentralization: Don't hire a specific talent, or a specific capability. Hire brilliance. Promote excellence, and let them become the leaders of their small realm. Just make sure they are team players too because communication is still a key component, in and among teams. That's why APIs are such a popular topic too.

So, more dumb Communication, right? Wrong. It's still the right kind of communication done in the right way within the right boundaries.

3 Size

3.1 Bezo's Two Pizza Rule

Bezo's two pizza rule originated from Sociologist Robert Dunbar. After stumbling over the number 150 again and again, he proceeded to discover why. Ultimately, he found his answer in the correlation between primate brain size and the number of members in their social groups. Taking that number and extrapolating for human brain size (the neocortex part of it), the most people comfortably maintained in a loose human group is 150.

> "Extrapolating from the relationship for monkeys and apes gives a group size of about 150 – the limit on the number of social relationships that humans can have, a figured now graced with the title Dunbar's Number." (Dunbar 2010) [4]

He further deduced that group sizes were associated to the number 3 and the next level down is 50 which constitutes a tight knit group. Then 15, and then 5.

Jeff Bezos, CEO of Amazon, correlated this into, "If I see more than two pizzas for lunch, the team is too big." We have primate brain sizes and a little Davinci Code thrown in to get here, but let's go one more level.

Richard Hackman, a Professor of Social and Organizational Psychology at Harvard University, spent a significant amount of his research on team structure and performance. His assessment? "Big teams usually wind up just wasting everybody's time" [5].

The number isn't really the magic. It's the bilateral relationships. The links between people.

The equation is n(n − 1)/2 where you put n as the number of people in the group.

- Five people = 10 links.
- Six people = 15 links
- Seven people = 21 links

With five people and ten links, you have almost no overhead keeping communication effective and in sync. Even just doubling the size creates 45 links. This creates significantly more overhead to manage (Fig. 1).

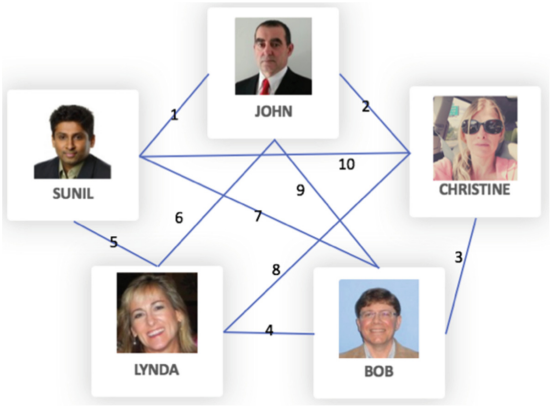

Fig. 1. Bilateral Relationships shown between a five person team

We also have to address motivation. In 1913, Max Ringelmann asked a group of men to pull on a rope attached to a strain gauge. He varied the number of participants pulling on the rope and noted that two individuals pulling the rope only exerted 93% of their individual efforts. A group of three individuals exerted 85% and groups of eight exerted 49% of their combined individual effort. As more individuals pulled on the rope, each individual exerted themselves less. This became known as social loafing [6]. As members of a group feel less responsibility, they also exert less effort.

4 Evolution

As we address evolving the team and continuous improvement, we would be amiss in a discussion of culture if we didn't mention Brook's law: "Adding manpower to a late software project makes it later." (Brooks 1975) [7].

This doesn't mean that you do not add people to a team. It only means to do it wisely and remember that like all relationships, it takes time. Adding someone to a team and developing them as a team member is a process. It can't be a quick fix. To do so wisely, we can follow the theory of constraints. Just as you can use these rules when you are behind schedule, you can also use them when making improvements.

Rule 1: Identify the Constraint: The natural human inclination when you are behind schedule is to throw more people on the team to help. The first step should always be to identify succinctly what is causing the delay. What is the constraint? Even without a delay, when trying to improve your team, make sure you fully understand what you are trying to improve

Rule 2: Exploit the Constraint: First make sure that you are making any incremental improvements within your teams that will help further exploit your constraint

Rule 3: Subordinate Everything to the Constraint: At this point, you make sure all the other people, process, or other are aligned with the Constraint. Adjust flow and speed so that they align. This helps to justify the decisions made in the next rule

Rule 4: Elevate the Constraint: This is where you may add more people, or invest in more technology, or provide additional enablement

Rule 5: Repeat: Keep evolving! Look for the next constraint to remove

As a note, the Theory of Constraints is similar to the DMAIC approach of Six Sigma [8] (Fig. 2).

Fig. 2. Theory of constraints

5 Conclusion

So What do We do to Check and Develop the Right Culture for Microservices?

- Right-size your team and focus on the communication. Small team sizes keep your communication overhead low and keeps the team cohesive.
- Create your teams with end to end capabilities instead of just one capability per team. Remember that the output is reflective on the structure and the communication of the teams. To have loosely coupled microservices, your teams have to be loosely coupled as well. Creating too many dependencies between your teams will

stagnate your development. Mirror the structure of Microservices first within your teams. The boundaries your draw around your teams should mirror the boundaries you draw around your Microservices.

- Create an environment where conflict and discussion can naturally occur and doesn't get overridden by consensus. When people in a group strive for consensus and adopt the opinion of the rest of the group, even at the expense of their own beliefs, was a psychological phenomenon coined groupthink in 1972 by social psychologist Irving L. Janis [9]. Groupthink is its own topic in many articles concerning Agile. So make sure you assign at least one devil's advocate.
- Empower your teams. Agile invokes "self-organizing teams" but this doesn't always work in organizations. Don't try to make a new starting point for yourself. Your current culture is your starting point and you have to understand it and what you need and can use from it. Leadership may need to empower these teams. Let it do so, and do so readily if that is needed. Once the team is empowered, let it run autonomously and take end to end responsibility. This responsibility helps avoid social loafing and enables senior leaders to stop being program managers and to focus instead on strategy, vision, culture, and cross-team communication.
- Evolve thoughtfully. Laws and Rules are good at the foundation but innovation occurs at the edges. Look for ways to improve and share share share.

Digital Transformation is now the accepted norm with 88% of companies reporting that they are undergoing digital transformation (Altimeter Group) [10].

Microservices is a large component of a digital transformation. But, before you look at decomposing your applications into Microservices; make sure the proper consideration and foresight has been committed for your team decomposition. And, implementing Microservices is just one blip in the continuum of evolution. The culture has to have evolved to that point, and it needs to continue evolving or all the work done initially will dry and wither instead of continuing to produce.

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Causal Analysis in Complex Environments

Challenges in Making Policy Decision-Support Systems Operational

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Abstract. Given the increasing complexity of the international policy environment, there are strong incentives to employ modern computation in the form of models and simulation to help analysts address and account for this complexity. While academic examples of such complex system policy models have been available for some time, they are not yet able to be used effectively and consistently in operational policy environments due to a range of technical gaps and challenges including: (1) simulation; (2) Human Machine Interface (HMI); and (3) data. Specific examples for each type of policy model challenge will be developed in this paper.

Keywords: Human factors · Human-systems integration · Systems engineering · Operational simulation · System dynamics · Operational policy · Complexity · Data requirements · Gray zone

1 Introduction

The growing breadth and levels of potential conflict faced by the United States Government (USG)—new tactics and complex political dynamics drive uncertainty-creating policy situations that require integrated 'whole of government' approaches to address. Beyond stalwart global policy activities (e.g., national missile defense, armed nation building, counterinsurgency), renewed strategic focus has turned to hybrid warfare, 'gray zone' activities, and megacity operations [1]. These new situations represent truly complex systems—systems that are dynamic and cross adaptive—characterized by both subtle and overt cross-domain activities that combine elements of cyber espionage, covert and psychological operations, military maneuvers, along with political and economic subversion [2]. Such systems and their adaptive behaviors are characterized by their dynamic policy complexity. However, the ability of analysts, decision makers, and policy makers to understand this systemic policy complexity and recommend courses of action is limited. Computer-based complex social systems (CSS) simulations have been built and demonstrated in research settings and can potentially help analysts address that complexity. However, such simulations are not yet capable of supporting analysts in an operational policy setting. This paper articulates the requirements for CSS simulations to provide such support.

M. Hoffman (ed.), *Advances in Cross-Cultural Decision Making*,
Advances in Intelligent Systems and Computing 610, DOI 10.1007/978-3-319-60747-4_10

The current paper outlines three challenges for creating an operational policy simulation capability to support whole of government decision-making. The specific challenges for policy simulation include: (1) the simulation itself; (2) human–machine interface (HMI) considerations for simulation interaction; and (3) the supporting data requirements. First, the simulation must be able to support the interaction, coordination, and communication between policy analysts and senior USG decision makers. This entails providing sufficient flexibility to craft a range of models that apply to a range of policy settings as well as the ability for analysts to query the simulation in support of the policy dialogue between analysts and senior USG decision makers. Effective analytic products are created and maintained through HMIs that mediate the interaction between analysts and the underlying technical tools. These will require a range of different displays—different frames of reference—that portray multi-dimensional system relationships from low-level data (e.g., spatial, graph, and temporal dimensions) to higher-level information relationships (e.g., force dynamics, points of leverage) by using a mix of familiar map-based geographic information system (GIS) tools as well as complex system behavior trends over time. Third CSS simulations must provide the capability both to focus data collection and interpret the data collected. In the current work, the political economy model developed in Quest for Viable Peace [3] will be used as it is based on representative operational USG policy experience.

A working systems-based theory of 'governance' is developed here based on distilled lessons learned from the international community's experiences in Bosnia and Kosovo during the 1990s. Governance is examined in terms of capable government institutions making decisions regarding both security and economy that result in state stability. Government capacity is expressed in terms of four governance elements: (1) political, (2) economic, (3) military, and (4) rule of law. These elements do not exist separately but instead weave together and influence one another like the strands of a rope. From a systems perspective, governance is a phenomena of interest based on (1) *interactions and emergence* from the relationships and interaction among parts, not a reductionist analysis of individual components; (2) the *cross-scale interactions* of states and dynamics; and (3) *perspective* at multiple levels of analysis [4, 5]. These two views on governance provide the basis for developing both the models, as well as the support tools—simulation and HMI–to explore and explain evidence against the model in a manner that supports scientific inquiry and that also supports interactions between analysts and senior decision makers in a manner that supports policy.

Figure 1 depicts the organizational structure of a state with ineffective governance, like the fragile states described by the Fund for Peace [6]. The state and its institutions have been captured by a criminal political elite, making it unresponsive to and effectively illegitimate for the mass of society. The economy is composed of three separate sub-economies: the legitimate economy in which transactions for legal goods occur and taxes are paid to the state, the gray economy in which legal goods are traded but taxes are not paid, and the illegitimate economy in which illegal goods like drugs, weapons, and people are traded and taxes are not paid. In a failed state the illegitimate and gray economies are large relative to the legitimate economy, and the benefits of the economy are directed by the political criminal elite to a favored client group rather than the mass of society. Potential economic pathologies from this arrangement include uneven development due to the two class system, economic decline due to illegal activity,

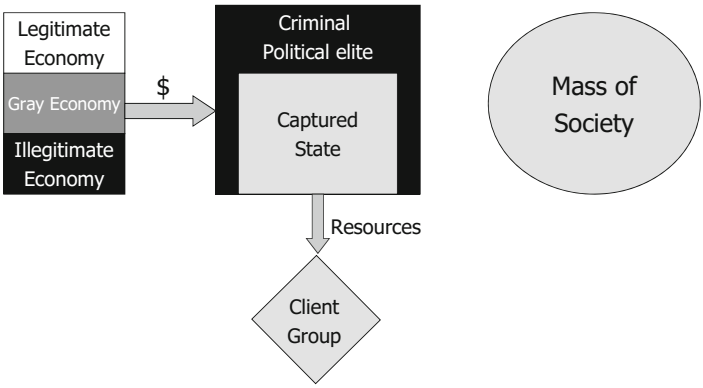

Fig. 1. Quest for Viable Peace (QVP) model "Start State": ineffective governance results in failed states [1].

and lack of public services for the most of the population. The state's military and legal frameworks are used to keep the criminal elite in power and oppress the mass of society, a misuse of the security apparatus that can cause group grievance, internally displaced persons, human rights violations, and human flight.

Figure 2 depicts the organization of a state featuring effective governance. Placed at the center is the mass of society who now receive the benefits of the economy and resources from the state. The legitimate economy benefits primarily the mass of society, while the smaller gray and illegitimate economies pass resources to a criminal subculture. The mass of society pays taxes to the state and in return receives benefits and services from the state, and the rule of law is used to keep the gray economy, illegitimate economy, and criminal subculture in check. Figure 2 presents a picture of rightly ordered relationships that provide stability and avoid the failed state pathologies depicted in Fig. 1.

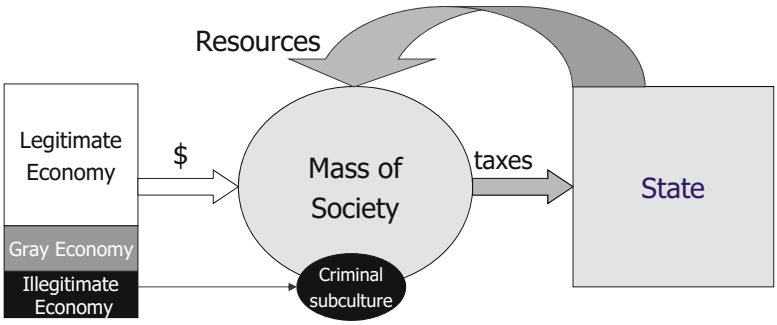

Fig. 2. Quest for Viable Peace (QVP) model "Goal State": effective governance leads to state stability [1].

In the 21st century, fragile states like those depicted in Fig. 1 are more than a national tragedy; they are an international security threat to effectively governed states through terrorism and weapons of mass destruction. This then provides an incentive for the international community to transform Fig. 1 states into Fig. 2 states as shown in Fig. 3. The process is accomplished through international assistance that must accomplish several things. First, it must engage militarily the criminal political elements and restrict resource flows to its client group. Second, it must stand up a state that provides effective governance and resources to society. Specifically, the state must provide rule of law, which entails the rehabilitation or creation of non-corrupt police, judiciary, and prison systems. Third, the illegitimate and gray economies must be reduced to lessen the strength of the criminal political elements and to create an incentive for them to reintegrate in society. The legitimate economy must be strengthened, and taxes must be collected to fund the state. Note the interrelationships among these various factors and that they must be changed simultaneously – hence the complexity and difficulty of international assistance and nation building.

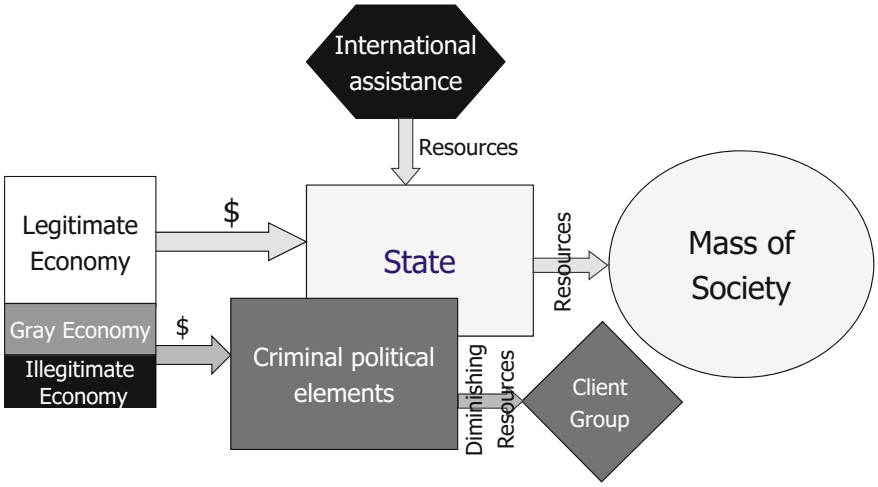

Fig. 3. Quest for Viable Peace (QVP) model "Missing Middle": international assistance seeks to transform failed states [1].

2 Simulation

While noting the dynamic complexity of the QVP model is duly noted and appreciated, it remains to be seen just how this complexity will be represented and handled. The complexities and difficulties associated with social systems and policy have long been noted, but the difficulty comes in designing and developing a way to depict and handle that complexity. This study proposes leveraging the power of modern computation to use simulation specifically and System Dynamics (SD) simulation specifically to handle the dynamics complexity of social systems and the policies designed to modify and improve them.

Figure 4 shows an SD simulation of the QVP model developed in Sect. 1, which provides several important benefits. First, it forces the analyst to specify, quantify, and make explicit the systems being studied and claims being made. All decisions and are made on models, usually mental models that are unspecified and hidden, while simulation-based models are specified and explicit. Human decision making is notoriously poor at judging the likely outcome of complex social systems [8], and computer-based simulation can help to identify, structure, and improve the understanding of the clashing social forces that generate dynamic complexity [9].

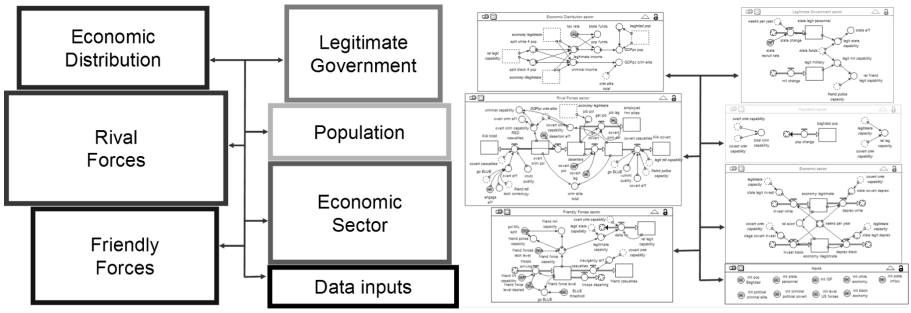

Fig. 4. Quest for Viable Peace (QVP) model structure specified, quantified, and made explicit using the System Dynamics (SD) simulation methodology [7].

While complex system simulation like SD might appear to solve the difficulties associated with social systems and policy, implementing it in an operational setting present several challenges. First, does the simulation model apply? Creating SD simulations is difficult, but determining if they apply to the policy situation at hand is even more difficult. Tests have been proposed to validate, verify, and accredit a simulation model [8], but no simulation model can ever be judged to be 100% accredited. There is a sliding scale for models from "wholly inappropriate" to "high degree of confidence," but models are by definition simplifications or abstractions of reality, so there will be situations when reality does something not predicted by the model.

Second, even if a simulation model were to be 100% applicable for a certain system at a certain time, systems have a way of changing or evolving over time so that assumptions that used to be valid are no longer so. In an operational setting, an analyst who created a simulation model may no longer be around when it is applied to a policy problem, which creates several problems. Most notably, complex simulation models are complex, which means they are hard to understand by those who created them and even harder to understand by those that did not. This makes simulation models hard to maintain, update, extend, and apply in an operational setting where analysts turn over and are replaced for a wide variety of reasons, and usually at the most inconvenient time.

3 Human Machine Interface (HMI)

As described previously, viewing governance from a systems perspective focuses on three core premises: *interactions and emergence*, *cross-scale interactions*, and *perspective*. To develop effective HMIs that account for and capture these phenomena, Cognitive Systems Engineering (CSE)-based HMI design approaches begin with establishing such a systems view, and then mapping informative system properties to define support requirements across explicit dimensions of the people to be supported (policy analysts), the underlying technology (i.e., simulations and models, support tools), and the functional work they accomplish (i.e., cognitive tasks and decision-making).

While new modeling and simulation technology has the potential to provide different representations of complex systems, analysts work with and understand these systems through Human Machine Interfaces (HMIs), which mediates the interaction of analysts with the system. The representations employed by the HMI (or selected by the HMI designer) also convey all information about complex systems to the analyst. While there is a constant desire to keep HMIs 'simple', poorly conceptualized or misleading interfaces can fail to provide the information and practice-centered external representations necessary to accurately and effectively convey a model of how a complex system or process works. Such complex system interactions are rarely simple. A variation on the representation effect [10], which holds that *how* a problem is represented impacts and affects the cognitive work required to then solve that problem [5]. Inaccurate or over-simplified representations can degrade performance, where the result is not lower workload for users as is often claimed. Since people generally and analysts fundamentally build explanations for the processes they confront everyday [10], system engineers and HMI designers can quite accurately predict what happens when HMI designs do not help their users build accurate models, at multiple levels of analysis, of the relevant processes: users will develop many diverse models of the process or device and these models will be quite wrong [11].

Consequently, SD simulation helps its users to understand complex systems by helping them to visualize the structure of the system being analyzed as shown in Fig. 4. Being able to point to a visual depiction or artifact of a system allows the analyst to gain a holistic understanding of the system by showing what parts of a system are connected to which other parts though explicit depiction of the system's causal connections. It also allows groups of analysts to share, contribute, and integrate their individual understandings into a holistic understanding that contributes to shared consensus and greater collaboration.

The computational infrastructure underlying simulation also provides the ability to generate scenarios and analyze them as shown in Fig. 5. The diagram on the left shows the desired response—capacity of legitimate institutions going up and the power of obstructionists going down, while the SD output to the right shows if this is the actual outcome given the system structure and equations that comprise the simulation.

While providing considerable power in a research-driven, academic setting, several SD simulation challenges have been identified in an operational setting. First, analysts and senior government officials do not easily interpret the behavior over time graphs shown in Fig. 5, nor do they readily understand the system structure diagram shown in

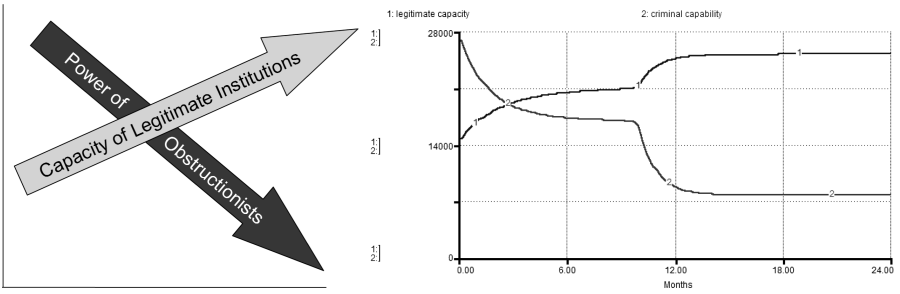

Fig. 5. Quest for Viable Peace (QVP) simulation "behavior over time" output showing capacity of legitimate institutions increasing and the power of obstructionists decreasing [7].

Fig. 4. While such displays may be fine in a research setting where there is time to contemplate such artifacts by people trained to do so, in an operational setting where lives and resources at risk, they have not proven persuasive.

This leads to the second HMI challenge: trust. Models and simulations will not be used by analysts and decision makers if they are not trusted, and that trust is established almost wholly through the HMI. Part of the problem is the fundamental nature of models and simulation—that is, they are by definition an abstraction of reality, so their utility is based almost wholly on the art of its creators and the testing that was done to it. However it is true that users trust models most when they have built them, so it is a goal of well-designed HMIs that they should engender a feeling of engagement and ownership in the model so that the user trusts it.

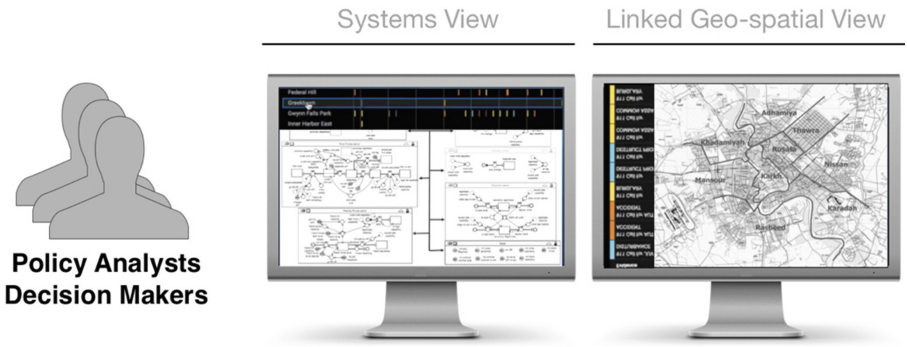

Fig. 6. System dynamics (SD) simulations handle behavior over time well but spatial analysis—which is necessary for military analysts as exemplified by the map of the nine districts of Baghdad, Iraq (as shown on the right display)—remains an ongoing research challenge.

Operational users do use abstract models in which they place a great deal of trust, which are maps. Once again, the visualization conveys a great deal of information in an intuitive and efficient manner. However, the behavior over time nature of SD does not mesh well with maps, so it is difficult to understand where on the map the model applies and where it does not, which makes it another research challenge (Fig. 6).

4 Data Requirements

The relationship between SD simulation and data is complex because it does not require as much data as other quantitative techniques, such as statistical regression, and for purely theoretical models requires no data at all. Once again though, one of the key strengths of SD is that it makes the assumptions clear, including data requirements. A great deal of energy, thought, and infrastructure has gone into "big data," the collection of data that can be used to structure a wide range of questions. However, big data is of limited value in the policy realm unless there are clear requirements for what data are required, and how those data are to be interpreted when they are acquired. One of the outcomes of SD simulation models, besides providing visualizations for system structure (Fig. 4) and behavior over time (Fig. 5) visualizations is an integrated metrics, the parameterization of which can be supported by empirical data. Finally, data requirements can be minimized by leveraging experience, expertise, and theory, which allows for simulation models to be applied in situations where data is scarce or expensive to acquire.

Simulation has its share of data challenges. First, even though data can be traded off in SD, it's hard to get all the data that's desired or required. This is especially true as some analysts or would be analysts hold unrealistic views about the availability, quality, and applicability of data because, even in an age of big data, there isn't as much available for some operational, policy areas as some might believe. That said, SD simulations provide a range of strategies to deal with and accommodate data limitations. Second, analysts in operational settings are usually short on time, and for situations in which data is plentiful, automated ways of entering and updating data are important and sometimes not available. They are important however because tools that are easy to use are more likely to be used by analysts. Third, as new or radically changing data becomes available, it can be difficult to determine if the data still applies to the, if the model still applies to the policy setting, and if not, then how the model should be changed.

5 Conclusion

This paper has identified the way simulations can be useful in an operational policy environment, but there are a range of challenges that prevent their application. These challenges were organized into three categories: simulation, HMI, and data. The simulation challenges concern its basic applicability to the policy domain, which is described in terms of validation, verification, and accreditation, and which remains difficult, uncertain, and expensive. And even if the simulation model is applicable, then it is difficult to maintain, update, and extend for those who didn't create it. Second, the simulation outputs, which have a certain engineering feel, can be hard to interpret and understand in an operational environment. In an operational environment, trust in the underlying simulation is paramount given the stakes and significance of the policy situation, so due consideration must be given to factors that engender trust in the analysts and senior decision makers for whom they work. Map-based analyses provide high levels of trust based on their extensive use in traditional policy environments, and

finding ways to combine models and maps to increase user trust is a challenge. Third, in operational environments, it's important to be realistic about the data that is available and to adjust the policy model accordingly. Moreover, analyst time is valuable in an operational setting, so automation should be provided that updates and enters the data automatically. Finally, it is as the policy environment changes and adapts, as reflected in the data, it is hard to know if the new data and the old model still apply. These challenges are articulated because the policy complexity of the international environment will only increase, and the drives for more operational policy simulation will only increase. Doing so requires means articulating these challenges accurately and addressing them effectively.

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Complex Causality: Computational Formalisms, Mental Models, and Objective Truth

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Abstract. There is a broad consensus that understanding causality is important for comprehending the world and making decisions. However, causality is notoriously difficult to understand and analyze, a challenge amplified in complex sociocultural systems. These challenges can be categorized as interactions among three critical areas of operationalizing causal analysis: Computational Formalisms, Mental Models, and Objective Truth. We provide a survey of causal research across these three key areas and identify existing gaps between objective truth, the way people understand and think about causality in mental models, and the modeling formalisms that have been developed to support representation and reasoning about causality. To bridge these gaps, we present a preliminary conceptual Meta-Causal Models framework to capture the semantic relationships between these three categories of causal analysis and identify the most effective combination of causal reasoning approaches to support decision-making requirements.

Keywords: Causality · Mental models · Causal models · Indeterminate causality

1 Introduction

Causality has enticed researchers and practitioners for hundreds of years in a wide range of fields, including philosophy, mathematics, physics, artificial intelligence, and social sciences. In particular, there is a large body of work applying casual analysis to sociocultural systems in an attempt to better explain and understand our world. In recent years, causality has enjoyed something of a resurgence in both technical and popular literature. This may be attributed to increases in computing power, the commoditization of Machine Learning, and the rise of so-called Big Data, that is, the ability to run ever more complex, self-calibrating, computational models over ever-larger data sets in the hope of finally achieving an understanding of the interactions in complex environments. Yet even with this new focus, critical conceptual and technical challenges remain in operationalizing the ideas of causality, that is, in using this knowledge to inform planning and decision making in ways that are effective, efficient, and subject to formal methods of experimentation and scientific validation.

M. Hoffman (ed.), *Advances in Cross-Cultural Decision Making*,
Advances in Intelligent Systems and Computing 610, DOI 10.1007/978-3-319-60747-4_11

These challenges can be categorized as interactions among three critical areas of operationalizing causal analysis: Computational Formalisms, Mental Models, and Objective Truth. It is notoriously difficult to rigorously establish the "truth" in complex sociocultural systems. Controlled experiments are rarely possible and capturing the rich and complex dynamics is challenging. The diversity of factors and data sources that comprise these systems span multiple domains of study; data, when available, is noisy and uncertain, and even the most learned and accurate experts can, and often do, disagree about the strength and existence of causal relationships. Similarly, mental models used by humans to understand and reason about causality are by necessity simplifications—cognitive capacities, such as working memory, are finite, and evolution has imbued us with a variety of cognitive heuristics that improve performance in some areas at the expense of bias in others. Finally, the computational formalisms for developing, calibrating, and using causal models vary widely: in the constraints and requirements on inputs (e.g., data versus knowledge), in the explicit and implicit assumptions (e.g., first-order and second-order uncertainty handling), and in the types of supported reasoning (e.g., retrospective explanation versus prospective prediction).

This paper surveys these three key areas, from several different research disciplines, and presents a preliminary conceptual framework for characterizing causal analysis methodologies and reconciling the existing gaps between formal models, mental models, and objective truth in causal analysis.

2 Background

Researchers have developed a variety of working definitions of causation, for example, as described by Sliva et al. in [1, 2], Goldthorpe [3] identifies three possible definitions or approaches to working with causality that have been prominent in social science research. The simplest view is causality as robust dependence, where causation implies some amount of association or correlation with strong predictive power. However, while prediction may be important in some contexts, this definition of causality is not applicable to situations where explanation, rather than forecasting, is the goal—researchers can discover statistically significant "causal" relationships, but explaining how and why these relationships develop requires additional theoretical insight. Another prominent approach to causality views causation as consequential manipulation. That is, causation means that there are different consequences when the causal variable is manipulated or varied (even if only theoretically). In this approach, researchers verify a causal relationship through experimentation—if X is manipulated, it produces systematic effects in the dependent variable Y. Finally, a growing field of study views causality as a generative process whereby the relationship between X and Y involves more than just time and precedence, but is determined by some underlying social process or mechanism, which itself may be unobservable. This generative process concept of causality prevails in many fields in both the natural and social sciences, focusing on the question of *how* the relationship between variables is actually produced. The intent is to explain and characterize interactions instead of simply quantifying them. In general, these three definitions represent increasing amounts of knowledge. Understanding a generative process

implies the ability to manipulate causes and effects, which in turn supports characterization of dependence.

There is a broad, modern consensus that understanding causality is important for comprehending the world and making decisions. For example, people use causes to reason about the present, past, and future; to develop hypotheses for comprehending the world, calibrating one's own thinking, and understanding the thought processes of others; and to plan behaviors and interventions designed to test hypotheses and achieve goals [4]. Gelman suggests classifying causal questions as either forward or reverse queries [5]. Forward questions ask "what if?", as when weighing potential interventions and actions, and attempt to characterize the expected outcome (effects) of particular causes. Reverse queries ask "why?", as when seeking to explain past events, and are of most utility in model checking and hypothesis generation [6]. Kleinberg introduces modern ideas in causality and formulates a succinct value proposition for understanding causes: she argues that one can do the following well only with an understanding of causes: explanation (of past events), prediction (of future outcomes), and intervention (or rational planning) [7]. Eric Siegel's popular introductory book about developing predictions from Big Data has a slightly different perspective [8]. It advises: "Causality is elusive. It just needs to work." This seeming disparity, however, appears to be a matter of application domain—the interventions Siegel explores tend to be relatively narrow and low-risk, such as targeting advertisements. It seems unlikely that he would suggest basing decisions on social science policy interventions solely of the outputs of big data algorithms, without considering alternative hypotheses and intervening or ancillary causes and effects.

Research into operationalizing causality, that is, formal study of the use of causal concepts, enjoys a long history. A thorough review of the past literature is beyond the scope of a single paper see [9–12]. Most modern researchers in causality begin their narrative with the philosophical tradition, describing Aristotle's theories that describe different types of causes [13]. Most jump directly to Hume [14, 15] and credit his work for posing the philosophical problem as understood today. His concepts of propensity, mutability, and covariance are defined (approximately and respectively) as the likelihood or plausibility that a cause might lead to an effect, whether an effect might occur without a cause, and the co-incidence of cause and effect. The history of computational models often begins with a recounting of empiricists like Bacon and Newton and their ideas for developing explanations from data [16, 17], cites the mathematics of Bayes et al. [18–20], and reaches the computer age with Von Neumann's first use of a general-purpose computer for weather modeling [21].

Recently the ideas of using research in causality to understand complex environments appear to have surged in the popular culture. This is running concurrently with other notable trends: far more data is available for analysis (e.g., "Big Data"), machine learning technologies are moving more into the public eye, and computer processing continues to become increasingly cheaper and faster (e.g., through "the Cloud"). Notably, Dubner and Levitt's Freakonomics (a New York Times #1 Bestseller) and the follow up Super Freakonomics [22, 23] analyzes thorny social science issues with data analysis and the language of economics. For example, they show that conditional bonuses actually incentivized teachers to help students cheat on standardized tests and use concepts like supply and demand, elasticity, price discrimination, product

differentiation to answer provocative questions such as "How is a street prostitute like a department store Santa?" Gladwell's The Tipping Point and Outliers [24, 25] explore similar phenomena, such as how some ideas or effects spread far more rapidly than others and why professional hockey players are more likely to have birthdays falling early in the year. Nate Silver [26] describes the Bayesian thinking behind his brief poker career and successful political prediction website, and discusses challenges and biases in modeling domains ranging from climatology to sports, economics, and terrorism.

3 Complex Causality and Truth

One of the key aspects of nearly all research questions in both physical and social sciences is to determine an explanation for some type of causal relationship. However, causality is notoriously difficult to analyze, a challenge amplified in complex social systems. When looking at physics at a Newtonian or even quantum scale, many question of causality are by mathematical models that are close representatives of the underlying objective truth. Reality at a larger scale, especially social systems, is much more complex, making the objective truth of causal relationships and processes difficult to define, observe, and measure.

The complex, indeterminate causation in a sociotechnical system can be characterized by structural and relational features that make it especially challenging to establish the underlying causal truth [4]. Structural complexity—such as a convergence of causes into a single effect, indirect causation or influence on more direct causes, long chains of cause and effect, temporal discrepancies (e.g., the cause may persist beyond the duration of some of its effects), and distinctions between the individual and aggregate system (e.g., is social behavior an aggregation of many individual behaviors, or are there higher level social causes as well?)—make it extremely difficult, if not impossible, to establish measurable variables and controlled, repeatable experiments to establish an understanding of these systems. Further relationship complexities, such as counter causes, enabling conditions that are not in themselves causal, and emergent or evolving effects, introduce an uncertainty to this complex environment that further defies precise measurement and experimentation. In this complex environment, many important events are so singular they will occur only once. For an extreme example, Taleb argues that some of the most impactful events in history are "black swans" [27] that were highly unlikely and not broadly anticipated. Finally, because experimental intervention in social systems tends to be limited by cost, time, and ethical constraints, data are noisy, biased, and incomplete even in the best of circumstances.

To address these challenges in measuring objective causality in social systems, researchers have developed some empirical approaches that attempt to mitigate some of the structural and relational complexity of the phenomena under study. For example, most social science experiments focus on a small number of measurable variables (e.g., GDP per capita, number of violent events per month, etc.). While such scoping can make the empirical work more tractable, it also often has limited utility in large-scale, complex social systems where the "real" causal relationships may be obscured. Another approach has been to redefine the problem—rather than attempting to understand the

full generative process, we can measure predictive relationships that can be used to forecast future events of interest. This approach views objective causality more according to Goldthorpe's robust dependence definition [3], and is employed by machine learning or data mining applications to predict outcomes in real data sets. However, by not describing the mechanism by which these predictors lead to certain effects, it is easy to find spurious relationships and easy to miss ancillary, but important, effects. Similarly, using markets or crowdsourcing to predict results can often lead to relatively accurate forecasts, such as for political or economic events [28], but with little insight into what causes these forecasts to be accurate. Tetlock [29], suggests that "superforecasters", or individuals that have a high success rate at such predictions, are those who do more research, enumerate deeper potential causal or counter-causal chains, think probabilistically, and can articulate their logic, indicating that deeper causal knowledge may be necessary even for making these types of yes/no predictions.

4 Mental Models

Despite the challenges of complex causality in sociocultural systems, policy-makers must still make decisions that influence and intervene in these environments. To accomplish this task, humans use mental models, or internal approximations of the complex causal relationships around them, in order to navigate this landscape and make decisions about the world. However, the mechanisms humans use to reason about causality are imperfect and only partially understood. The limitations of human reasoning are most apparent in complex environments, where humans commonly adopt heuristics to simplify intense cognitive tasks [30]. These heuristics can generate cognitive biases that result in flawed information reliance, hypotheses, analyses, and conclusions in domains that feature complex environments with significant amounts of data and uncertainty, such as social science research and intelligence analysis [31–34]. These limitations pose significant challenges for technology developers, who risk building tools that introduce errors or reinforce existing biases. This complexity contributes to a dialectal gap between humans, who can naturally reason in uncertain and nebulous situations, but who have finite cognitive capacities—and computational models, which tend to capture ambiguities and subtleties by growing larger and more complex.

The phrase "mental model" is often associated with the work of Johnson-Laird, whose Mental Model Theory [35] is dominant in the field of Cognitive Science. The excellent history of mental models [36] attributes the inspiration of that theory to the philosopher Charles Sanders Peirce for proposing a "diagram" [37] and psychologist Kenneth Craik for his idea of "a small scale model" [38]. The research into how people develop and use mental models about causality is voluminous and diverse [39–46], and many works consider aspects of indeterminate causality, such as uncertainty and ambiguity. For example, [47] explores how similarities and differences between the ways individuals model uncertainty—via mental models shaped through the culture and context of ideologies and institutions—might be a basis for understanding how and why behaviors diverge from classical economic rational choice theory. However, the scenarios explored in detail in much of the literature (understandably) tend to be

relatively simple cases, so it is difficult to determine how well a given approach might scale to realistic complex indeterminate causal cases.

Research psychologists Gary Klein and Robert Hoffman and their colleagues explore this gap through the lens of Naturalistic Decision Making [48], a framework that encourages study of how people make decisions in real-world settings. They argue that causal reasoning is central to many crucial Macrocognitive [49] functions, that is, higher-order thinking activities that allow people to interpret information, plan, and make rational decisions in complex situations. Figure 1 illustrates the complexity of a macrocognitive model for indeterminate causal reasoning. For example, Moore and Hoffman have found that people use a Space-Time Envelope to select different types of data and reasoning patterns the farther back (or forward) in time they are considering in an analysis [50]. Another promising finding is that a set of archetypal causal themes and patterns appears to recur when humans are reasoning about complex, indeterminate causation in real scenarios [4, 51]. Further experiments suggest that these models may not be stationary, for example, preferences for explaining complex events seem to vary with the intended target audience, the presenter, and the presentation format [52].

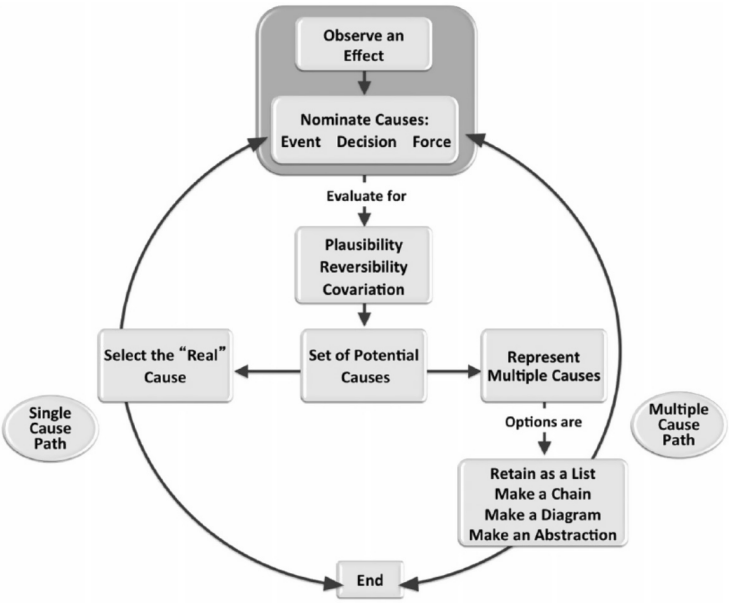

Fig. 1. Macrocognitive model for causal reasoning (see Hoffman et al. [4]).

5 Causal Modeling Formalisms

In cybernetics and systems theory, Conant and Ashby theorize "every good regulator must be a model of that system" [53]. This concept applies strongly in sociocultural systems—in order to make optimal decisions and intervene, we must have effective models of system functions and dynamics. However, what comprises a sufficient model

can vary widely depending on the characteristics of the system under study and the types of reasoning and decision making necessary in that system. For example, recent approaches have applied techniques from chaos/complexity theory, explicitly acknowledging that social systems exhibit non-linear, emergent properties that are not always uniform in magnitude or character [54]. These applications have been in domains as varied as ethnic violence [55], civil war [56], banking regulations [57], and urban planning [58]. These types of models may not be the best approach, as these models can be very complex and opaque, making it difficult to validate assumptions and conclusions to support concrete decision making.

Another approach to formalizing complex causality are methods that explicitly address the uncertainty or structural complexities (or both), abstracting the problem to something more computable and interpretable by researchers. For example, Pearl presents mathematically rigorous causal models based on probabilistic graphical models (e.g., Bayesian networks) [59, 60]. Similarly, structural equation modeling [61, 62] uses mathematical equations to represent relationships of interest, particularly between measurable and latent (or non-measurable) variables in social science research. These types of modeling approaches tend to be mathematically sound, but are valid representations of reality only to the extent that modeling assumptions are met by the real world. More recently, Mooij et al. has developed computational approaches for extracting causal relationships from purely observational (as opposed to experimental) data, which was previously thought to be impossible, using additive noise models that quantify the relationship between the noise distributions of causes and their effects [63].

One aspect of these approaches that stands out across a variety of domains is the focus on pluralism of modeling or representational approaches—an acknowledgement that no single approach has the best answer for formal reasoning about causality in all situations. For example, "mixed-methods" research is gaining in popularity among social science researchers seeking to combine the statistical generalizations available through many quantitative techniques (typically based on the general linear model) and the specific causal pathways identified by case-studies or theory-driven qualitative research [1, 2, 64, 65]. In the business world, Armstrong stresses in *Principles of Forecasting* [66] that there are a variety of different situation-dependent tactics for distilling and using causal information. In modeling and simulation, there is a growth in the field of multi-method modeling, such as combining the paradigms of agent-based, systems dynamics, and discrete event simulations to achieve more nuanced, accurate representations of the world at different levels of abstractions [67]. A similar pluralism is echoed in the machine learning literature, where ensemble-learning approaches are capable of producing better predictions and results than any single approach. We see this pluralism as an attempt to mitigate the challenges of mapping a formal model to objective reality while also supporting human understanding and decision making—what models or combination of models can best achieve this balance? In the next section, we present a preliminary conceptual framework to help researchers and decision-makers identify the best ensembles for approximating the complex system of interest.

6 Conceptual Framework

Taking advantage of the recent explosion in data and advances in algorithms promises to enable decision-makers to better understand causal processes in social systems and develop more-effective policies. To achieve this, it is critical to align formal, computable models with the actual causal mechanisms present in the world and human perceptions and mental models of these causal relationships. A key insight for making these connections comes from the pluralism observed in both the mental models of human causal understanding and formal models of causality. The real challenge is not in constructing a single perfect model of causality that serves all purposes, but to identify the "right" combination of models that will best represent the domain or problem of interest while also remaining consistent with the human perception of causality to explicitly address the decision-making needs of the human users.

In prior work [1], we demonstrated the utility of model pluralism for representing different facets of causality in a complex sociocultural system. However, while the efficacy of ensemble models was established, the process for developing these models was largely manual due to the semantic mappings necessary to identify the models that answer the desired questions, identify the appropriate level of abstraction, and identify the potential causal interactions to include in the analysis.

To bridge this divide between human mental-models and formal causal models, we propose a conceptual framework around Meta-Causal Models. Meta-Causal Models capture the features of various mental models and formal modeling approaches and explicitly identify their relationships to each other as well as to objective causal processes. When reasoning about causality and making decisions, people use mental models whether they know it or not. By capturing this in a meta-model that relates mental models and formal models, researchers or policy-makers will be able to infer which formal models are useful in particular situations. In addition to making this choice of models based only on the technical features of the problem (e.g., the type and quantity of data), Meta-Causal Models also represent the underlying assumptions of the model and their means of presenting results either supports or conflicts with the way causality is perceived at a human level. Recognizing that different formal causal models may be appropriate for different aspects of the same problem, this framework will also provide a rigorous way of selecting which models to combine in an ensemble that will effectively support a decision-making task.

Our Meta-Causal Models framework contains an ontology for representing the features and concepts necessary for describing causal processes, mental models, and formal models and the relationships between them. We have developed a preliminary ontology, illustrated in Fig. 2, to describe the representational power of various formal causal models, dividing them into the types of objective causality they can represent (i.e., correlational/predictive versus a generative process) and looking at features such as the type of data or relationships they represent (e.g., temporal, spatial, relational), their ability to represent the direction of the causal relationship (e.g., does X cause Y or vice versa?), and their support for complex causal structures. We are currently extending this ontology with concepts to represent features of mental models. Using this ontology, we can start drawing connections between different model features to

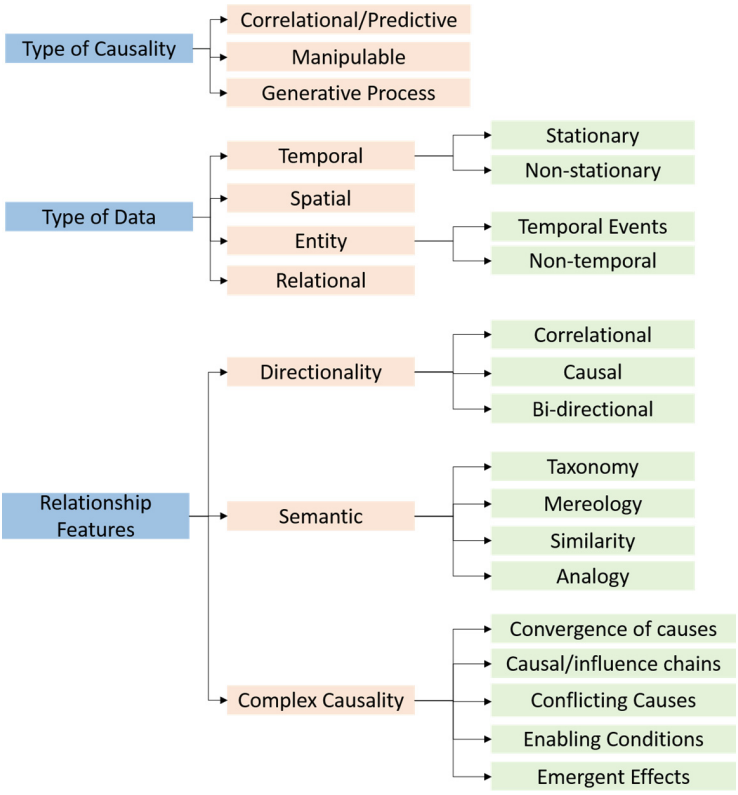

Fig. 2. A preliminary ontology of causal model features.

explicitly identify interactions that may impact the choice of formal model. For example, temporal models that cannot represent complex causality, such as causal chains, may be useful for short term or immediate analyses to suggest possible causes of an observed effect, but may less useful for projecting into the future.

By making explicit the normally implicit aspects of causal analysis—specifically the perception of how useful a model is based on the current situation and decision-making tasks—the Meta-Causal Modeling framework can help steer an ensemble or multi-modeling approach to causal analysis and reasoning. Not only can we use this framework to identify the linkages between formal and mental models, but we can also identify shared aspects of models and places where they may interoperate to provide a more complete and coherent solution to a problem than any single model might individually.

7 Conclusions

In this paper, we explored the current divide between causal processes, mental models used by humans for understanding causality, and the formal modeling tools available to represent and reason about causality. The challenges of causality are particularly acute in the social sciences, which do not have access to the same types of precise measurements or mathematical laws available for explaining the world from a physical sciences perspective. We provided a survey of approaches to understanding causality in sociocultural systems from an empirical perspective as well as various mental and formal models that are used to approximate and understand this objective reality, ultimately for the purpose of making decisions that will have the intended impact on the world. Finally, we presented a preliminary conceptual framework for bridging the gap between formal and mental models to better enable researchers and policy-makers to choose the best formal models—or combination of models—for a given situation.

As future work, we plan to expand our conceptual model ontology to represent the features of human mental models as well as formal models, enabling us to begin expressing the explicit relationships between the two. We also plan to validate these relationships by exercising the Meta-Causal Modeling framework in a variety of situations to compare and assess the ensemble models that are developed. In addition, we plan to research methods for transforming this purely conceptual model to a computational model that can be used to automate the identification of appropriate models and how to assemble them into an effective ensemble. One approach under evaluation is to use probabilistic programming [68] as a language for representing the features and relationships between modeling approaches and reasoning about how they might best support each other.

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Enabling Mixed Method Modeling Through the Use of Causal Networks

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Abstract. Mixed method modeling has been shown to be successful for understanding dynamic operating environments (e.g., geopolitics) by combining diverse computational models. These models tend to be fairly homogenous in that they focus on the same dependent variables, which both simplifies composition but also limits their applicability in broader domains. For complex problems, such as analyzing the factors that affect human populations in dense urban areas, there already exist many varied yet complementary models that could be leveraged in concert. However, challenges are encountered when combining independently developed models not designed with interoperability in mind. Such models can have a wide variety of data inputs, differing outputs at potentially differing timescales, implicit domain restrictions, and distinct underlying computational mechanisms. This paper investigates the use of causal networks of information to help apply these disparate models towards a common goal. We first discuss the challenges of model representation, provisioning, composition, and explanation in traditional mixed method modeling approaches. We present potential advantages and limitations that the addition of causal information provides. Finally, we offer an example of our approach using multiple models to understand security courses of action in an urban environment.

Keywords: Modeling and simulation · Ensemble modeling · Causal networks

1 Introduction

For many complex domains, it is time and cost prohibitive to build new computational models and simulations that are representative of real situations. In these cases, it would be sensible to leverage previously built models done on related sub-domains to provide a complete abstraction. In practice, discontinuities between these existing models, whether semantic or syntactic, are likely to make such combinations difficult to achieve.

There are a few ways to resolve these model alignment problems. The most common way is for a developer or modeler to manually align disparate models. This often is done through actually updating the models themselves or building translators between the languages used in the individual models. In this work, we assume the

M. Hoffman (ed.), *Advances in Cross-Cultural Decision Making*,
Advances in Intelligent Systems and Computing 610, DOI 10.1007/978-3-319-60747-4_12

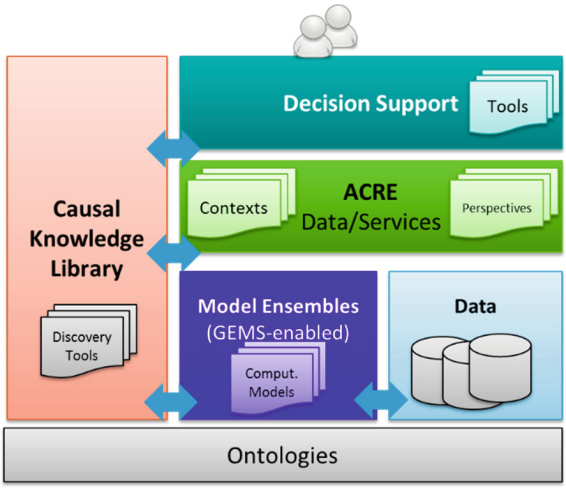

Fig. 1. Overview of approach

existence of causal information extracted from text related to the models and explore how it enables our approach to mixed method modeling.

We demonstrate an approach shown in Fig. 1 that ultimately provides decision support capabilities to a user based on some large number of overlapping and computational models that adhere to specific ontologies and data sets. A causal knowledge library contains information on how concepts may influence each other. These causal linkages could be extracted from existing data sources, or they can be provided manually by a human. These causal relationships inform the ensemble process and provide the candidate workflow of individual models. These workflows can be executed through the Animated Causal Representation of the Environment (ACRE) which is the logical output of the orchestrated model runs. This data can provide various contextual information that aid in a larger decision support process.

In this paper, we first survey some background work in model composition and the development and application of causal networks. Then we detail our approach to the problem of multi-model integration with a discussion on representation, composition, and explanation. Finally, we present an example application along with lessons learned and future work.

2 Background

Composing multiple models has been applied successfully to a number of noteworthy problems, such as weather forecasting [1]. The problem of bringing multiple models together touches a broad spectrum of difficult interaction problems that are faced in process modeling, service/agent workflow composition, and semantic integration. In this section, we describe the lineage of past work that influences our approach.

Based on this prior work, this team set out to incorporate multiple models for decision support tools [2] which leveraged the use of Athena [3], a regional stability simulation model, and CMSim [4], a traffic model. As with most models, these work well on the very specific problem they were intended to resolve. In our application of the models, it was apparent that some of the original assumptions that went into the models may not apply to our domain of interest. Rather than painstakingly update the existing models, we looked for alternative approaches to augment them with other models.

The use of model ensembles is now widely adopted to improve forecasting where multiple models are available [5, 6]. For our decision support domain of interest, most of the focus of using ensemble models is based on models that predict the same variable [7]. Combinations of multiple models are prevalent [8], but they rely on the model author to combine different models explicitly. Our goal is for the application of disparate models to be relatively straightforward for the author.

There has been a long history of work in the related areas of agent and service composition that was in part, an inspiration for our approach. Sycara's work [9] discusses how agents or web services could be described explicitly in the language DAML-S. This work helped lead to OWL-S [10] that defines the definition of services to include input, output, preconditions, and effects. Our work uses this as a launching point with the problem that the legacy models we are using have complex representations with potentially unknown preconditions and effects. These models abound with semantic mismatches and discontinuities that would take significant effort to resolve manually. Using dictionaries [11] to perform this alignment would be useful but incomplete.

This trouble led us to explore alternative ways to bridge the disparate semantics. What is helpful is the semantics between the available models, not just the individual ontological terms. This led us to explore extracting causal information from text, a proposition that is becoming increasingly possible as shown in the medical [12] and the socio-cultural domains [13]. The work presented here does not discuss how the causal information will be extracted, but it assumes that work will progress to improve the accuracy of such information in the future.

3 Methodology

This work developed an encompassing methodology for the use of causal information in integrating and composing heterogeneous models with the goal of generating user-focused forecasts. Though our experimentation was in the area of socio-political forecasting, we believe such a general methodology would be widely applicable to a variety of modeling domains.

We began by developing a *dynamic representation* that links causal information with model parameters and simulation-specific modeling data, using a common ontological point of reference. With this in place, we addressed the challenges of model *integration and composition* in such a way that we could leverage existing casual information to compose our disparate model suite under the guidance of user priorities such as speed or accuracy. In this, we discuss how models were integrated and the

underlying data storage requirements, along with the potential to leverage automated techniques for composition and linking of models. Finally, we discuss the problem of *results explanation* as it relates to large, interconnected suites of models. Included is a discussion on automatically summarizing model output for the better explanation of noteworthy points in the model runs.

3.1 Dynamic Representation

In exploring how causal information could be used to enhance mixed method modeling, we began with two initial hypotheses: (1) that the causal network could help bridge the semantics between the models, making it easier to determine appropriate compositions; and, (2) that emerging causal information could determine discrepancies between the legacy models and the current situations. Such a representation would be highly dependent on both the underlying causal knowledge that was available along with an ontological understanding of all available models. The key challenge lay in how to mesh this information together while also layering the domain data needed for simulation purposes atop it.

To address this challenge we developed the Animated Causal Representation of the Environment (ACRE), an object-centric representation of model data and casual knowledge backed by extensible, interoperable ontologies. We used the Web Ontology Language (OWL) for our ontologies, and RDF/XML to represent all other information. Ontologies link the concepts within the modeling world into the causal network.

ACRE is meant to be a dynamic representation, in that it can support multiple contexts providing interactive views of maps, network, and narratives supporting different user viewpoints. Typically ACRE exists as a subset of a much larger information graph and is tailored to show only the concepts that are relevant to both the focus of the user and the concepts active within the models. Figure 2 shows a graphical depiction of ACRE evolving over simulation time. As simulation time advances, one of the agent-based models present in the model suite introduces new agents. Not all of these agents, however, are added to ACRE. Instead, the causal knowledge is used to

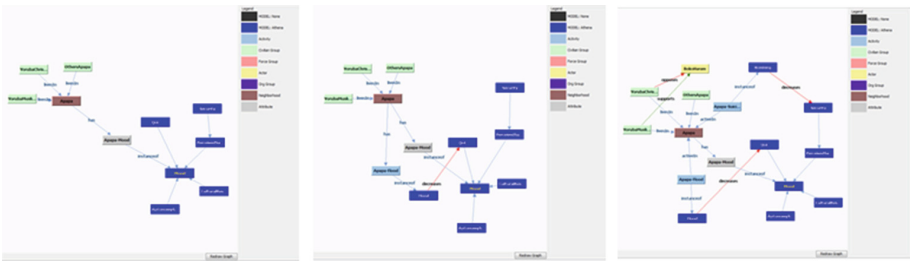

Fig. 2. Time t = 0, in the image to the left, shows a focus on the concept of Mood in a region, along with those factors which directly or indirectly contribute to it. At time t = 1, shown in the middle image, the development of a flood is shown to negatively impact an area's Quality of Life, which contributes to Mood. Finally at time t = 2, a bombing in the area is shown to negatively impact the Security of the region, ultimately affects the Mood.

determine which agents have a direct or potentially indirect effect on the user's focus of interest. Only those agents are automatically added to the graph. Similarly, for statistical models the data and concepts that are shown to be significant contributors for a given forecast value, as determined by sensitivity analysis or other means, would be automatically added to the graph as time progresses.

3.2 Integration and Composition

Model integration and composition are central to the interoperability of large numbers of models. Model integration refers to taking an existing model and hosting it within a framework such that it can be configured, data provisioned and executed as desired. Model composition relates to selecting an appropriate subset of models from amongst a larger set so that a given domain problem can be properly analyzed.

For model integration, we extended an existing framework known as the Generic Environment for Modeling and Simulation (GEMS), an extension of the ADvanced Architecture for Modeling and Simulation (ADAMS) framework [14]. GEMS is a framework for quickly integrating disparate models, and supports aligning disparate data between models. GEMS requires a developer to wire together the models, but it automates much of the processes. Wrapping a model into GEMS means it should interoperate with all other models correctly wrapped, eliminating the need for exponential numbers of point-to-point integrations. We extended the GEMS framework in our effort to use OWL as its data formalism, which allowed us to map model concepts (e.g., parameter inputs and outputs) into the casual network as part of ACRE. Though we did this mapping manually in our experiment, we anticipate that such a semantic alignment could be achieved in a semi-automatic manner through techniques to similar those developed on the related problem of ontology alignment.

For the problem of model composition, we used an automated approach that leveraged multiple technologies to include AI planning and analogical reasoning along with our existing causal graphs and model-related data products. By creating a robust approach, we were able to reduce the trial-and-error burden on the human analyst performing an unguided and manual composition of models, all while remaining sensitive to user preferences such as computation time or level of detail.

Our approach began with a query analysis that used hierarchical planning to refine a given goal in the current situation awareness to generate a relevant model-composition context. This initial analysis stage was necessary to translate a user's query, expressed graphically in our experiment and via ontological terms, into a more formalized Planning Domain Definition Language (PDDL) needed by the hierarchical planner used to compose the models. This translation heavily leveraged the causal network information for its understanding of the various interrelated factors affecting the expressed problem area. Performing this initial query analysis also allowed us to address several compositional challenges related to scaling and expressiveness. For scaling, we were able to minimize the problem space for the optimal composition solver in the face of large suites of models. We also leveraged ontologies, along with numerical, analogical, and causal reasoning, to address problems of expressiveness related to fuzzy input/output matching.

Following the query analysis, we used a hierarchical task network (HTN) planner to take the PDDL input and generate composition graphs. The planner we used was a variant of the SHOP2 open source HTN-based planner, developed at the University of Maryland, College Park [15]. The planner operates by taking the PDDL developer during the query analysis, which represents the necessary model composition requirements as tasks, and then decomposes the tasks into subtasks and then ultimately into planning operators, which are essentially instructions for how to compose the models. An example of planner output is shown in Fig. 3 below.

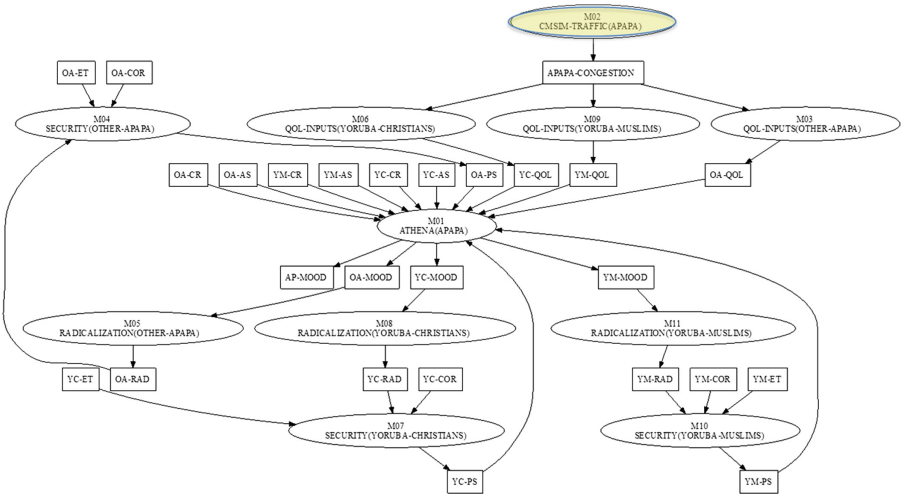

Fig. 3. Task decomposition that supports the decision to the use CMSIM Traffic Model, shown in the node highlighted in yellow, to support the calculation of populace mood, given the user's preference in accuracy over computational time requirements.

A final complication in model composition was found in situations where no existing model in our suite expressed some causal relationship central to our problem domain. We refer to such a situation as a *causal gap* in model composition. Our solution to this problem involved using human guidance to develop light-weight *linking models* to bridge the causal gap. We base these linking models on available templates that associated two or more input variables to produce an output variable using numerical calculations. Available model data is offered to the user as an exploratory means to aid in the construction of these linking models.

3.3 Results Explanation

The output of integrated model run may result in a single answer to a user's query, but there is a vast amount of data and calculations that go into the seemingly simple result. For example, consider the problem of forecasting overall stock market movement

during the next twelve months. Some models concerning the economic, social, and political situation within the country may be used to come up with the forecast of ten percent market gains within the next year. Once a forecast is given, however, many questions arise. What are the primary drivers for this predicted increase? What happens if one of those drivers behaves differently than initially modeled? What stimulus might cause the forecast to improve? What might cause it to worsen?

We refer to the problem of satisfying such user's questions as results explanation. Many analytic and numerical techniques already exist for providing such insight into the underlying models. For example, sensitivity analysis is used to determine the key 'tipping points' in a model, where subtle changes in model inputs can cause a significant change in their forecast. These analytics are often presented in graphs, such as those in Fig. 4 below, and are left for the end user to interpret.

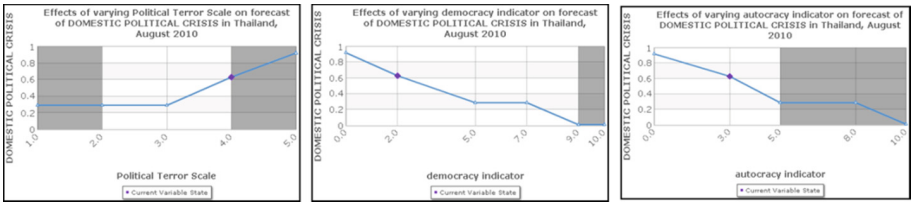

Fig. 4. Results explanation of a suite of model forecasting the probability of political crisis in Thailand. These graphs show the sensitivity of several inputs into the models, and how they affect the forecast result.

In our effort, we chose to focus not on graph-centered results explanation, but instead on textual narratives as the means of explanation. We identified several areas where we felt such narratives could aid the user in understanding a complicated model forecast:

- *Change detection:* Identifying significant change points within a simulated model run.
- *Niche finding:* Identifying noteworthy, special interest events, sometimes referred to as the "golden nugget of knowledge".
- *Knowledge aggregations:* Merging stats and data into a larger element of knowledge.

We based our narrative generation on work on EMBERS (Early Model Based Event Recognition using Surrogates), an anticipatory intelligence system in use for over five years to forecast significant societal events through models based on open source data such as news stories, blog posts, and currency rates [16]. This project implemented an automated narrative capability that composed its forecasts as English language prose. These narratives were based on many different sources of information such as historical statistics and knowledge graph identification techniques. We experimented with the addition of causal knowledge networks as a means to enhance such narratives.

4 Results

We explored our methodology with a scenario focused on a series of ongoing crises in a large African urban area, which included both natural disasters (floods, cholera epidemic) and insurgent violence (direct attacks, bombings). We tasked our proxy user with analyzing multiple pre-developed courses of actions (COAs) that the US military could invoke as a response to these crises. Their domain-focused goal was to assess each COA in regards to improving conditions within the city, as reflected by the overall mood of the populace, while not damaging the perception of the US forces involved. This goal allowed them to evaluate the various elements of our system during their work. We developed a simple user interface for them to use in the course of this evaluation, shown in Fig. 5.

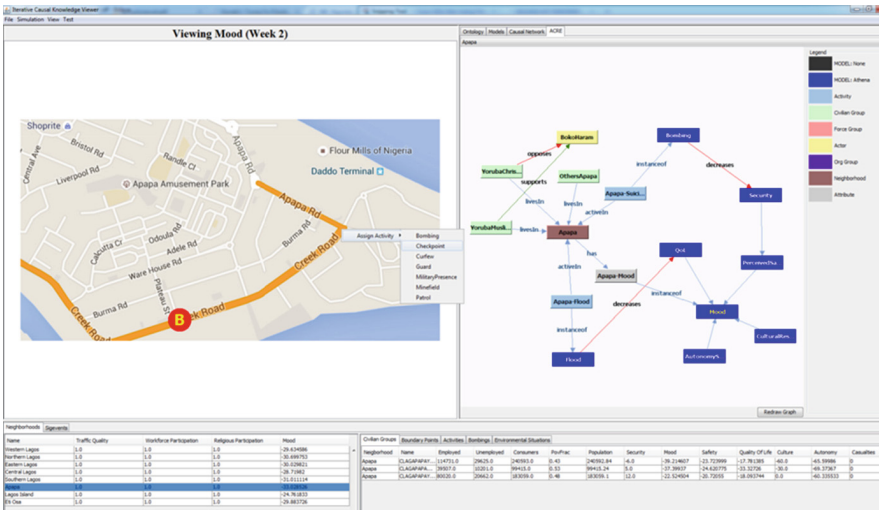

Fig. 5. Prototype interface of the enabling mixed method modeling (EM3) interface used for concept evaluation.

The available model suite consisted of four models of varying degrees of sophistication:

1. *Athena Regional Stability Model* [3]: A multi-model simulation developed by NASA's Jet Propulsion Laboratory (JPL), composed of over a dozen tightly integrated models spanning the Political, Military, Economic, Social, Infrastructure and Information (PMESII) dimensions.
2. *CMSim* [17]: An urban terrain and traffic simulator capable of simulating hundreds of thousands of entities. This model was previously extended to model the traffic impact of various external stimuli such as military checkpoints and flooding.
3. *Dissident Hostility Model*: A statistical model designed to estimate the degree of separatist violence in a city based on its social and political environment.

4. *Acme Traffic Sim*: A simplistic traffic model built exclusively for the purpose of this experiment.

The first COA explored involved establishing US checkpoints near areas of known attacks. The second COA involved neutralizing the insurgents through direct attack. Both COAs were focused on improving the security of the surrounding areas.

Whereas the simulation of COA 2 involved only the Athena model, the simulation of COA 1 was more complicated. When the user inserted the checkpoint activity as part of COA 1, the system automatically alerted the user that due to the causal impact of checkpoints on traffic (and indirect driver of both the quality of life and mood of the populace), they should consider including a traffic-focused model. Given the availability of two such traffic models, the user could prioritize either depth of analysis or speed of analysis. Choosing to focus on depth of analysis recommended the inclusion of the CMSim traffic model.

Once this model was selected and added to the model suite, a new alert signified that there was a causal gap due to the known effect that traffic had on quality of life. Though CMSim was capable of forecasting traffic in the city, and Athena was able to relate quality of life to the mood of the populace, no model existed to equate changes in traffic to changes in quality of life. The user therefore constructed a linking model to relate the two.

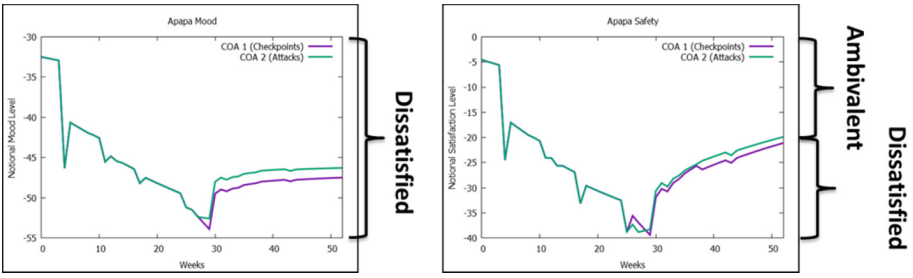

Fig. 6. Graphs showing the different effects of the two COAs on populace mood and perceived safety

Detailed: Starting on day 4, a massive flood strikes the eastern parts of **the city of Lagos, a port city which is also one of the largest cities in Nigeria**. A week later, a cholera epidemic breaks in **Apapa, one of the 16 neighboring local government areas that make up the Lagos Metropolitan Area**. In coming weeks, as the cholera epidemic spreads across the Lagos Metropolitan Area (LGA), repeated attacks with increasing severity by Boko Haram ensue. Their attacks on both local and foreign installations have killed over 500 civilians and law enforcement personnel. US military forces have been deployed.

These attacks include **kidnappings of 5 Doctors Without Borders workers** in 2 separate incidents, **leading to mass exodus of organization's personnel** from the area. Closely followed by a fuel depot bombing in Apapa and an attack on US embassy. The **combined casualties include deaths of 15 US soldiers, several dozen locals and 1 Boko Haram insurgent**.

User readability | Change Detection | Knowledge Aggregation | Niche Finding

Fig. 7. Sample narrative for COA 2.

Both a series of analytical graphs and a set of narratives were generated to explain the differences in the two COAs. Figure 6 shows a graph differentiating the effects of the two COAs on mood and perceived safety, while Fig. 7 shows a narrative focused on COA 2.

5 Conclusions

This paper shows how to apply mixed method modeling techniques for understanding dynamic operating environments (e.g., geopolitics) by combining diverse computational models. We articulated ways to resolve interoperability problems through manual and automated mechanisms for extracting causal information. The approach was illustrated through an example of modeling human populations in a dense urban area using real heterogeneous models. These models had a wide variety of data inputs, differing outputs at potentially differing timescales, implicit domain restrictions, and distinct underlying computational mechanisms. As the extraction of causal information from text improves, the ability to combine disparate computational models will improve with this approach.

We plan to extend this approach by applying automatically extracted causal information. We believe that recurring characteristics of that data are likely to lead to refinement of the composition process. This could include relaxation of semantic terms to find workflows that are not necessarily a perfect fit. Additionally, more work is planned to articulate the output of the models in a meaningful way. Interpreting model results can be difficult, and that is only exacerbated by multiple models. We plan to explore means to interrogate the models beyond the straightforward narrative approach described. We believe that all of these enhancements can make the widespread use of disparate mixed method models possible.

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Gray Zone Challenges

Examining How Perception of External Threat Influences the Popularity of Government Leaders

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Abstract. This paper seeks to explore the conditions where leaders from open democracies to authoritarian states become more or less popular in response to perceived economic and social threats to society, along with increases in societal (economic and social) hardship and group polarization effects. To further explore these conditions, we used a psycho-social approach to develop a preliminary conceptual model of how the perception of threats, changes in societal conditions, and the polarization of society can concurrently influence the popularity of a government leader.

Keywords: Popularity of government leaders · Rally round the flag · Perception of threat · Causal diagrams

1 Introduction

Throughout history, there are many examples where the popularity of a government leader has been influenced by factors other than the respective citizenry's perception of personal economic wellbeing [1]. For example, government leaders such as Venezuela's Hugo Chavez and Russia's Vladimir Putin have remained popular even when their respective country's economies have performed poorly through their tenure. If leader popularity is strictly based on perceived economic benefit, then the popularity of these leaders should have been greatly reduced during poor economic periods. Obviously, there are many factors that can influence the attraction of citizens towards their leader. A factor that is explored here is the perceived threat from an outside force, such as another government or organization, towards the citizens of that country. Leaders throughout history have exploited the perception of an external threat to rally domestic support [2]. This might occur through redirecting a populous' focus from negative internal matters to the perceived external threat. The question being explored here is what external and internal factors and conditions can affect the support for a leader?

The perception of threat from an external country or organization can have strong and lasting effect on both the attitudes and ultimately the behaviors of a population. Furthermore, in some circumstances during times of a perceived threat, citizens have been found to 'rally-round-the-flag' to provide heightened support for the government (and those associated with that government), which would have the effect of increasing

M. Hoffman (ed.), *Advances in Cross-Cultural Decision Making*,
Advances in Intelligent Systems and Computing 610, DOI 10.1007/978-3-319-60747-4_13

support for acentral government leader [3]. The rally-round-the-flag concept has been supported by findings which show increases in approval rating during times of war and other major crises. For example, after the September 11 terrorist attack, instead of potentially blaming President Bush for not doing more to protect the U.S. from this attack (and thus, having lower approval ratings after the attack), his approval rating actually increased from 51% to 86% [4]. Scholars have attempted to explain the cause of this phenomena by focusing on both contextual and psychological reasons. The most common explanation focuses on the absence of elite criticism directed towards the government in response to the early stages of a major crisis (perhaps to not look unpatriotic by criticizing the government in time of need) [5]. Others focus on anger and fear reactions to the crises and the desire by citizens to support the representatives of their government [6]; while others focus on reactions promoting self-respect and hope in the government in its response to the crisis [7].

When considering longer-term conditions where there is a lower-level conflict (i.e., not a specific attack on a country or war), the reasons for a shift in popularity towards or away from a government leader might include a combination of the factors described above, as well as others. To consider these factors, a psycho-social approach was taken that explored how perceived threats, changes in societal conditions, the desire for societal affiliation, and the polarization of groups effect the relationship the citizenry has with its leader over time. To help represent and explain the interrelations between these factors, this paper will present a conceptual diagram of attitudes and behavioral shifts associated with perceived threat conditions. These include changes in social and economic conditions as they mutually affect the society in which they are situated. The discussion will highlight the complexity of these issues and how various factors can dynamically play a role in the multi-faceted picture regarding the relationship the citizenry has with its own society and its leaders.

2 The Perception of Threat

The perception of a threat by an external group (i.e., country or organization) can have a strong and lasting effect on the attitudes and ultimately the behaviors of a population. This perceived threat (whether it is actual or not) can create the potential for animosity towards the perceived threatening group, as well as increase intragroup (within group) affiliation within the perceived threatened group [8].

Research suggests there are two major types of threats that can influence attitudes towards an external group. The first is the concept of realistic threat. Realistic threat refers to a perceived threat by an external group that has the potential to significantly affect one's own power, resources, and general welfare. This can take the form of military, economic, and/or other physical or material threats to the group [9]. For instance, a rise in prosperity among some states in the Middle East, such as Iran, will influence its relative power within the region, potentially being perceived as a greater realistic threat among states that consider Iran to be an adversary. This could be offset somewhat by an increase in military spending by one or more adversarial states. Of course, this has the potential for a tit-for-tat response, thereby increasing the perceived threat by states within this region [9].

The second type of threat, called symbolic threat, concerns the threat to a group's honor, religion, values, belief system, ideology, philosophy, morality, or worldview by another group. Here, external groups that are perceived as having a different worldview and values can be perceived as threatening the cultural identity of a society. This threat is particularly strong if the external group dominates, which can lead to a heightened fear that this culture will override the internal group's (i.e., one's own society or organization) way of life. The realization of this threat could be the perceived loss of the internal group's social identity, values, and honor. Scholars studying the concept of symbolic threat have suggested that racism is often a result of conflicting values and beliefs—even more so than from realistic threats [10]. For example, perceived threats to a larger group's values by immigrants were related to increases in negative attitudes toward these immigrants [11]. Studies that have measured both realistic and symbolic threats have shown that both types of threats can account for different portions of the variance in attitudes toward an external group [12]. Moreover, Riek, Mania, and Gaertner found that intergroup (between group) identification had a significant impact on realistic and symbolic threat, but the impact was stronger for symbolic threat than realistic threat [13]. Perceptions of conflict with an external group have shown to be positively related to negative evaluations and aggressive attitudes toward the eternal group. For example, the relationship between intergroup anxiety and negative external group attitudes has been observed across a variety of natural settings, as well as in the laboratory [14]. Moreover, the stronger the identification with the internal group, the stronger the reactions to group esteem threats [15]. For example, when the internal group is of low status, high identifiers increase their contributions to the group significantly more than low identifiers, most likely in an effort to increase the internal group's status [16]. For instance, this behavior might be seen in diaspora communities, such as in Europe, where they are often at the margins compared to the rest of society.

To help explain this phenomenon, intergroup threat theory proposes that both realistic and symbolic threats (as well as group esteem threats) can account for unique portions of the variance in attitudes toward external groups [17]. Intergroup threat theory is not as concerned with the actual threat posed by external groups (e.g., rising rates of unemployment or immigration) but to the degree to which threats to the internal group are perceived to exist. These perceptions, in turn, affect intergroup emotional concerns, such as fear and anger, to affect behaviors and attitudes.

As an illustration, considering the tension between Russia and the West, many Russians currently perceive the West, particularly the U.S., as a military threat to its borders and affect its ability to project power within the region [18]. Also, with the Western-imposed sanctions and the lowering of oil and gas prices, many Russians believe that the West is attempting to economically strangle Russia in order for them to capitulate to the West [19]. The Russian leadership might perpetuate this perceived realistic threat with the narrative that Russia has been encircled via NATO expansion in order to make it subservient to the West. This stokes the long memory of invasions by Mongols, French, Germans, and others. The belief that the West (i.e., NATO) is constantly seeking to take former Soviet territory, like Ukraine, and further break up Russia is part of that narrative [19].

Russians are extremely proud of their culture, believing their culture is a driving force in the world. However, today many believe that the West is using it cultural

influence via the media, the Internet and the like to chip away and vilify the long-standing Russian culture and its ways of practice. Also, the use of Western non-governmental organizations (such as pro-democracy or humanitarian organizations) within Russia are often seen as attempts by the West to both weaken Russian culture and it's standing in the world. Both of these perceptions can be seen as symbolic threats to Russia. It also should be emphasized that the breakup of the Soviet Union was thought of, and is still thought of, in tragic terms by a large number of Russians.[1] The general loss in global standing and hegemonic might—having "lost" the Cold War—accompanied with an economic downturn in recent years will reduce the general esteem and confidence of Russian citizens. Together, these perceived threats are believed to increase the general anxiety of the Russian population, increasing negative attitudes and behaviors towards the West [19].

Using another illustration, the Wahhabist in Saudi Arabia, have perceived the West as posing a symbolic threat against their Islamic culture. According to Salman Rushdie, there is a "loathing of modern society in general, riddled as it is with music, godlessness, and sex; and a more particularized loathing (and fear) of the prospect that their own immediate surroundings could be taken over—"Westoxicated"—by the liberal Western-style way of life" [20]. Further, as stated by Bernard Lewis, "when Ayatollah Khomeini denounced the U.S. as the "Great Satan," he referred to the well-known last verses of the Koran, which describe Satan as "the insidious tempter who whispers in the hearts of men." Thus "Satan is not a conqueror, imperialist, capitalist or exploiter. He is a seducer. He comes with Barbie dolls and cocktails and provocative TV programs and movies and, worst of all, emancipated women" [21]. It is this sense of threat that can cause the rejection of and struggle against Western culture and lifestyle. If the perceived threat is great enough, it could lead to movements against Western symbols.

Within Western counties, such as in Europe and the U.S., the perception of threat from "external" groups can be just as strong. Because of the spillover of violence in Europe, terrorist acts, and certain behaviors associated with Islamic traditions, diaspora communities have been stereotyped by many as hostile towards the West. The perception of this stereotype, along with the rejection of Western culture society by some, has led to a general increase in distrust of Western society. This, in turn, has led to a self-reinforcing two-way threat dynamic. For example, after September 11, 2001, these communities became the targets of increased hostility across Europe [22] and the U.S. In fact, after September 11, 2001, the Federal Bureau of Investigation (FBI) reported a 1,700 percent increase in hate crimes against Muslim Americans between the years 2000 to 2001 [23]. While the Muslim faith pertains to a religion not a race, elements of racism are noticeable here in that they are often perceived as a monolithic ethnic group that think and act alike [24]. This is especially true for those who bear some physical resemblance to stereotyped members of extremist organizations [25]. Generally, Muslims have been perceived as a realistic and symbolic threat against the larger, more

[1] In his Putin's speech to the Russian parliament, Putin stated, "Above all, we should acknowledge that the collapse of the Soviet Union was a major geopolitical disaster of the century. As for the Russian nation, it became a genuine drama. Tens of millions of our co-citizens and co-patriots found themselves outside Russian territory. Moreover, the epidemic of disintegration infected Russia itself" (Kremlin Archives).

culturally dominate U.S. and European societies. Conversely, a relatively large number of Muslims may see many of the behaviors from the majority, non-Muslim society as a realistic and symbolic threat to themselves. These conflicting perceptions can naturally lead to animosity between the two cultures, which further exacerbate differences in their respective worldview.

It has been argued that perceptions of both realistic and symbolic threats can account for large portions of the variance regarding attitudes toward external groups [9]. Perceptions of conflict with an external group have been shown to be positively related to aggressive attitudes toward the external group, along with negative evaluations of the external group and negative indices such as desire to live in that country [26].

2.1 Intragroup Affiliation

A large body of research supports the notion that individuals tend to favor their own group in social dilemma situations [27]. One of the more prominent examples of this effect was shown by Sheriffin his boys' camp studies [28]. Sheriff examined factors that either increased or decreased intergroup affiliation. When two groups were placed in competition with each other, the choices of group members shifted towards greater bias towards their group, with few intergroup associations with the competitive groups. This relationship changed only when both groups faced a superordinate challenge. Thus, it is certainly possible that intragroup affiliation can increase in response to perceptions of both realistic and symbolic threats coming from an external group. Consequently, perceived threats could evoke responses to protect one's own group. According to social identity theory, group members are motivated to develop and maintain biased, positive intragroup comparisons in order to promote a positive social identity [27]. This behavior would tend to favor preferential treatment of one's own group members compared to an external group. This is particularly true when there is high intragroup commitment and which external threats are treated as threats to one's personal identity. For instance, the stronger the identification with one's group, the stronger the reactions to group esteem threats [29]. When someone's group is of low status, high identifiers increase their contributions to the group significantly more than low identifiers, most likely in an effort to increase their group's status [16].

When a group perceives itself as being isolated or threatened, the drive for intragroup inclusion is thought to increase [30]. Here, the existence of a shared threat (realistic and/or symbolic) is believed to help promote solidarity among individual members [31]. For instance, Quillian examined national survey data in 12 countries and found that when economic conditions were poor and the size of a racial minority or immigrant group was large in proportion to the majority group, bias toward these groups was high [32]. Related to this the strength of personal identification of one's country could also be associated with positive internal bias and perceptions of external treat. For example, according to the Pew Research Center, Russian's perceptions of Putin have increased (88%, as of 2015), while perceptions of the Russian economic situation have decreased (73% believe it is poor shape, as of 2015), and perceptions of NATO as a major military threat to Russia has increased (81% perceive NATO as a threat, 50% perceive NATO as a major threat). Moreover, as of 2015, more than ninety

percent (93%) of Russians have a favorable opinion of their own country. The percentage who have a very favorable opinion of their country is up 12 percentage points in recent studies [33].

Factors that can clearly contribute to the popularity of a leader are perceived levels of positive stability within that society. For example, economic and social stability can typically affect the popularity of a leader over time, where poor economic growth and social disruptions will typically reduce the popularity of the leader. However, a long history of poor economic conditions or social disturbances can reduce the expectation of responsibility on the part of the leader. As discussed in the example above, the popularity of president Putin remains very high, despite the current perception of poor economic conditions.

2.2 The Polarization of Groups

Even a slight bias towards one's group and prejudice towards an external group can increase in strength through social interaction. The idea of strengthening one's attitude from the interactions of others is called group-induced attitude polarization [34]. Group polarization is said to occur when an initial tendency of group members' attitudes toward a given direction is enhanced following group interactions [35]. This can result in more and more extreme positions in the same attitude direction over time. For example, a slight tendency for aspecific group bias could produce an even greater bias after group interactions [34]. To illustrate a real-world example, Myers and Bishop found that groups with prejudice-leaning individuals became more prejudiced as a group over time, while groups with less-prejudice leaning individuals became less prejudice over time [36]. This polarization effect can occur for decision makers as well. In examining the decisions of Federal district court judges deliberating either alone or in groups of three found out that when judges deliberated alone, they took an extreme course of action only 30% of the time. However, when deliberating in a group of three, the judges took an extreme course of action 65% of the time [37]. In considering a societal example, the behavior of many extremist groups today have the characteristics of group polarization. For instance, the ratcheting of violence coming from ISIS or al-Qaeda could, in part, be a struggle between leaders within each terrorist organization (as well as between organizations) for more dominant positions—which can bea driver behind increasingly more extreme ideological positions.

Since the effects of group polarization favors more extreme positions in attitudes, it can also promote a more positive bias towards certain individuals, such as government leaders. For example, Moscovici and Zavalloni observed that French students' initially positive attitudes toward French president Charles DeGaulle and negative attitudes toward Americans were strengthened through discussion [38]. The effect of greater support for one's own government leader, along with greater animosity for an external group, such as a Western society, can be further enhanced via pervasive messaging by a pro-government/anti-external group movement that seeks to encourage acceptance of certain belief. The sources of this messaging should, however, be considered legitimate by the society intended to receive the messaging in order to have any substantial effect.

A typically cited reason for this phenomenon involves the idea of information exchange and social comparison. Specifically, when individual group members exchange concurring information, this information can serve to both strengthen and add to each member's beliefs about a specific topic. Also, through dialogue with other members, each member can discern the general group orientation towards the topic and can support the group, as well as bolster one's position within the group, by taking on positions that further drive the position of the group in that direction [36]. As mentioned above, coordinated messaging (such as through the news media) could potentially enhance the polarization effect by continuously providing arguments favoring one position over another and helping to establish a sanctioned point of view. Cultural difference can also provide a basis for group polarization and can lead to the development and expansion of ethnic and religious boundaries between groups [39].

3 Assimilating Factors Affecting Leadership Popularity

The perception of threat and the effect of polarization as described above, are argued here to play a role in both increasing the affinity of a population towards their leader and greater antagonism towards a selected external group. To help consider this process, factors discussed in this paper were integrated into a conceptual model of leadership popularity. Figure 1 portrays conceptual mapping of the general level of potential intensity of intragroup bias (positive or negative), which could favor government leadership, as well as disapproval for an external group.

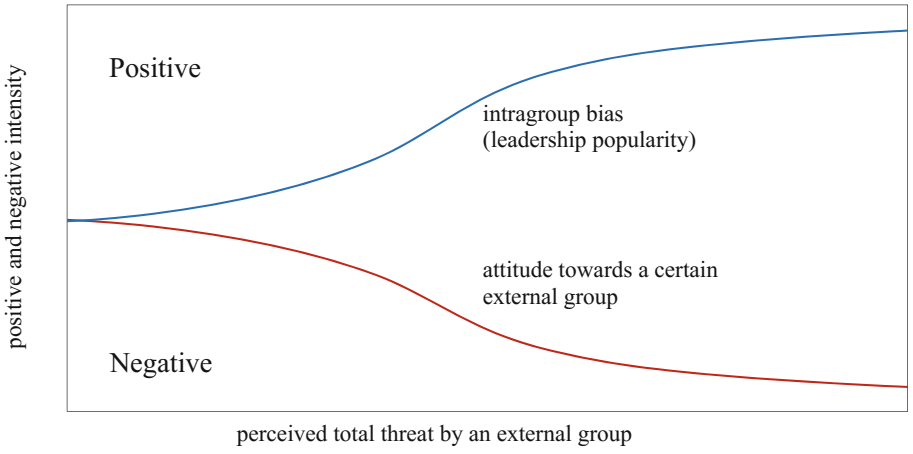

Fig. 1. Positive and negative intensity versus perceived threat by an external group

This concept is further expanded as a causal loop diagram (Fig. 2) to express the interrelations between the various variables discussed in this paper. Here, the exogenous variables of social and economic stability as well as realistic and symbolic threat (green text) represent actual (measurable) indicators that affect this system.

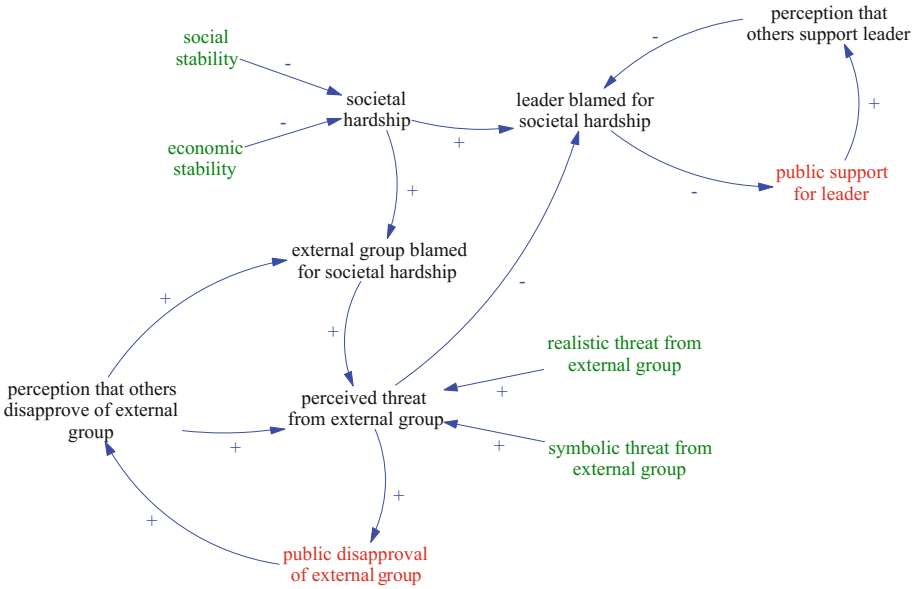

Fig. 2. Preliminary model of how the perception of external threat and societal hardship, as well as group polarization influences the popularity of government leaders.

Social and economic stability can independently affect the perception of societal hardship. As social and/or economic stability goes down, a society's perception of societal hardship goes up. This will typically cause the government leadership to be blamed for the societal hardship, which would negatively affect the popularity of the government leader. This perception could grow especially within communities that already have some degree of negativity towards the current government.

Realistic and symbolic threats can independently affect the perception of an actual threat for a certain external group. This might be based on actual negative encounters with that group or the belief they might eventually be a threat at some later time. This could be based on an underlying prejudice towards the external group. In either case, the perceived threat would cause greater public disapproval of the external group, which could be strengthened through group polarization effects (perception that others disapprove of the external group). This would increase the likelihood that the external group would be blamed for societal hardship if any connection can be made between the external group and societal hardship that the society is facing. If prejudice against this group is high, this linkage will not need to be as strong and logically supported. The higher the societal hardship, the more likely the external group would be blamed. Here, reductions in social stability would be most tightly coupled with the perception of symbolic threat. This perceived threat has the potential to be re-directed as a distraction or a scapegoat for increases in societal hardship due to downturns in economic and social stability. The result of this could reduce government blame for the societal hardship (particularly if the downturn coincides temporally with the perceived threat). That is, having a group (that could be a minority group within the society or a more

powerful country that is external to that society) that is recognized as being a threat provide government cover, at least temporarily. This would, in turn, pose an opportunity for the government leader to exploit this phenomenon and increase his or her popularity with the citizens of that country. Charismatic leaders seem to have the best ability to take advantage of the opportunity to focus blame on external groups while minimizing blame for governmental miscalculations. In addition, if the government promotes this narrative (and potentially works to exclude any contrary narrative) then it is possible it could take advantage of the group polarization effects shown in Fig. 1. Here, the effect of group polarization would work to both increase the popularity of the government leader and the negative bias towards the external group.

4 Conclusions

Seeking to better understand the conditions where leaders from open democracies to authoritarian states become more or less popular is a difficult challenge. This paper explored psycho-social factors underlying leadership popularity by examining perceived threat and polarization that can be influenced by economic and social conditions. This resulted in a preliminary model of how the perception of external threat and societal hardship influences the popularity of government leaders. The focus of this model is less on large-scale disruptions, such as a 9–11 terrorist event or act of war, and more on smaller scale, longer-term conflict between a society and an external group. For example, simmering conflicts such as between Israel and the Palestinians, Cuba or Venezuela and the U.S., and North and South Korea can serve as instances where both sides see each other as a threat and seek to vilify each one another. In many cases, this vilification provides some sort of gain for the country or organization—often as a means to obfuscate internal problems that are difficult for a country or organization to solve.

Acknowledgements. Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly-owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. Approved for unlimited release: SAND2017-2693 C

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A Fast Track Approach Towards Automatic Detection of Gray Zone Activities from Text

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Abstract. Gray Zone Operations (GZ Ops) are increasingly being used by countries to achieve national security objectives that have historically only been achieved through armed conflict. GZ Ops employ actions that are diverse, covert, and adversarial but fall below the threshold required to trigger an aggressive response from major powers. We aim to help analysts with early identification of Gray Zone Operations by automatically detecting taxonomy-backed Gray Zone activities in news stories and text. We map our proven geo-political event extraction and data processing capabilities previously developed under the World-Wide Integrated Crisis Early Warning System (W-ICEWS) program to Gray Zone activities and apply these mappings to text from a corpus of Russian news stories from 2015 to 2016 to generate a set of sentences labeled with specific Gray Zone activities. We evaluate the validity of these matches to determine if the sentences and stories accurately reflect their label.

Keywords: Gray zone · NLP · Text analytics · Event coding · Data mining · Taxonomy

1 Introduction

Gray Zone Operations (GZ Ops) are becoming an increasingly common means for nation states to shift global distribution of power and influence by employing gradual actions that do not reach the threshold required to trigger an aggressive response from major powers [1]. Over the past year, many US government organizations have identified the problem of Gray Zone Campaign recognition, mitigation, and offensive planning as issues of grave concern to US interests. USSOCOM has released 3 new Joint Pubs focused on addressing Integrated Campaigning, Gray Zones, and Gray Zone Indicators and Warnings and in January 2016, USSOCOM requested a Strategic Multilayer Assessment (SMA) to investigate the identification, diagnosis and assessment of the different types of Gray Zone conflicts [2].

A well-studied example of a Gray Zone Operation is Russia's operation in Crimea where the Russians issued Russian passports to Ukrainians and then fomented social unrest against ethnic Russians on social media, complained about the resulting violent protests, and then intervened with force to "protect" Russian citizens (and annex Crimea). The international community reacted strongly to this final step; however, one could imagine a stronger response had Russia only declared they were annexing

M. Hoffman (ed.), *Advances in Cross-Cultural Decision Making*,
Advances in Intelligent Systems and Computing 610, DOI 10.1007/978-3-319-60747-4_14

Crimea without laying the groundwork for a plausible backstory over the preceding 3 years. Should the international community have known this was Russia's ultimate goal from the beginning? Early campaign recognition of situations like this could leave many more options open regarding deterrence, intervention or mitigation [3].

Detecting GZ Ops is complicated by the diverse nature of covert, adversarial strategies being employed across the Diplomatic Intelligence Military and Economic (DIME) spectrum. However, in this paper we describe our effort to rapidly develop and deploy a system capable of identifying taxonomy backed Gray Zone activities in unstructured text (i.e. news media) by mapping them into relevant combinations of event and actor data developed under the World-Wide Integrated Crisis Early Warning System (W-ICEWS) program, and by further constraining results by the presence of contextual keywords in the stories in which the W-ICEWS events and actors occur. We identify a subset of Gray Zone activities to map from the Gray Zone Activity Taxonomy (GZAT) developed by GMU in conjunction with military operators in support of the Office of the Secretary of *Defense's Strategic Multilayer Assessment (OSD SMA)* on Gray Zones. These mappings are hand built by subject matter experts (SMEs) and executed against our W-ICEWS data processing pipeline to label text at the sentence level with specific Gray Zone actions. We then evaluate the validity of our labels and discuss lessons learned. We do not claim this is the optimal approach to find Gray Zone activities in text. Rather we explore this approach primarily because it allows for very rapid application and repurposing of our existing capabilities. *We believe GZAT is the first Gray Zone activity taxonomy to be developed and we believe this will be the first attempt to automate the detection of activities from this taxonomy in text.*

2 Background

We leverage the Gray Zone Activity Taxonomy (GZAT) developed by GMU in conjunction with military operators in support of the Office of the Secretary of Defense's Strategic Multilayer Assessment (OSD SMA) on Gray Zones. This taxonomy was developed to capture classes of actions, and individual actions that may be part of a GZ Op. This taxonomy contains 19 high level classes of actions, each of which contains actions with additional specificity. For example, one class of actions involves *Military Security and Stabilization Actions* while one of the 24 specific activities within this class is to *Train and equip government opposition forces*. Table 1 shows the 19 classes of activities and Table 2 shows the specific actions of a single class to help illustrate the level of granularity of the actions.

The Worldwide Integrated Crisis Early Warning System (W-ICEWS) is a DARPA-funded research project designed to predict political events such as insurgency, rebellion, or international conflict [4]. The system contains three major components focused on event forecasting, data analytics, and social media sentiment analysis. The data analytics component, known as ICEWS Trending, Recognition and Assessment of Current Events (iTRACE), processes open source news stories in real-time to generate event data expressing *who* did *what* to *whom* as well as *when* and *where*. A subset of the data, which withholds the last year's worth of information, is available to researchers via Harvard's Dataverse [5]. The full data set cover from 1991

Table 1. Gray zone activity taxonomy classes

GZAT classes	
1	Gray Zone Actor Diplomatic Actions
2	Activities to Undermine Targeted Gov't Mil and Political Support
3	Military Security and Stabilization Actions
4	WMD Shaping Activities
5	Internal Political Activities to Undermine Gov't
6	Activities in Support of Counter-Gov't Factions
7	Activities to Undermine Gov't Refugee Support Activities
8	Partner Terrorism Support Activities
9	Infrastructure Activities
10	Activities in Support of Security and Civil Order in Partner-controlled areas
11	Border Control Activities
12	Activities to Partner Civil Administration
13	Public Diplomacy and Propaganda Activities
14	Activities to Undermine Gov't Rule of Law
15	Corruption-related Activities
16	Economic Activities
17	Activities towards Partner Employment Generation and Business Development
18	Support to Partner Civil Society Activities
19	Activities to Accuse Former Gov't of Human Rights Abuses and War Crimes Activities

Table 2. Actions from the diplomatic actions class

Gray Zone Actor (GZA) Diplomatic Actions	
1	Consult with target nation opposition groups
2	Consult with neighboring states and regional powers
3	Consult with regional organizations
4	Establish a "Friends Group"
5	Appoint a Special Envoy
6	Support the political and security needs of threatened parties
7	Diplomatically isolate the government
8	Persuade other governments to initiate or support sanctions
9	Pursue regional basing and over flight rights
10	Build a multinational coalition to support opposition groups
11	Collaborate with troops for hire
12	Impose sanctions /arms embargo to government
13	Coerce gov't compliance with ceasefire milestones and conditions
14	Provide diplomatic recognition of opposition government

to present and contains over 41 million news stories, from which some 24 million events have been extracted.

An example of a W-ICEWS event expressed textually is: "German police arrested a German man in Lower Saxony, Germany on February, 2016." The action part of the

event – "arrested", in this case – is known in W-ICEWS as the *event type*. These event types derive directly from the CAMEO Conflict and Mediation Event Observations Codebook [6], and describe over 300 potential actions grouped into 20 different categories. In addition to having a name, identifying code, and descriptive information, each event type has a numerical score ranging in value from −10 to +10 that describes the amount of hostility or cooperation implied by the event type, where −10 represents extreme levels of hostility and +10 represents extreme levels of cooperation. These scores, known as either the Goldstein value or intensity score, derive from the Goldstein scale for WEIS event coding originally developed in the early 1990s [7]. An example of several event types is shown in Table 3 below.

Table 3. Example event types and corresponding CAMEO code and intensity scores

CAMEO code	Name	Intensity score
0871	Declare truce, ceasefire	+9
046	Engage in negotiation	+7
082	Ease political dissent	+5
043	Host a visit	+2.8
202	Engage in mass killings	−10
151	Increase police alert status	−7.2
103	Demand material aid	−5
111	Criticize or denounce	−2

The "who" and "whom" parts of the event are known in W-ICEWS as the *source actor* and *target actor* of the event. Actors are defined primarily in what is known as the W-ICEWS Actor Dictionary, which contains metadata information concerning over 55,000 named persons or groups (e.g., Vladimir Putin, NATO). A secondary source of actors is the W-ICEWS Agent Dictionary, which contains over 700 generalized persons or groups which can be combined with a country to form an actor (e.g., Chinese-police, Russian-ambassador). Both actor and agent dictionaries contain information about the known affiliations their entries, as expressed in terms of the *sectors* in which they are involved. There are nearly 600 sectors arranged hierarchically, and include examples such as the government sector, the business sector, and the religious sector. As these sectors are hierarchical they can be further decomposed, an example of which is the government sector that decomposes into the executive, judicial, and legislative branches, each of which is represented by a sector.

3 Methodology

At a high level, our experimental goal was to quickly identify gray zone activities in English language text by leveraging existing work – to include both data and tools – wherever possible. In our work, "quickly identifying" means not only that the raw text could be processed quickly, but that the overall analytical process was quick to implement. Because of this, we chose to avoid AI techniques such as Bayesian classification,

Natural Language Processing (NLP), or machine learning where the need to create training data can delay the experimental process and the algorithms themselves can be prohibitively time-consuming when run over large volumes of text. Though we fully believe that such techniques are well worth pursuing, our goal of immediate results dictated a different path.

Experimentally our design was simple: start with an already coded set of geopolitical event data, and map it into gray zone activities where it made sense. Given our access to and familiarity with the W-ICEWS event data we chose it as our starting point. This gave us several immediate advantages: not only did we have access to the underlying text from which the events were extracted; we also had access to data processing tools developed specifically for the data. As we still needed a way to express our gray zone activities, we used the comprehensive GZAT taxonomy as a classification system. With over two hundred different gray zone activities specified, we felt that it was a comprehensive survey of the activity space.

We began by assessing the taxonomy of GZAT activities and grading them on the perceived ease in which we could map them to W-ICEWS events. Following that, we took those gray zone activities judged the easiest to map and designed a set of filters to extract the relevant W-ICEWS events for each of them. After running these filters over the set of W-ICEWS news stories in which Russia or China was involved between 2015–2016, we took our results and performed a series of quantitative and qualitative analyses.

3.1 Assessing the Gray Zone Activities

In assessing gray zone activities and how they might map to W-ICEWS events, we considered two aspects of the activities: what is being done, and who is involved in doing it. The "what is being done" component is primarily expressed in the CAMEO code associated with the event, while the "who is involved" component is found in the sector affiliations of the source and target actors of the event. In either case, we often found that it was necessary to add additional keyword constraints on the underlying story text to prevent an otherwise overly broad activity-to-event mapping.

To begin our assessment we looked for gray zone activities that closely corresponded to existing CAMEO codes. As the CAMEO taxonomy captures geopolitical events of a general nature and not gray zone type activity specifically this was not often the case, but a few close matches were nonetheless found. Common activities across the two taxonomies include the establishment of sanctions (CAMEO codes 163 and 172), diplomatic recognition of government (054), and the refusal to allow international involvement in mediation (1245).

Out of the 209 activities we assessed, we judged that only 31 of them mapped to specific CAMEO codes. Of those 31, well over half of them required additional keyword searches on the event story text to adequately capture the gray zone event. This was primarily because while CAMEO codes are defined relatively broadly, gray zone activities within our ontology were much more specific. We experimented with two different techniques in developing our keyword constraints. For the first, we used a list of Gray Zone activity keywords generated by NSI Inc., also under the SMA effort that

generated GZAT, and mapped them as applicable to one or more gray zone activities. In the second technique, we started with words within the description of the activity and augmented them through thesaurus and Wordnet entries. Several examples of mappings are shown in Table 4 below.

Table 4. Mapping gray zone activities to CAMEO codes, sometimes with the addition of key-word constraints (not all keywords are shown for reasons of space)

Gray zone activity	CAMEO code	Keyword constraints
Provide diplomatic recognition of opposition gov't	054 (grant diplomatic recognition)	
Provide financial support for terrorist groups	071 (provide economic aid)	
Restrict cross-border arms flow	191 (impose blockade, restrict movement)	"guns", "arms", etc.
Provide equipment and train faction border police	062 (cooperate militarily)	"border police", etc.
Provide equipment and train opposition police forces	062 (cooperate militarily)	"police" without "border police", etc.

For the remainder of the activities we were left with the broader CAMEO categories, restricted by keywords. There is a wide mismatch in specificity between CAMEO categories, which represent broad concepts such as "fight" or "aid", and the more granular activities within the GZAT taxonomy. We typically increased the number of keyword constraints in these cases in an effort to better target the activities. Even so, we felt that only a further 29 activities could be adequately covered in this manner. This led to a total of 60 GZ activities being mapped.

A final concern in our assessment was whether we could match the persons and groups active in the gray zone activities with the actors in our event data. In one sense this was an easier problem; those performing the activities were generally assumed to be state actors, with the activities targeting other governments, opposition groups, dissidents, or civilians. The W-ICEWS event data richly represents affiliations such as these in its actors. More problematic was the possibility of those involved in gray zone activities working through intermediaries, as such "proxy relationships" are not expressed in the event data.

3.2 Designing Event Filters

To map event data to gray zone activities, we used the concept of a set of filters operating over the entire set of event data to capture relevant events and associate them with the proper gray zone activity. This is actually a subset of a common task performed on W-ICEWS event data, that of aggregating events into targeted numerical time series data (Fig. 1).

The W-ICEWS aggregation tool works by filtering events based on their event types and involved actors, and then bins them by country pairing to create time series data.

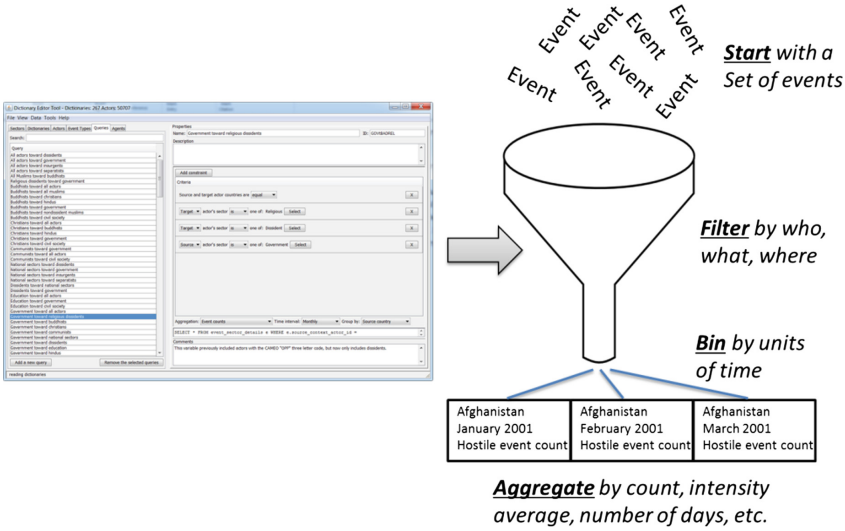

Fig. 1. Existing W-ICEWS data tools are used to support event aggregation, a process that relies on designing filters to identify common groups of events

Filters are constructed via a graphical editor that ties into the CAMEO and actor taxonomies. We extended this tool to include the concept of a keyword search on either the full text of the story or the specific sentence from which the event was extracted. In addition to generating time series data the tool has the ability to map the filters with their associated events, something used for traceability of time series aggregate data. By leveraging these mappings, we were able to extract the events corresponding to each filter – that is, to each of our definitions of what a gray zone activity would be – for evaluation purposes. Though we did also create time series data for these activities, we did not analyze those results during this study.

3.3 Analyzing Our Results

Our corpus of 3,530,417 news stories involving Russia or China, published between 2015 to 2016, resulted in the identification of 1,673,781 W-ICEWS events and 292,599 GZ activities. From this total count, we break out a count of matches for each type of GZ activity. Of the 60 GZ activities we mapped, 42 of these had at least one match, 29 of them matched at least 100, 16 matched at least 1,000, and 4 matched at least 10,000. The majority of matches 219,060 (~75% of the total number) were attributable to a single activity, *Consult with neighboring states and regional powers*. See Table 5 for all GZ Activities that accounted for at least 1% of all matched activities.

For analysis of validity of the matches, we randomly select 100 matched activities from the above set, weighting our selection so that we get a proportional number of matches for each of the classes that have matched, and manually review the text (sentence and story) on which they matched to ensure it represents the matched GZ activity.

Table 5. List of GZ Activities with at least 1% of total matches

Gray zone activity	# Matched	% matched
Consult with neighboring states and regional powers	219060	74.9%
Diminish popular support for government	11281	3.9%
Create lack of confidence among govt agencies	10588	3.6%
Collaborate with troops for hire	10417	3.6%
Dismiss and isolate national and local officials who support moderate political efforts	7797	2.7%
Consult with target nation opposition groups	6259	2.1%
Diplomatically isolate the country	4191	1.4%

We weight our selection to avoid selecting an overwhelming number of Consult type activities as these are the most frequent by a large margin (i.e. *Consult with target nation opposition groups*, *Consult with neighboring states and regional powers*, *Consult with regional organizations*). Each match was evaluated on a Likert scale where a score of *1* represents a *good match*, *2* represents a *partial match*, and *3* represents *no match*.

A *good match* represents a GZ activity that is well represented without ambiguity in the sentence with which it is linked. For example, the GZ activity *Train and equip government opposition forces* was matched to the sentence *The Wall Street Journal reported that under the plan the US considers not only supplying Syrian opposition fighters with machine gun-equipped pick-up trucks, but also might grant them powers to call in US-led coalition airstrikes.* A *partial match* represents a GZ activity that is mostly related to the sentence from which it is linked, but is missing some aspect of the activity, or has significant ambiguity. For example, the GZ activity *Collaborate with troops for hire* was matched to the sentence *Taliban delegation's visit to China*. This indicates collaboration with an unconventional militia, but it's not clear that they are *for hire*, this is why it's a partial match. A *no match* represents a GZ activity that appears unrelated to the sentence with which it is linked. For example, the GZ activity *Undermine government provision of basic services* was matched to the sentence *France has joined the U.S. in conducting airstrikes in Iraq, but Paris and other Western capitals have refused to deploy ground troops to the country.*

In the results section, we report the results of our analysis as well as the events most frequently associated with *good matches* and those most associated with *no matches*.

4 Results

From the 100 sampled and scored matches, 37 were scored *good match* (37%), 34 were scored *partial match* (34%), and 29 were scored *no match* (29%). In thinking about the usefulness of this data to an algorithm or analyst, we could state that 71 matches (71%) were at least partial matches or better (i.e. likely of interest). Some GZ activity types perform better than others. This appears to be largely a function of how well we are able to map them to our existing CAMEO codes. For example, the GZ activity *Consult with neighboring states and regional powers* performs well and maps well to two of

our CAMEO codes: *Host a visit* and *Consult*. Other GZ activities such as *Damage government-controlled transportation facilities and systems* and *Degrade government facilities for power generation and transmission* perform poorly, as we have no CAMEO codes that capture the specificity of damaging transportation facilities or power generation equipment.

Ultimately, our experiment highlighted several themes that underlie most of the difficulties found in a straightforward mapping of typical geopolitical event data into gray zone activities.

- Event data such as W-ICEWS, GDELT, and Phoenix primarily express discrete facts without analysis as to their intent. For example, one CAMEO event type involves establishing a blockade. Missing, however, is its intended purpose. A blockade may be meant to harm the populace by containing them in a dangerous region, or it may be meant to help them by preventing the flow of arms into their homelands.
- Event data captures direct events, where the use of indirect (or proxy) actors is concealed. For example, consider the case where a state actor is seeking to support a separatist group in a neighboring state. One way it might do this is by supplying arms to fighters through an intermediary. Though the event data might capture the flow of arms, it wouldn't track the ultimate catalyst of the event back to the state actor.
- Gray zone activities can be more complex or more specific than the CAMEO codes used in many event data sets. An example is the CAMEO code for providing military aid to person or group. When classifying gray zone activities it can be desirable to know more specifically the type of aid given: money, training, conventional weapons, WMDs.
- Gray zone activities can be more general than CAMEO codes. When this happens, a single gray activity can manifest in multiple CAMEO codes. Undermining a government election in a neighboring state, for example, could involve anything from coordinating protests to spreading propaganda to threatening politicians. Further complicating the fact is that not all propaganda or all political threats are necessarily concerned with undermining elections. This gets back to the general problem found in coded event data, that in determining the intent of an event.

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Challenges and Opportunities in Gray Zone "Combat"

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Abstract. The Gray Zone lies between peace and war, where and when adversaries increasingly orchestrate campaigns using multiple elements of power to achieve political-security objectives minimizing the risks of engaging in direct kinetic warfare. Actions motivated by a Gray Zone campaign are deliberately ambiguous - sometimes deceptive - to hide the ultimate intent, cloud attribution, or leave the target of the campaign a choice among only acquiescence or escalation. Recent Gray Zone campaigns include the Russian occupation in the Ukraine and the expansion of Chinese influence and control in the South China Sea. In this paper we define competition in the Gray Zone, characterize the concurrent interactions between campaigns and counter-campaigns of two adversaries, and provide an Indications and Warnings (I&W) framework for detecting Gray Zone campaigns early. We propose combining bottom-up analysis, such as changes in the intensity and tone of messaging in media, economic investments, and other actions in the Diplomatic, Information, Military, and Economic (DIME) spectrum, with top-down analysis of the master narratives of nation states and other actors. We propose that interdiction of a Gray Zone campaign is best structured by analogy to the approach for disrupting the cyber kill chain.

Keywords: Gray Zone · Framework · Indicators and warnings · Kill chain

1 Introduction

The Gray Zone is formally defined as "a conceptual space between peace and war, occurring when actors purposefully use multiple elements of power to achieve political-security objectives with activities that are ambiguous or cloud attribution and exceed the threshold of ordinary competition, yet fall below the level of large-scale direct military conflict, and threaten US and allied interests by challenging, undermining, or violating international customs, norms, or laws" [1].

The Gray Zone is not a new concept, the Cold War is often cited as a good example of a US victory in a Gray Zone campaign. In fact, the objectives embodied in Gray Zone actions are reflected by Sun Tzu "The supreme art of war is to subdue the enemy without fighting" [2].

Thus, while not a new concept, the Gray Zone is increasingly becoming the norm for interactions, even "combat" of sorts, between the US and many of its adversaries. Several conditions are driving our adversaries toward Gray Zone interactions. These include:

M. Hoffman (ed.), *Advances in Cross-Cultural Decision Making*,
Advances in Intelligent Systems and Computing 610, DOI 10.1007/978-3-319-60747-4_15

1. US dominance in kinetic warfare capabilities when compared to even near-peer adversaries;
2. The ability to leverage the increasing interconnectedness of world politics, finances, and activities to impact both directly and indirectly the way of life around the world; and
3. Through the democratization of the internet, our adversaries are becoming increasingly adept at deceiving, distorting, manipulating, and even mobilizing public/international opinion/attention through an increasingly connected world. This has enabled many non-peer US adversaries such as ISIL to engage the US much more effectively than possible even a decade ago.

In addition, several asymmetries exist that put the US at a significant disadvantage when competing in Gray Zone activities including:

1. By the nature of the Gray Zone, it involves the coordinated use of multiple elements of power. These include diplomatic, military, economic, legal, informational, psychological, and others. By virtue of the very structure of US governance many of these elements are purposefully isolated from each other and/or designed (legally) to operate independently. Even when coordination is undertaken, the checks and balances involved demand extensive effort and time to overcome. Thus, the wielding of coordinate elements of power for the US is much more difficult than many of our adversaries thus making them more diverse and nimble in their options and actions in the Gray Zone.
2. Beyond the ability to wield the elements of power, there are the mores that control their use. Specifically, the US operates by a different and much more restrictive set of mores than do many of our adversaries that further restrict our potential operations in this space.
3. Gray Zone campaigns undertaken by many of our adversaries involve the "long game" and indeed play out over decades or longer. Many of our adversaries have political structures and objectives that endure over these timeframes. Within the US, military officers often change duty billets every two years. Every four years the US undergoes the potential for major political change. The ability of the US to set and maintain a consistent and the political will to enforce that US policy for these long timeframes is severely hampered.

These asymmetries have driven our adversaries to increasingly choose the Gray Zone as the battlefield for trying to achieve their national objectives. Given the asymmetries that our adversaries enjoy and expecting that the US will not sacrifice our beliefs or values to level that playing field, the US must learn to identify our adversaries plans and activities much earlier in their evolution so that less effort might be needed to effectively mitigate those plans. In essence, we must learn to leverage the asymmetries that we enjoy to either "change the games" as they are being played or become more effective operating on that uneven playing field.

2 Conceptualization of Gray Zone Competition

Gray Zone campaigns may be thought of as playing out across a two dimensional grid as depicted in Fig. 1, which considers a GZ campaigns as a competition between two players: us (blue or the US) versus an opponent (red). The axes represent the "owner" of the campaign being waged – in essence "whose objectives are being pursued". This is not equivalent to the "instigator" of the campaign as will be described in a moment. The other axis is to whether the US is being reactive (defensive) or proactive (offensive) in that campaign. Typically, the proactive party has a first-mover advantage, especially if the opponent does not recognize that the proactive party has started a campaign or does not recognize the goal of the campaign early enough.

These quadrants of concurrent interactions play out concurrently across the Gray Zone campaign. Indeed, multiple campaigns between the US and the same actor or between the US and multiple actors are active at the same time, sometimes interacting with each other, but we will focus our initial discussion on a the state of a single campaign.

Each quadrant is labeled with the main challenge blue must meet to prevail in the GZ competition. In the upper right quadrant, "I&W Recognition", we (blue) are trying to discern the existence an adversary's campaign and thus activities revolve around GZ campaign recognition through identification and tracking of Gray Zone indicators and warnings. In the lower left quadrant, "Planning & Execution", we have the proactive development of our own (blue) GZ campaign(s) designed to achieve our own end goals and objectives. The lower right quadrant, "Prosecution/Disruption", represents us becoming proactive in defense of a (partially) recognized adversary's GZ campaign, while the upper left quadrant, "Assessment & Hardening", represents our defensive assessment of vulnerabilities of our own GZ campaigns in order to assess their weaknesses, reinforce their elements, build alternatives, and track/assess their progress.

Fig. 1. Gray Zone quadrants of concurrent interaction

In these last two off-axis elements, this is where the Gray Zone campaigns are fought. Here we recognize an analogy to the notion of a "cyber kill-chain" where early recognition of the enemy's "kill chain" or partially ordered sequence of objectives and actions allows the potential for early mitigation of those campaigns using actions designed to:

1. Delay: actions designed to slow the progression of a possible GZ campaign in order to allow time to further assess and discern the existence and the particulars of an adversaries GZ campaign;
2. Probe: actions designed to help clarify the extent and details of a GZ campaign that may be executing;
3. Derail: actions designed to degrade and/or derail an adversary's GZ campaign – leading to dissolution of the campaign and peace or, alternatively, risking escalation to a more kinetic conflict; or
4. Flip: actions designed to change the nature of the ongoing campaign. These actions are typically designed to exploit an asymmetry in a GZ campaign so as to benefit our own objectives (e.g. changing the cold war from a GZ campaign of democracy vs. communism to that of an economic competition).

Actions in the Gray Zone typically aim at increasing influence over other actors, frequently neighboring countries, by biasing political decisions that change any of the Political, Military, Economic, Social, Infrastructure, and Information (PMESII) factors, such as trade-agreements, separatist movements, military alliances, etc., in favor of the campaign initiator. Actions include diplomatic, information, military – though mostly exercises and demonstration of capabilities, economic, and financial, intelligence, and law enforcement actions (DIMEFIL).

As mentioned, multiple campaigns may be underway at any moment in time across the same or different adversaries. Further, one might be proactive in one dimension of a Gray Zone campaign (e.g. the political dimension) while being reactive in another (e.g. information/cyber). And, one might in fact, alternate back and forth within a dimension based on the ebb and flow of the "game".

The remainder of this document will describe each of the quadrants depicted in Fig. 1 in more detail.

3 Gray Zone Campaign Indicators and Warnings (Upper Right)

One of the key challenges associated with Gray Zone operations is being able to detect and understand Gray Zone operations and their objectives being executed by our adversaries. This difficulty is in no small part driven by the complexity of the PMESII spectrum across which Gray Zone campaigns play out. It is further complicated by the use of allies and proxies by, with, and through GZ actions can take place. Lastly, Gray Zone campaigns are further shrouded by a fog of deception that adds to the innate noise of worldwide activities.

To recognize meaningful signals in a sea of noise is a data and analytic challenge of unprecedented scope. To achieve this objective, a system of systems approach must be

taken to harness the investments, data, and forecasts generated from a range of extant and emerging systems as illustrated in the lowest layer of Fig. 2.

These extant systems might include but would not be limited to:

- The DARPA Integrated Crisis Early Warning System (ICEWS) [3]: Forecasts strategic socio-political events using news reports of events at initially country-month and now province-week granularity.
- The IARPA Mercury program [4]: Forecasting similar events as ICEWS but using classified intelligence data.
- The IARPA Open Source Indicators (OSI) [5]: Forecasts mass protests, contagions, and other social events using social media at the city-day level of granularity.
- The IARPA Cyber-attack Automated Unconventional Sensor Environment (CAUSE) [6]: Forecasting cyber events against US sectors/companies/agencies with days-to-weeks' notice.
- The IARPA Aggregative Contingent Estimation (ACE) program [7]: Forecasting a very broad range of social, political, and economic events using a highly tuned human prediction market approach.
- The Intelligence Community's Political Intelligence Task Force: A group of highly skilled social scientists and government experts who develop models for key countries/issues to forecast instability several months to years in advance.

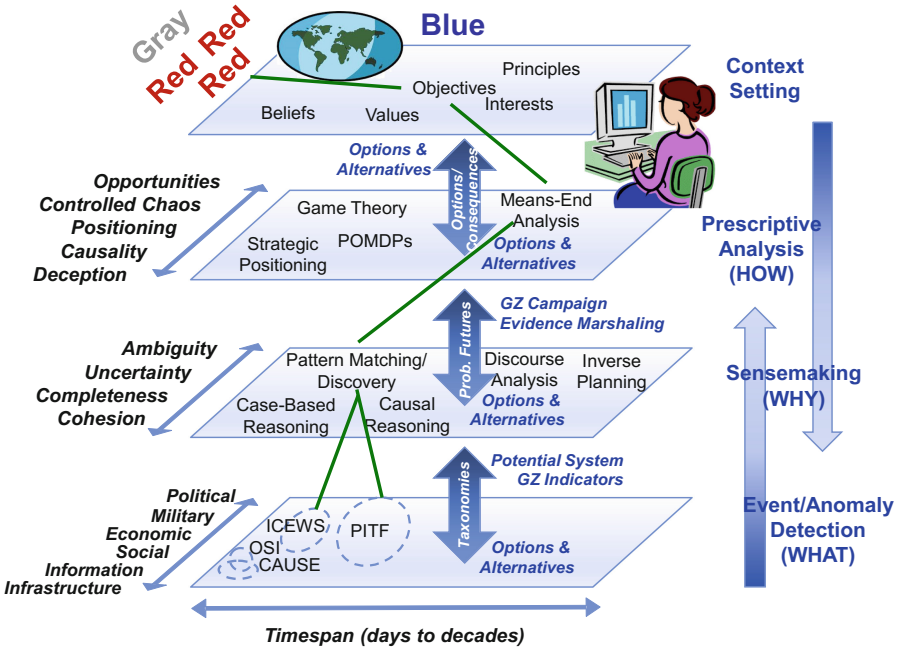

Fig. 2. Gray Zone system of system I&W concept

Those systems (both government and commercial), while typically constrained to one or two PMESII dimensions that align with adversaries elements of power, can provide key indicators along those dimensions. It is our hypothesis that once diverse indicators from this layer are accumulated in a sensemaking layer (Layer 2 of the diagram), that evidence of Gray Zone operations may be able to be identified across the PMESII dimensions using a range of technical approaches each providing a triangulation input on Gray Zone activities. The third layer in this architecture puts this evidence into the context of potential adversarial strategies.

This recognition can be further obscured by additional concurrent adversary Gray Zone campaigns or even campaigns being waged by allies or neutral parties whose objectives and actions may not be fully transparent to our collection and sensemaking. Based on the huge operating space of Gray Zone activities, a true GZ common operating picture may only be assembles through the merging of a bottom-up anomaly detection and evidence collection process in combination with a top-down down adversary strategy and plan exploration process.

Figure 3 illustrates one approach to the layer-2 problem of sensemaking. Here we see the matching of known adversary goals that we believe to be in play with various world actions that have taken place are we believe are impending. We then use generative planning technology applied in an inverse planning manner. In essence, we run our planner in a reverse direction, starting with what we see or anticipate seeing in the world to satisfy higher-level goals. These goals are then used as sub-goals to explain potential higher-level goals. We do this until we connect what we believe "could be" an adversary's active overall objective. This then provides us with a formal theory that *could* explain the evidence that we are seeing with respect to what could be part of an adversary's plan. In doing this, we may generate any number of possible plan fragments that lead to various sub-goals that could then lead to the same or even alternative high-level objectives that our adversary may hold. The ambiguity introduced by multiple planned paths between actions and goals could be product of natural world competitive actions, our lack of full understanding of what is happening around the world (our data), or even layers of deception introduced by our adversaries and their allies/proxies. However, once these (partial) theories are identified and available for vetting by human experts, they may then provide the cueing that we need for further focused collection, discriminating actions on our part, or even potential disruption.

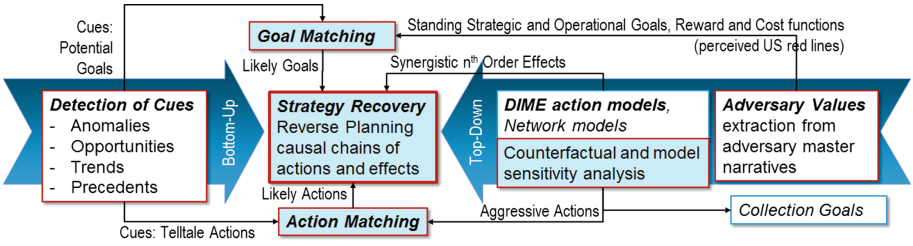

Fig. 3. Reverse Planning used to map actions back to possible goal explanations

4 US Gray Zone Planning and Execution (Lower Left)

In Influence actions, such as social media or economic campaigns, short of direct attack, take time to employ and to develop their full effect and, thus, are most vulnerable to counter-action in their early stages. This observation highlights the importance (a) of recognizing an adversary's influence campaign as quickly as possible and (b) of hiding the true intent of our GZ actions to give them time to take effect before the adversary recognizes them and implements counter actions. This section will focus on this latter capability.

A key challenge, therefore, is to plan GZ campaigns that include deception to hide the actual intent of the campaign as long as possible. To achieve deception, two main types of actions are employed: hiding the real and showing the false [8, 9]. Deception aims to defeat the adversary's discovery process. The means to achieve deceptive hiding include misdirection that focus the adversary's attention on the wrong activity, exploiting the adversary's expectations that bias their interpretation of observations, and altering or judiciously choosing the environment, e.g. to blend in better [10–12].

Whether one considers a classical, hierarchical task network (HTN), case-based, or probabilistic [e.g., Partially Observable Markov Decision Process (POMDP)] planning algorithm, they all consist of a general planning algorithm configured with domain knowledge. Classical, HTN, and POMDP express goals differently, but represent state and state transition knowledge using models of the domain, via plan operators, goal decomposition, or probabilistic state transition models, respectively. Advanced models express probabilistic effects and incompleteness of precondition and effect models [13], but planning models do not typically represent the interaction of positive and negative influences (actions), which is required to model the nonlinear feedback system usually expressed in PMESII Models. Some modeling methods, such as System Dynamics Models, model such interactions explicitly.

Our recommended approach is inspired by and extends the similar, well studied problem of network interdiction, which involves two players, an interdictor and an intruder. In our case here, intrusion corresponds to our influence campaign and the interdictor corresponds to the adversary who is assumed to be trying to detect and thwart our campaign. The intruder attempts to optimize an objective, such as the cheapest path through a network, for example, to carry out an attack in a cyber network, or to move undetected through a network of roads or corridors at an airport (here, the best way to influence a populations beliefs without being detected). The interdictor attempts to make it maximally difficult for the intruder, i.e., to minimize the evader's objective function, by deploying detection resources to optimal points in the network. In almost all cases, the stated goal of existing approaches is to improve the defense against an adversary trying to intrude, in contrast to the proposed work which focuses on the success of the intruder/influencer.

Solutions to interdiction problems are often drawn from leader/follower games, such as Stackelberg games, where it is assumed that the leader and follower know each other's strategy and are rational, i.e., choose game-theoretically optimal actions. Various extensions have been developed to model more realistic situations, but most researchers limit the complexity of the problem formulation by their desire to specify a

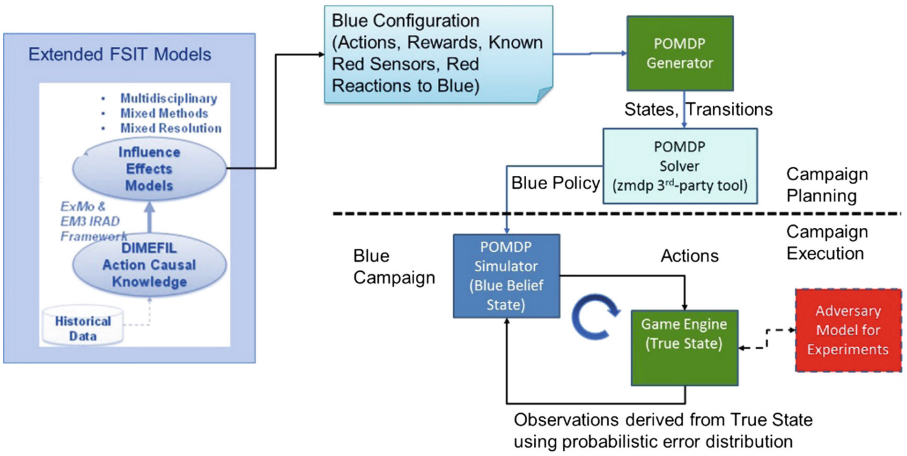

Fig. 4. Partially observable markov decision process leveraging deception techniques to obscure blue action/intent

closed-form equilibrium solution. So far, there are no approaches that address sequential (multi-turn), dynamic, games with partial, uncertain information. The use of deceptive actions makes the game dynamic, since the intruder attempts to change its reward probabilities by influencing the perception of the game by the defender (Fig. 4).

The POMDP-based planning approach sketched below optimizes the game (campaign) outcome according to this formulation.

5 Adversary Gray Zone Campaign Interdiction (Lower Right)

A key question that remains after we build a working hypothesis about the GZ strategy of our adversary (described in Sect. 3) is how to best counteract that strategy if indeed it runs counter to our own principles and objectives. We suggest drawing a solution based on an analogy in cyber defense and involves the understanding of the adversary's "kill chain". Figure 5 is an adaptation of that kill chain illustrating a comparison between early and late phase detection of a threat. In early phase detection, the option exists to synthesize a remediation/mitigation plan and in essence, break the attack chain being leveraged by the adversary.

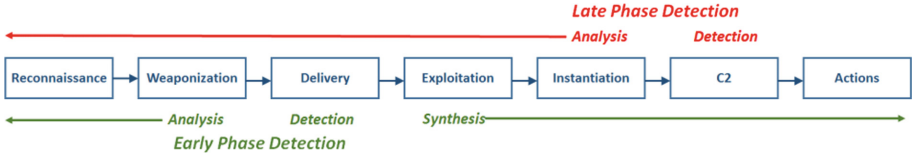

Fig. 5. Cyber kill chain - early vs. late phase detection

Unfortunately, the Gray Zone domain can be a significantly more complex operating environment as it can contains, as just one of the dimensions of its PMESII effects, the domain of cyber activities. However, that complexity can be mitigated to some extent.

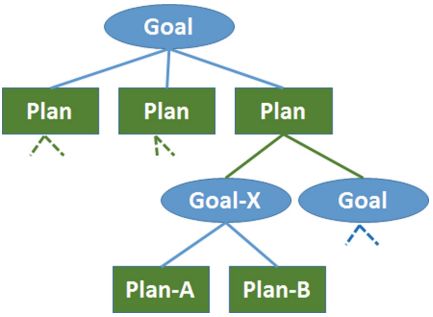

Fig. 6. Notional GZ campaign plan

A Gray Zone campaign may be thought of as a complex network of these chains. Interconnected goals, with plans to achieve those goals, and with each plan having its own subgoals to further be achieved. This is depicted in Fig. 6. The organization of these goals and plans can be further complicated by their interdependence, both logically (this AND that OR something-else) as well as their temporal relationships (before, after, during, not-after, etc.) as well as dimensions such as partial-fulfillment. These constraints can become quite complex and include many additional context dependent constraints in order to achieve their ultimate objectives. However, one must not necessarily understand the full plan (campaign) in order to potentially derail it.

Identification of a campaign fragment (for example Goal-X to be achieved by either Plan-A or Plan-B) may provide an opportunity to foil or at least mitigate an adversary's campaign by interfering with the execution of those plans. In fact, many elements (subgraphs) of GZ campaigns may be common across a broad range of potential campaigns. Highlighting or even manufacturing inequities for one sub-group versus the majority might be a common strategy to attack that group's cohesion. In the Ukraine it was used focus on prejudice against ethnic Russians. This could have been done as an instrument to increase sensitivities in the local government to ethnic Russian issues; or could have been to try and force more pro-Russian stances by the local government; or it could have been used to foment unrest by the ethnic Russian population who might force a change in local governance. Or, as it turned out, it might be used as justification for a cross-border incursion to "protect the local ethnic Russian population". However, again, one need not necessarily understand the "end-game" in order to recognize an early/mid-game strategy in play. In much the same way as master chess players cannot envision an entire game before the opening move, there are strategies at work to help "position the board" in ways more advantageous for opportunism as the game evolves. This "board positioning" can be read as a basic tenant of a doctrine that has been attributed to Russia's Chief of the General Staff Army-General Valeriy Gerasimov in his article "The Value of Science is in Foresight" [14]. This board positioning and counter-positioning by analyzing the adversary's kill-chains and continually working to disrupt them must become an area of excellence if the US is to prevail in the Gray Zone.

6 US Gray Zone Campaign Hardening (Upper Left)

This forth quadrant in our interaction matrix represents the counterpart to that discussed in Sect. 5. Here, we proactively work to harden, identify alternatives for, and defend those Gray Zone activities that we are undertaking. In this area, we must apply those same techniques described above to our own plans to identify those indicators, patterns, fragments, and flaws that our adversary might indeed themselves recognize. In fact, even those elements we could not detect ourselves must also be protected (though possibly not to the same extent) given that our adversary may indeed detect signatures of our activities beyond those that we ourselves might detect.

One approach to hardening the blue campaign is to model the potential counter-actions of the adversary as the moves of an opposing player in the game formalism introduced above. Under the assumption that a reasonable, probabilistic model of adversary observations can be constructed, it is then possible to perform some experiments to characterize the likely effectiveness of the campaign and evaluate its robustness against various assumptions about how sophisticated the adversary's detection and counter-planning capabilities are. Thus, it should be possible to at least estimate bounds on the risk associated with executing a campaign.

7 Conclusions

Since WWII, the US has sought to develop strategies, processes, systems, and technologies that provide asymmetric advantage to the US in kinetic warfare against any nation in the world. Unfortunately, as a byproduct of that success, our adversaries have been driven to explore other means of achieving their national objectives that fall short of triggering that level of US engagement. As something of a victim of our own success in our ability to conduct kinetic warfare, our adversaries have resorted to waging their campaigns on the Gray Zone battlefield where, unfortunately, the US is currently being "Outplayed" [15].

However, as described, the asymmetric advantages that our adversaries currently enjoy in that battlespace could be offset through the use of information technology asymmetries that the US enjoys through the development and use of a comprehensive framework for recognizing, planning, and waging "all of government" Gray Zone campaigns. Many of the constituent technologies and systems currently exist that, if integrated and purposed, could provide an effective framework for waging war in the Gray Zone.

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Intra-group Tension Under Inter-group Conflict: A Generative Model Using Group Social Norms and Identity

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Abstract. Group behavior is an important feature of conflict scenarios. Often such groups are chaotically organized, but their ideals are sociologically embedded across members such that the group has expected behavior that can represent a major threat. Therefore being able to model the evolution of groups on a generative basis, to anticipate their possible mutation, is valuable. However this is complex due to the diverse nature of human behavior and scenarios. In this paper we present an innovative approach to modeling these issues. Group identities are represented in terms of the behaviors (social norms) that members are expected to carry out towards other groups. Individuals predominantly compose their identity from the identity of the groups to which they belong, which is known to occur in situations of heightened conflict. The model introduced enables exploration of tensions associated with affiliation to multiple groups and the influence on inclusion and exclusion of individuals.

Keywords: Groups · Conflict · Social norms · Identity · Generative modeling

1 Introduction

Understanding group behavior is highly valuable in situations of conflict and political instability. Over the years numerous significant theoretical insights have been made [1–3], but particularly profound contributions have originated from Social Identity Theory [4]. A person's social identity is broadly a perception of who they are [5], and in situations of heightened tension, the identity provided by a membership of a particular group can take precedence over the individual's sense of self (i.e., ones identity

M. Hoffman (ed.), *Advances in Cross-Cultural Decision Making*,
Advances in Intelligent Systems and Computing 610, DOI 10.1007/978-3-319-60747-4_16

in the absence of any group). As a consequence of a heightened sense of belonging to a group, an individual naturally become disposed to adopting the beliefs and behavioral expectations, or social norms, of the group. Recent contributions have sought to develop this direction further, with Identity Fusion Theory [6] addressing the interplay between group and individual identities.

From these and other works, social identity has established itself as an important concept through which we can better understand human groups. In this paper, we use Social Identity Theory to develop a new and generative model of group behavior, specifically focusing on the tensions associated with affiliation to multiple groups. Our approach explores the natural pressures that exist between groups and the influence on inclusion and exclusion of individuals. We emphasize that our model does not seek to predict human behavior, but it exposes the potential tensions upon individuals when groups have conflicting expectations of the behavior of their members. This allows us to explore how group members become forced to migrate between groups, or become embedded within the social norms of a group. The use of simulation in this manner has become an important tool for identifying latent forces that shape behavior (e.g., [7]).

Our contribution also adds to the state-of-the-art in generative modeling of group behavior [8, 9] by providing a simple but effective event driven approach. The state-of-the-art in this area is at a formative stage, with numerous interesting approaches now emerging (e.g., [10]). The key distinctive feature of our model is the assumed prevalence of groups and their influence on the individual: specifically each individual is represented as a combination of the identities of the groups to which they belong. This is motivated by Social Identity Theory and contrasts with a conventional modeling approach where individuals are the dominant modeling element, from which groups are then defined based on a collection of common characteristics.

A further advantage of our approach is that it provides a flexible framework for controlling and extending the number of parameters in the model, which enhances prospects for useful experimentation. This is an important element in generative modeling for social computation, particularly from the user's perspective, as it reduces the extent of a-priori learning required to understand parameter sensitivity and parameter interaction. This supports the exploration of groups, including the prospects for intelligent forecasting of changes to their size and individual affiliations.

2 Model

The model we adopt has simple underlying principles. A population of individuals and a set of groups represent the main components. Individuals, or agents, are affiliated with multiple groups, dividing their commitment (i.e., time and resources) across their group affiliations. This is modeled by each individual having a weighting vector $(w_1, w_2, \ldots w_n)$ where w_i indicates the proportion of the agent's commitment to group G_i $\left(\sum_{i=1}^{n} w_i = 1\right)$. The weighting vector signals the groups to which an individual is affiliated and for demonstration purposes we use a population of 100 agents and four groups. Individuals are randomly assigned to groups at the beginning of the simulation. In all experiments, G_0 initially has 73 members, G_1 and G_2 have 78, and G_3 has 76 members.

2.1 Representing Group

Each group has an identity that is described by the degree to which its members should perform different actions towards the other groups. Table 1 shows the five types of action that have been chosen for demonstration purposes. Each action is described by a cost to the individual and an impact (positive or negative) on the receiving group. This framework allows extreme as well as mainstream out-group behavior to be modeled. Table 2 shows how we represent a group's expected norms, defining the expected frequency of different actions, which we call a social norm vector. A group may apply different expectations of behavior to different groups: Table 3 demonstrates this using our four example groups.

Table 1. Specification of actions that individuals may perform in terms of cost to the individual and impact on the receiving group.

Action type	Description	Cost to individual	Impact on the receiving group
1	Strong positive action	100	500
2	Positive action	5	10
3	Indifferent action	1	0
4	Negative action	5	−10
5	Strong negative action	100	−500

Table 2. Social norm vectors used in the scenarios by groups and individuals, describing the mean frequency of actions types.

Social norm vector	Description	Action type 1 (strong +ve)	Action type 2 (+ve)	Action type 3 (neutral)	Action type 4 (−ve)	Action type 5 (strong −ve)
SN_1	Mainstream	5%	60%	34%	0.9%	0.1%
SN_2	Negative	0%	10%	75%	14.9%	0.1%
SN_3	Extremist	0%	1%	49%	40%	10%

Table 3. Scenario specification: three groups are mostly mainstream (G_1, G_2, G_3), and one is extremist (G_0).

Group	Social norm vector applied to group			
	G_0	G_1	G_2	G_3
G_0		SN_3	SN_3	SN_3
G_1	SN_2		SN_1	SN_1
G_2	SN_2	SN_1		SN_1
G_3	SN_2	SN_1	SN_1	

2.2 Representing the Individual

Although individuals act on behalf of the groups that they are affiliated with, we also make provision for individuals to possess their own individual identity. This is a social norm vector (Table 2) that they will choose to identify with in the absence of affiliation with any group. We assume the individual social norm as the mainstream behaviour SN_1 for 75% of the population, SN_2 for 20, and SN_3 for the remaining 5%. We also invoke an individual compliance parameter for each agent j, denoted $comp_j$, which governs the chance that j complies with a group's norm, rather than its own norm, when conducting an action on behalf of a group (Sect. 2.3). This is set as 95% chance for all individuals.

2.3 Individuals Perform Actions on Behalf of a Group Towards Other Groups

The simulation applies a sequence of 100 rounds, after which an evolutionary step is applied (Sects. 2.4 and 2.5), creating the next generation and after which a new sequence of rounds occurs. For this demonstration, 100 generations are performed and individuals have 100 units of resource available for performing actions at the start of each generation.

In each round, each individual j randomly selects a group to act for, from the groups to which j belongs (determined as i for which w_i is >0), and performs an action towards another group if their current associated resources is equal or greater to the chosen action's cost. The group that j chooses to act for, say G, is randomly chosen but weighted by j's weighting vector. At the same time, a target out-group, say G^*, is randomly selected for the action, where G and G^* are distinct. Note that j may also be a member of G^*. If j is not a member of any group (due to previous exclusion) they are considered independent and can continue to act, and effectively constitute their own group.

The action that j undertakes is defined by the social norms of G in respect of G^* and by the individual's compliance parameter $comp_j$ (Sect. 2.2). For example, using Table 3, if $G = G_1$, and $G^* = G_0$, then j selects an action on a random basis weighted by the social norm vector SN_2, as defined in Table 2, which overall represents negative behavior. Whether the individual performs the action is determined randomly using $comp_j$, in which there is a $1 - comp_j$ (5%) chance than an individual reverts to a action with the probability of selection weighted by its own norm (Sect. 2.2). If a user is not affiliated with a group then the action towards G^* is chosen from the individuals own norm.

When an action is performed, j uses their associated resources defined in Table 1. At the same time the cumulative impact on group G^* is recorded, as defined by the schedule in Table 1. For demonstration purposes we perform 100 rounds before evolution is applied (Sects. 2.4 and 2.5).

2.4 Evolution and Exclusion from a Group

After the sequence of 100 rounds has been completed (Sect. 2.3), an evolutionary step is performed. This step looks at the overall actions that individuals have performed against the expectations of the groups to which they are affiliated, and considers whether they are candidates to be excluded. This is carried out using processes under two themes: (i) the *tolerance* that a group applies with respect to impact on the group by its own members while they are acting on behalf of other groups; (ii) the *normativity* of group, representing the strictness with which group members should perform actions on other groups consistent with expected social norms.

The tolerance and normativity are attributes that characterize the nature of a group, alongside the group's social norm vectors. For example, extreme groups would be expected to exhibit high levels of normativity, while liberal groups would be the opposite. Additionally, defining tolerance and normativity allows us to characterize groups based on their in-group/out-group disposition, since tolerance is focused on in-group expectations while the normativity is focused on out-group expectations. Our definition of normativity is inspired by its sociological definition [11], representing the extent to which members should feel that they *ought* to behave in a particular way.

For exclusion based on intolerance, assuming that j is a member of G, if the cumulative negative impact that j has performed towards G within a generation is beyond the value of $ex\text{-}tol_G$ then j is flagged for removal from G. This can occur if j acts negatively towards G when representing another group. The value of $ex\text{-}tol_G$ for all groups G is defined in Table 4.

Table 4. Scenario specification: normativity (i.e., strictness) and tolerance for the four groups.

Group	In-strict_G	Ex-strict_G	In-tol_G	Ex-tol_G
G_0	.1	.1	50	−50
G_1	.5	.5	50	−50
G_2	.5	.5	50	−50
G_3	.5	.5	50	−50

For exclusion based on deviation from normativity, each group G considers the percentage of positive impact verses negative impact that each individual makes towards all other groups after 100 rounds. This is compared with their own social norms towards other groups. The exclusion strictness, $ex\text{-}strict_G$, is the parameter used to determine how much an individual can deviate from G's expectations of out-group behavior. If an individual deviates in their out-group behavior towards all groups and is a member of the G, they will be flagged for exclusion.

Using G_0 as an example, the expected impact of the social norm applied by G_0 toward other groups is calculated and used for comparison with group member j. We use G_0 as defined in Table 3, where G_0 is an extreme group applying SN_3 (Table 2) to

all other groups. Starting with G_1, only 1% of actions from G_0 are expected to be positive leading to an expected positive impact of just 0.1 units. 40% of expected actions are negative and 10% of expected actions are strongly negative, resulting in an expected negative contribution of −54 units. This means that 0.18% of total impact on G_1 is expected to be positive and 99.82% of impact is expected to be negative.

These values are similarly computed in respect of G_2 and G_3, and compared to the negative/positive impact made by j towards G_1, G_2, and G_3 during the previous 100 rounds. If at least one of these are within $ex\text{-}strict_{G1}$ percent of the expected positive/negative impact on each group (i.e., 0.18 and 99.82% respectively for this example) then j remains in G_0, otherwise j is flagged for exclusion from G_0. This process is then repeated for G_1, G_2, and G_3.

After considering all individuals in the population, those that are flagged to be excluded from each of the groups are removed by setting their commitment weighting (w) to zero for the these groups. For such individuals, we re-normalize the non-zero elements of the weighting vector (w_1, w_2,…, w_n) to ensure that $\sum_{i=1}^{n} w_i = 1$ once again. This represents the agent increasing their commitment to the groups that they remain affiliated with, while preserving the ratio of time spent between them.

2.5 Evolution and Admission to a Group

The concepts of tolerance and normativity can also be used to model admission to a group, analogous to the processes for exclusion. We use the threshold, denoted $in\text{-}tol_G$, to govern the admission of j to a group G (shown in Table 4). The individual j must have made a positive impact to G, which is at least $in\text{-}tol_G$ in magnitude, over the previous 100 rounds. A threshold $in\text{-}strict_G$ is used to govern admission based on normativity (shown in Table 4), adopting a process that works analogous to that for exclusion based on normativity; with the exception that for an individual to be flagged for inclusion into a given group G, their impact towards all other groups must be within $in\text{-}strict_G$ percent.

Using these processes individuals are flagged for potential inclusion to particular groups, joining with a weight w of 0.1. Additionally, there is a small chance that an individual will join a group with a weight of 0.1 through mutation, set at a probability p_{join} of 0.01 for testing purposes for all groups. Mutation represents serendipity and random changes in behavior or scenarios. For each individual j, to accommodate the commitment to new groups, we renormalize the existing group weights, while preserving the ratio of time spent between pre-existing group affiliations, to ensure that $\sum_{i=1}^{n} w_i = 1$.

2.6 Presentation of the Model

Example pseudo-code summarising the evolutionary steps.

```
program Group evolution (Output)
 begin
   Set individual agent parameters;
      Set group parameters;
      Set affiliation of individuals to groups;
      Generation=0;
      repeat
         Initialize agent resources;
         Set to zero the received impact on groups;
         for i = 1 to num_rounds
               for j = 1 to num_agents
         j chooses group to act for, if they are affiliated with at least
         one (Section 2.3)
         j chooses group G to act upon (Section 2.3) action performed
         (Section 2.3)
         cost to j and impact on G recorded
   // perform evolution
   exclude individuals from groups (Section 2.4)
   include individuals in new groups (Section 2.5)
   Generation++;
   until Generation = Max_generations
end.
```

Above we summarize the overall pseudo-code that represents the simulation framework. Monitoring the weighting vectors throughout the simulation allows group size and shape to be assessed. We set Max_generations to be 100, num_rounds to be 100, num_agents to be 100, and resources to be 100.

3 Scenarios

We adopt a scenario of four groups as described in Tables 3 and 4, which documents how each of the four groups expect their members to behave towards other groups, and how tolerable they are to in-group impact and strict towards out-group impact. The social norm vectors defined in Table 2 determine these behaviors. In turn, the social norm vectors are specified by the actions in Table 1. In the scenario, G_0 is an extremist group that is strongly negative to all other groups, while the others (i.e., G_1, G_2, G_3) are negative towards G_0, but not extreme, and positive towards each other.

We note that the format of input in Tables 1, 2 and 3 means that interesting and complex scenarios can be defined and examined. The range of action types (Table 1) is extensible and can be specified to include a wide range of potential actions that are specific to a particular group or scenario.

4 Results

In this section we present proof of concept results that show how different assumptions affect the size of groups over time, and effects on multi-group affiliation.

4.1 Applying Tolerance but not Normativity Allows Extremist Groups to Dominate

We begin by exploring how in-group tension can form. Figure 1 shows the sizes of the four groups after each generation when tolerance (*ex-tol*$_G$ and *in-tol*$_G$, in Sects. 2.4 and 2.5 respectively) is the only measure used for inclusion and exclusion. Normativity criteria are not applied. In Fig. 1 and similar plots the y axis is cumulative.

The results (Figs. 1 and 2) show G_0 continuing to grow over time with the other groups shrinking. This occurs due to the heightened positivity in the social norms for G_1, G_2, and G_3, in comparison to G_0. Individuals perform generally positive actions

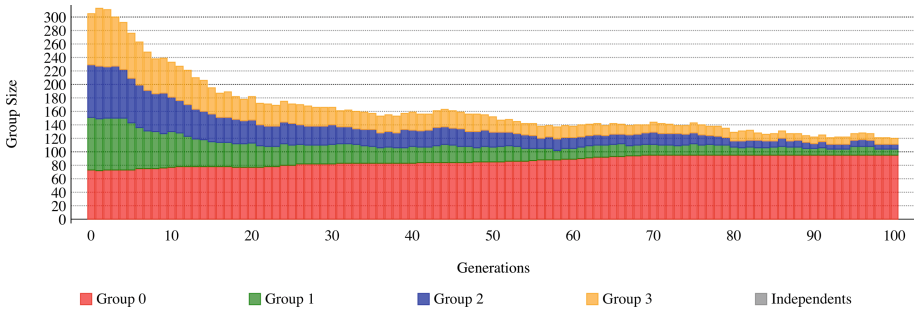

Fig. 1. Changes in group size based on groups only using tolerance but not normativity.

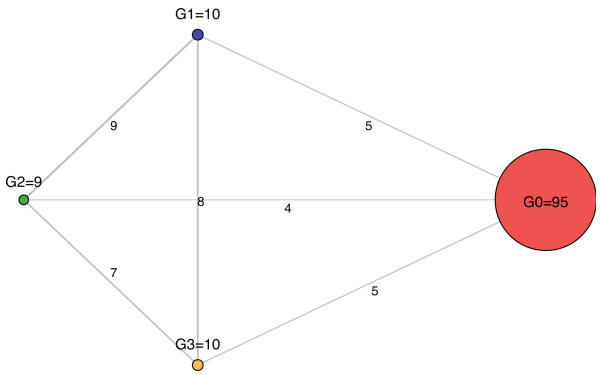

Fig. 2. Cross-group membership after generation 100 when only in-group tension is considered using *ex-tol*$_G$ and *in-tol*$_G$. Nodes are scaled proportionally to the group they represent. Edges represent the size of the intersection in membership between two groups.

towards G_0 when representing G_1, G_2, and G_3, presenting no barrier to inclusion to G_0. As the same time, individuals acting on behalf of G_0 perform negative actions towards the other groups, resulting in an increased chance of exclusion from G_1, G_2, and G_3.

Additionally since exclusion mechanisms are only based on the negative impacts received, extremist groups tend not to expel members that may be acting according to the social norms of mainstream groups. Members of G_0 are not invited into mainstream groups as they very infrequently perform any positive actions.

This is evident in Fig. 2, which shows the majority of members of G_0 cutting ties with the other groups by the time of generation 100, except for a small percentage, who are sustained through a the combined effects of mutation (i.e., random incidences) and use of individual identity and their own social norm (5% chance).

4.2 Tolerance and Normativity Lead to Group Stability, and Suppress Dominance of the Extremist Group

In contrast to Figs. 1, 2 displays the results when both tolerance ($ex\text{-}tol_G$ and $in\text{-}tol_G$) and normativity ($ex\text{-}strict_G$ and $in\text{-}strict_G$, in Sects. 2.4 and 2.5 respectively) are applied in the inclusion and exclusion processes. The results show that considering how members act towards other groups impedes G_0 from growing. All groups co-exist over time with relative stability, which is without any one single group dominating.

The greater number of mainstream groups means that there is a greater chance of individuals acting towards G_0's out-groups in a manner that it deems incompatible to expectations. This reaffirms the presence of the groups G_1, G_2, and G_3. It also indicates that the number of groups, as well as their size, impacts on the dynamics and this is worthy of further investigation.

This is also reflected through individuals in G_0 cutting ties with other groups, with Fig. 4 showing all members of G_0 cutting ties by generation 100 (a small number occasionally re-appear for a short period through the subsequent generations, due to mutation). In contrast, members of the mainstream groups are more capable of maintaining strong ties among each other and this reaches a 100% level of shared membership after a relative short number of generations.

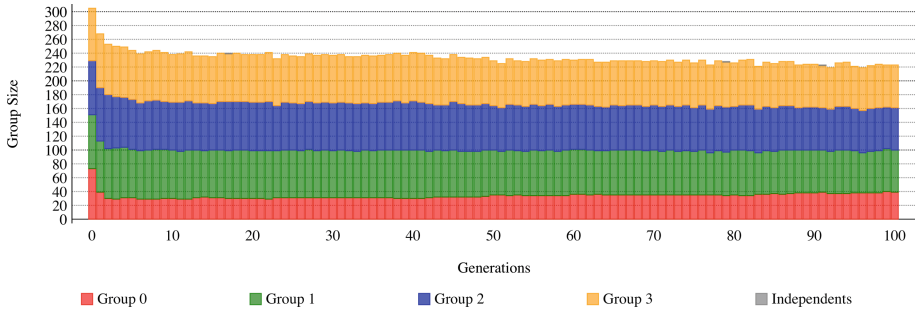

Fig. 3. Changes in group size based on groups only using tolerance and normativity

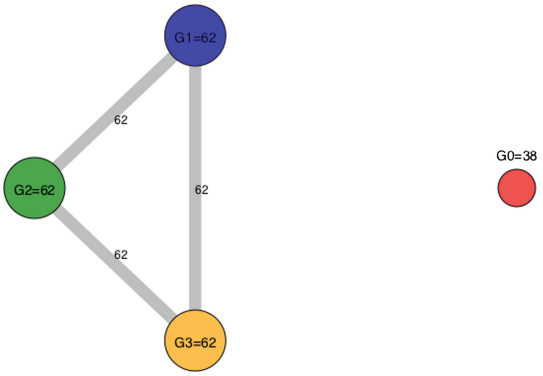

Fig. 4. Cross-group membership after generation 100 when both tolerance (*ex-strict*$_G$ and *in-strict*$_G$) and normativity (*ex-strict*$_G$ *and in-strict*$_G$) are considered. Nodes are groups sized proportionally with the number of members and edges represent the size of the intersection in membership between two groups.

It is also worth commenting that during the course of this investigation, we experimented with the extent of the strictness parameter for normativity, particularly for G_0. Under definition of the parameter, increasing the parameter increases leniency, potentially increasing the pool of individuals that can be admitted to G_0. We find that due to the extreme social norms of G_0, high levels of leniency (e.g., >.98) are required to substantially increase the size of G_0. This destabilizes the scenario allowing G_0 to dominate. This also reflects the potentially crude nature of the judgment process used to model normativity.

In Fig. 5 we show the number of inclusions and exclusions that occur over course of the simulation. The results show high levels of changes to initial membership, which is due to the random allocation of group membership at the beginning. However, after around 10 generations this reduces and any events predominantly due to mutation or the resulting change in behavior due to mutation (discussed in Sect. 2.5). This supports the findings in Fig. 4: under these conditions the population quickly divides between positive and negative norms.

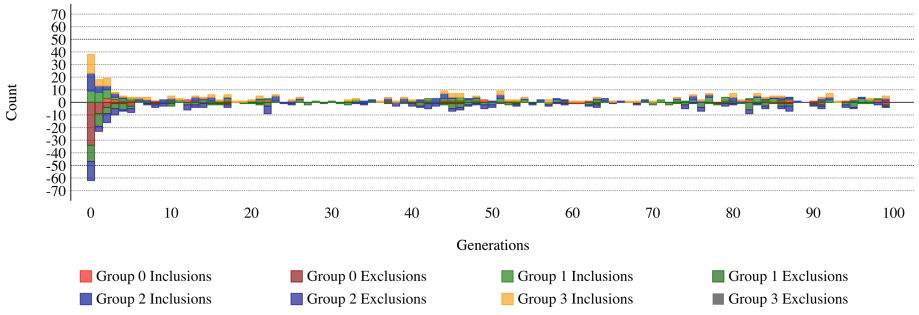

Fig. 5. Changes in group size based on groups only using tolerance and normativity

A final observation is that some individuals occasionally get excluded from all groups and become independent. However, this is unsurprisingly short-lived (as shown in Fig. 3), because when this happens individuals revert to their own social norms, which for this scenario, align closely with those used in at least one group.

4.3 Prohibiting Re-admission to Groups After Exclusion Marginally Affects Mainstream Groups More Than the Extremist Group

Figure 6 shows the effect of prohibiting re-admission to each group after their first exclusion. Once individuals become affiliated in the extremist group, their affiliation with other (mainstream) groups is severed (Fig. 4). This is occurs as a consequence of the mainstream groups executing exclusion. As extremist group members are more likely to be isolated to that group, there is much less a likelihood of them acting on behalf of other groups in an incompatible way.

As a result we observe that the extremist group G_0 tends to remain relatively static in size while the mainstream groups tend to marginally decline in membership (Fig. 6). At the same time the number of individuals without affiliation to a group grows.

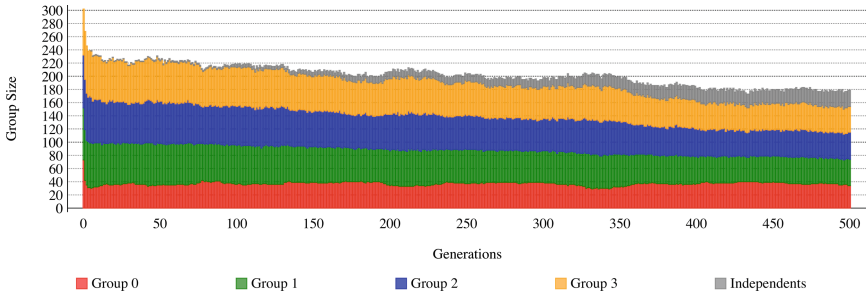

Fig. 6. Group size over 500 generations when re-admission to groups is prohibited.

5 Conclusions

The results demonstrate a first proof of concept for a model concerning the tensions on individuals that belong to multiple groups where expectations on behavior differ. This is a new approach to modeling groups that allows us to assess the changes in a group's size as a consequence of behavioral social norms of groups and the affiliation of individuals between them. The model represents a group's identity behavioral expectations (social norms), which can also be included for individuals.

The model allows observation of the natural tensions that exist between belonging to multiple groups when their social norms differ. Consequently we can use the model to gain insight into the features that influence the evolution of particular types of groups, such as those with extremist tendencies.

From testing, the initial results exemplify conditions that affect the stability and growth of groups. In particular, the judgment processes that groups apply for inclusion

and exclusion have a significant effect. Extreme groups prosper, in terms of recruitment, when they are in-group focused, making judgments only based on the extent of negative actions done towards them by individuals. As soon as extreme groups judge potential members based on their actions towards the out-groups, this restricts admission and their subsequent growth, unless there is extreme leniency. This reaffirms that recruitment strategies for extreme groups may masquerade in mainstream forms to gain traction.

The results also show that individuals can successfully coexist in mainstream groups while membership of an extremist group requires that individuals sever their affiliations with other groups. Numbers of groups and their relative similarity also appear to influence potential growth of groups, and this warrants further exploration.

5.1 Future Work

In summary, the model represents an interesting framework for considering group dynamics based on the natural tensions that exist between behavioural expectations. It can be extended and refined in a number of directions to include group-based scenarios for wide ranging situations, and with additional levels of detail. This development can also include modeling interventions and assessing their effects, with calibration of parameters based on real world scenarios. Further contextual factors, individual differences and group effects can potentially be included. These will support future generative modeling capability, which is currently at a formative stage.

Acknowledgements. This research was sponsored by the U.S. Army Research Laboratory and the U.K. Ministry of Defence under Agreement Number W911NF-16-3-0001. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the official policies, either expressed or implied, of the U.S. Army Research Laboratory, the U.S. Government, the U.K. Ministry of Defence or the U.K. Government. The U.S. and U.K. Governments are authorized to reproduce and distribute reprints for Government purposes notwithstanding any copy-right notation hereon.

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Security Challenges in the 21st Century: The Changing Nature of Risk, Security and Sustainability

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Abstract. Security concerns facing the United States today are broader and more complex than at any time in our history. They range from concerns arising from threats to systems that allow society to control intergroup and interpersonal conflict to more recently recognized concerns associated with threats to social and economic systems, and threats to the natural/environmental systems on upon which society depends. Each major type of threat represents a form of "fat-tailed risk," where extreme consequences are far more likely than expected but possess significant uncertainty regarding their severity and timing. Each type of threat shares the common characteristic that some elements are non-negotiable because they contain requirements that society must address to avoid or suffer irreparable consequences. Based on these assessments, we discuss the implications of societal threats on the development of global institutions, cooperation, social justice and human rights.

Keywords: Security · Fat-tail risk · Conflict economic systems · Social systems · Climate change · Environmental systems

1 Introduction

The security challenges facing the globe today are far more complex and interrelated than at any point in our history. Evidence suggests that as intergroup and interpersonal conflict has begun to recede, there has been a corresponding escalation of other, less understood known threats including threats to the natural, economic and social systems we have developed upon which society depends. This paper examines some of the differences, commonalities, and interconnections that exist among the major types of societal risk. Each of these dimensions adds to the complexity of threats facing society, but also creates the potential for developing integrated strategies that produce multiplicative returns on societal investments and initiatives. The paper will also examine the extent to which we are entering into a post-Nash Equilibrium context where society must meet externally imposed requirements for reasonably sustainable development.

M. Hoffman (ed.), *Advances in Cross-Cultural Decision Making*,
Advances in Intelligent Systems and Computing 610, DOI 10.1007/978-3-319-60747-4_17

2 Intergroup and Interpersonal Conflict: Successes

Recent scholarship has convincingly argued that intergroup and interpersonal violence has declined exponentially since the era of Enlightenment, reaching an all-time low at the turn of the twenty-first century. Despite accounts of the threat of Islamic terrorism, urban homicide and other violence, systematic analysis of data on rates of violence over time suggests that "today we may be living in the most peaceable era in our species' existence" [1, p. xxi]. These developments are in sharp contrast to past history. Before the onset of the Enlightenment and development of the nation-state, existence was brutal, short and violent for most. During the Medieval Ages in Europe, for example, "States were ineffectual, and the king was merely the most prominent of the noblemen, with no permanent army and little control over the country. Governance was outsourced to the barons, knights, and other noblemen who controlled fiefs of varying sizes, exacting crops and military service from the peasants who lived in them" [1, p. 67].

However, along with the development of the nation state, over the last 600 years, there has been a huge decline in both interpersonal and intergroup violence in Europe. From "the 13th century to the 20th, homicide in various parts of England plummeted by a factor of ten, fifty, and in some cases, a hundred" [1, p. 60]. In 14th century Oxford, there were 110 homicides per 100,000 people; in mid-20th-century London, there was less than one homicide per 100,000 [2, pp. 303–313]. Research by Eisner [3] similarly shows a massive decline in homicide in five Western European countries between the 14th and 21st centuries. Over an even longer time span, the overall homicide rate for much of human society declined from "triple-digit values" (i.e., homicides per 100,000) for pre-state societies and double-digit values for medieval Europe [1, p. 87] to worldwide homicide rates of under 10 per 100,000 as based on WHO estimates in 2000 [4].

On an international level, society has become increasingly effective in its commitment to peacekeeping operations since the 1980s and allocated greater resources to peacekeeping initiatives. Moreover, according to research by Fortna [5], the presence of peacekeepers in a society transitioning from conflict reduced the risk of a re-escalation of intergroup conflict by 80 percent. The reasons for the effectiveness of such interventions are at least threefold. Firstly, strong peacekeeping forces can directly respond to violence by a violating regime. Secondly, the process of facilitating an agreement through the presence of international forces can act to appease non-state actors by granting them acknowledgment as political leaders [5]. Thirdly, "The very act of accepting intrusive peacekeepers is a costly (hence credible) signal that each side is serious about not attacking." [1, p. 315]. The progress identified in these assessments, however, is at least partially mitigated, by the emergence of significant civil conflicts in the Middle East over the last five to ten years.

The most impressive effort to control violence over the last 70 years has been the world's success in avoiding the existential threat of nuclear war between major powers. This achievement has been accomplished by the development of international and bilateral agreements that have greatly reduced the risk of major power nuclear war. These agreements include the 1968 Non-Proliferation of Nuclear Weapons Treaty, the Strategic Arms Limitation Talks (SALT) of 1972 and 1979, the Strategic Arms

Reduction Talks (START) a decade after SALT, and most recently the Joint Comprehensive Plan of Action (JCPOA) commonly known as the Iran nuclear deal [6]. However, it was also achieved through an emerging recognition that nuclear meant mutual assured destruction or MAD [6].

These remarkable reductions in interpersonal and intergroup violence have been attributed to a set of parallel developments. As argued by Pinker [1], five major developments helped societies become less violent. They include the development a Hobbesian Leviathan state, possessing a judiciary with a monopoly on the legitimate use of force and norms and institutions that enabled societies to defuse the temptation of exploitative attacks, inhibit impulses for revenge, and circumvent the self-serving biases that of parties in conflicts. The emergence of commerce as technological progress increasingly supported the exchange of goods and ideas over longer distances and among larger groups of trading partners. In such a positive-sum game where increasing numbers of people could win, other people become more valuable alive than dead, and as such, they are less likely to become targets of demonization and dehumanization. The development of cultural norms that respect the interests and values of women and empower women help societies move away from the glorification of violence, and are less likely to breed dangerous subcultures of rootless young men. Increasing cosmopolitanism through literacy, mobility and mass media can prompt people to take the perspective of people unlike themselves and to expand their circle of sympathy to embrace them. In addition, an intensifying application of knowledge and rationality to human affairs can help people recognize the futility of cycles of violence, ramp down the privileging of their interests over others', and reframe violence as a problem to be solved rather than a contest to be won [1].

From a game theoretic perceptive, the developments identified by Pinker [1] and others can be thought of as societies developing sets of institutionalized Schelling points, which he describes as "focal point[s] for each person's expectation of what the other expects him to expect to be expected to do" [7, p. 57]. Here we are referring to societal values, norms, agreements, laws, and institutions as focal points that act as agreed upon and often enforceable guideposts for highly complex and dangerous interactions. These institutionalized guideposts have provided mechanisms for addressing violence and conflict as societies had come to understand them by the end of the 20th century. However, these are not simply lessons of the past, nor is this discussion limited to a dialogue on conflict and violence. As new threats emerge, whether they be in the field of conflict, economy, natural/environmental systems or beyond, society can learn from these past successes and develop and implement new Schelling points (e.g. values, laws, institutions) to confront emerging societal threats.

3 Intergroup and Interpersonal Conflict: Emerging Threats

Despite the past advances in addressing conflict, rapid technological developments are emerging that may greatly exceed the ability of established societal values, norms, laws and institutions to reduce or even control violent conflict. James Clapper, the former U. S. Director of National Intelligence (DNI) in his testimony to the Senate Armed Services Committee on the Worldwide Threat Assessment of the US Intelligence Community

(February 9, 2016), outlined how technological advances can put at risk the basic elements of our society such as power and cyber infrastructures, financial services, health systems, transportation systems, etc. as they become more and more interconnected and also dependent on intelligence devices that are potentially "susceptible to a range of disruptive and deceptive tactics that might be difficult to anticipate or quickly understand" [8, p. 1]. Taken together technological advances in the computer and information technology are rapidly increasing the potential impact of cyber terrorism and warfare in ways that are not anticipated, fully understood or prepared for by the international community, nation states, corporate entities or individuals.

Technological advances in what are termed dual-use technologies may enable less technologically advanced nations and even small sub-state groups to potentially commit great harm to society in the future. For example in the area of biological weapons, James Clapper states "that given the broad distribution, low cost, and accelerated pace of development of the dual-use technology, its deliberate or unintentional misuse might lead to far-reaching economic and national security implications" [8, p. 6]. In the area of biological weapons, cost reductions in powerful dual-use technologies are proceeding at almost unimaginable rates. For example, the cost of sequencing a human-sized genome, a dual-use technology has declined from $95,263,072 in September of 2001 to $1,245 to October 2015, a 99.9% decrease [9].

Technology can also significantly increase the endogenous effect of violence on societal decision-making. Today's communications technologies have the ability to dramatically amplify and sensationalize acts of violence that in turn may drastically alter political dialogues and policy and often produces unanticipated and unrecognized outcomes. Thus although society typically focuses on how to control violence, there is relatively less focus on how even low impact violent events can impact political and societal choices.

Dual-use and other technologies represent threats to society, which currently does not have the systems in place to respond effectively to such threats. The key point is that these technological developments present risks of very severe consequences with an unknown but potentially very high probability of occurring. Unfortunately, they also represent developments that society is only beginning to assess and develop institutional standards and norms to control them. Only recently, the president of Microsoft proposed convening a Geneva Convention on Cyber Warfare [10].

Other externalities may disrupt our current ability to deal with violence and two of which, the economy and climate change, are examined in the following sections. However, despite progress in controlling violence, society is now facing another round of challenges that will require additional enforceable Schelling points. These undoubtedly will require stronger international coordination and regulation, something that is becoming less popular in a number of developed nations.

4 The Challenge and Opportunity of Economic Change

Between the end of World War II and the 1980s, the world witnessed historic economic gains by the United States, followed by Europe, Japan and later by various South East Asian nations, including of Korea, Singapore, China (Hong Kong) and Malaysia.

The two decades following the 1980's saw dramatic reductions in extreme poverty among developing countries across much of the world, and they witnessed a dramatic growth in middle-class level incomes in select South East Asian nations, especially China and to a lesser extent India [11]. However, during this same period much of the world has also experienced significant economic challenges that have negatively affected the stability of many countries, and the well-being of their citizens in unanticipated ways.

This period has witnessed increasing instability and increasing inequality in select labor markets, increasing economic insecurity among previously advantaged middle-class citizens of developed nations and continuing extreme poverty across a large number of nations. Inequality has increased in unexpected ways both within nations and across nations [11]. It also appears to have increased regionally within a least some nations (e.g., the Rust Belt in the US and Silicon Valley). In recent decades, incomes in developed nations have risen dramatically for the top one percent of their citizens but have stagnated or declined for many of their middle-class citizens [11] and decreased significantly for less educated members of their societies [12].

A great amount of research indicates that four major global forces are at work for most of the economic trends observed over the last three-plus decades. The four forces are the usual suspects of globalization, technology, financialization, and a weakening of social support systems [12]. Each of these forces is credited with contributing to an observed growing disconnect between wages earned by salaried workers and the productivity of workers [12]. Much discussion has revolved about the impact of globalization and technology on labor force jobs and wages. The globalization of trade along with the financial flexibility and incentives to improve operational efficiencies and lower the costs of production is recognized as motivating business enterprises to move the production of goods and services to lower-wage regions. This is credited with having had a significant effect on lowering or constraining the wages of workers in regions that lose jobs to other locations [11, 12].

Globalization and technology have also been identified as key sources of the overall loss of jobs from at least some higher wage nations to lower wage fast developing countries [11, 12]. More recently, fears are rising that technology may produce significant net jobs losses across both developing and developed countries as the pressures of competition to increase efficiency push enterprises to substitute capital for labor especially as the cost of technology decreases and as knowledge about how best to integrate technology into enterprise operations increases [13]. Integration of innovative technologies typically takes longer than anticipated but then later produces unexpected increases in productivity as they are integrated into enterprise operations and procedures [14].

The extent of such expected job losses has been debated with fairly divergent projections arising from different methodological approaches. The most extreme job loss projections due to technological advances and automation come from Frey and Osborne who found that 47% of US jobs are at risk of being automated [15. p. 25]. Using a methodology, based on the automation of job tasks versus the occupation-based approach used by Frey and Osborn, McKinsey Global Institute estimates that although less than 5% of all current occupations contain job tasks that are 100% automatable, at least 30% of job task profiles are automatable for about 60% of

current occupations [13]. They argue that workers in occupations classified as vulnerable to automation may, in fact, be less exposed than previously thought, because they perform a substantial share of non-routine interactive tasks, which are known to be less automatable, at least in the present. Using this methodology, Arntz, Gregory and Zierahn [16] conclude that only 9% of OECD jobs are potentially automatable.

These divergent projections highlight the challenges of projecting job loss due to technology, but there is reason to consider that the potential severity of risks arising from technology may tilt towards more disruptive societal consequences. The potential for a more negative prognosis rests on considerations not generally addressed in current labor market research, which include the need for more direct feedback from business leaders and managers and an under-appreciation for ongoing systemic changes in commercial markets and the labor force structure. Regarding business leader feedback, there are now suggestions that Artificial Intelligence (AI) may be replacing or greatly reducing the need for workers with advanced analytic skills [17]. This suggests that over the longer term AI will have an increasing ability to handle very complex tasks and managerial decision-making and thereby reduce the number of workers required to conduct them. Like manufacturing, human workers will still be required to manage and assess the work of AI systems, but many fewer workers will be required actually to do the work. These may represent currently higher order cognitive and better-paid occupations such as accounting and perhaps financial services.[1]

In addition, technology and globalization also produce what can be termed winner-take-all remuneration structures across industries, within enterprises, and across different regions and countries [11]. At the worker level, technology is creating the phenomenon of scalable jobs where a person's unit of labor can be sold many times over again with no extra effort [11, 18]. Thus in the past, an individual pianist could only give one concert at a time (and thus there was a demand for multiple pianists to give concerts) today one pianist can distribute music to anyone across the world. If this person is deemed the "best" pianist then there is significantly less need for additional ones. Likewise, information technology companies are increasing providing cloud-based centralized management and security services to business enterprises. The businesses that purchase such services are then able to then replace their own IT workers or reassign them to more routine and lower paid work. This creates a situation where very small differences in individual talent, training or luck can lead to the very large income differences across workers. In this example, a manager of centralized technology services probably draws a much larger salary than the IT specialists supplying centralized services and these relatively few centralized IT service workers likely receive much better wages than do IT workers working for individual business enterprises. This dynamic appears to create very large wage differentials and produce a reduction in the total number of workers required in a given occupation.

At a nation state level, technology and globalization also appear to be creating winner-take-all processes between regional economies. The productive capabilities of

[1] Nearly, all researchers caution that the rate of technological innovation will likely disrupt labor markets in the short run, as workers may not be able to adapt easily to the new skills or jobs that emerging labor markets require [16].

technology combined with national/regional prior advantages (e.g. low wages. highly educated workforce, pre-existing economic organizational conditions, existing financial services/incentives, natural resources, etc.) give regions or nations the ability to dominate particular industries. Moreover, the increases in productivity that technology provides can make it difficult and unnecessary for other nations/regions to try to enter a dominated market. That is to say, only so many Germanys are needed in Europe, and if say Italy was to become 25% more productive than Germany, then much of German industry would no longer be needed. The result is that labor market and income inequities have grown in ways that help create social and political instabilities in unexpected or at least unaddressed ways. Thus, Middle Eastern countries have some of the highest youth unemployment rates in the world, which has likely added to social unrest in those nations, and over the last 30 years, middle-class citizens of developed nations have experienced deteriorating economic circumstances, which has contributed to political alienation and xenophobia among individuals hardest hit in those nations.

Beyond labor market instabilities, today's economic and financial systems have shown significant instabilities often in unanticipated ways. After the onset of the 2008 recession, everyone asked why no one saw it coming. Since then economists and other experts have failed to develop reliable explanatory models of the economy and financial system that would allow us to assess and respond to or better yet prevent such crises. Galbraith [19] argues that for a variety of reason current economic systems are inherently unstable over the long run and subject to crashes of varying but unpredictable severity. He postulates that these systems tend to create unstainable bubbles as actors (individuals and enterprises) within the system begin to engage in risky behavior or even corrupt practices to advance themselves often at the expense of other actors. Moreover, these tendencies often go unrecognized or are consciously ignored by an individual with the most to gain from the systems while they are stable and growing. However, at some point, as in the financial crisis of 2008, inconsistencies in the systems build to such a point that they unexpectedly collapse in highly destructive ways [19]. In the wake of such collapses, those most disadvantaged often suffer the most. In the period following the 2008 crisis, unemployment rates rose in Middle Eastern countries, in financially stressed Southern European nations [12], and even in selected middle-class groups in developed nations. These shocks further aggravated already unstable conditions in at least some of these nations.

Apart from economic circumstances, technological change and globalization also are producing unanticipated destabilizing pressures on cultural traditions, individual's social statuses and the connection of individuals' to their societies. This can be tremendously stressful and disorienting for persons experiencing such change. The World Economic Forum (WEF) reports that deepening "social and cultural polarization" [20, p. 24] is a significant trend factor that can undermine democracy. Giddens [21] terms this the process of "detraditionalization" and contends that in a globalizing world, individuals are increasingly in contact with others who think differently and live differently, from themselves. This occurs through the almost omnipresent exchange of digital information and images that are now routinely transmitted across the globe, and also occurs even more directly through the ongoing massive migration of rural populations to urban areas in developing countries. Individuals benefiting from these processes welcome them, whereas those who do not benefit or understand such

development may find them disturbing and threatening. Individuals who are threatened by such developments may revert to traditions that are familiar to them, whether in the form of religion, ethnic identity, gender identity or nationalism. Such processes produce stresses on the individual that make it easier to fuel divisiveness between different groups of actors, which can be exploited by leaders of opposing factions [22, 23]. In fact, the salience of populist movements has been associated with framing job insecurity as an outcome of globalization [24]. Such outcomes can lead in unexpected ways to intergroup conflict or, more subtlety but equally negative, major misallocations of societal resources (e.g., guns versus societal investments).

Over the last 70 years, our current economic systems and technology have produced unparalleled economic growth, lifted large numbers of humans out of poverty and created new and growing middle lifestyles in developing nations. At the same time, continued progress is not at all guaranteed. The global character of economies and the financial industry along with rapid technological change produce growing equality and high levels of stress, anxiety and in some cases anger among those who have become disadvantaged by the economic and social change. More generally, today's economic and financial systems are prone to potential severe instabilities in fairly unpredictable ways. Finally, our economic system and the profit orientation of our financial systems have accumulated what amounts to as massive environmental debts that must be paid for society to survive. Addressing the challenges presented by our economic and technology systems will undoubtedly require stronger international coordination and regulation, something that may meet increased resistance from rising nationalism in some countries.

5 Threats to the Natural/Environmental Systems

Threats to natural systems, upon which society depends, represent the most obvious case of how humans must address externally imposed requirements or suffer severe and perhaps catastrophic consequences. These requirements represent the range of material conditions required for natural systems to continue to support sustainable human communities. The causes and inevitability of climate change are well documented by an extensive body of research across a broad range of scientific disciplines [24]. The severity and especially the timing of potential consequences of climate change are being debated but the prospect of potentially very severe consequences on a human time scale (e.g., one to several generations) are quite possible and not easily correctable once climate systems equilibria have changed [25]. In addition, climate scientists continue to discover positive feedback loop processes (e.g., the increasing escape of the greenhouse gas methane from thawing permafrost and from warming ocean floors) that may accelerate climate change [26].

The impact of climate change on social and economic systems over the next century include the potential to undermine the world food supplies and access to fresh water, increase the prevalance of infectious deseases, increase sea levels and bring about extreme weather events, such as droughts, heat waves, tropical storms [26]. Such conditions, not only directly affect the well-being of individuals who experience them but also can indirectly affect society by producing unexpected displaced populations

and more generally destabilizing communities. The civil war in Syria has been associated with a severe drought that internally displaced 1.5 million citizens from rural to the urban area of Syria before the civil conflict that started in 2011. Climate modeling research, "indicate that a drought of the severity and duration of the recent Syrian drought, which is implicated in the current conflict, has become more than twice as likely as a consequence of human interference in the climate system" [27, p. 3241].

The key challenge to addressing climate change is the need to develop and implement global strategies and institutions that will keep our climate within the environmental system boundaries necessary to support sustainable human societies. One of the clearest general strategies was recently published in the journal Science [28], which proposes establishing a carbon roadmap, based on the simple principle or "carbon law" of halving greenhouse gas emissions every decade" [28, p. 1269]. Rockström et al. [28] argue that such a roadmap can help align actors and organizations to implement technological and institutional breakthroughs necessary to meet the collective challenge of climate change. They also note that, if political signals do not support rapid economic systems transitions, "for example, by a failure to implement worldwide financial and regulatory reform that places a cost on carbon, then it is difficult to imagine keeping warming" [28, p. 1271] at levels considered essential to avoid severe climate change related consequences.

Critically, like threats arising from intergroup conflict or instabilities in our social and economic systems, addressing the challenges of climate change and environmental degradation will require developing and implementing new external standards and that in turn will require much greater levels of cooperation among members of the global community.

6 Summary and Conclusions

The interconnected and interdependent structure of the comprehensive threat environments described above, along with the often unpredictable and uncontrollable threat outcomes and cascading impacts associated with fat-tail threats follow a dynamic complex system structure [29]. In each case, society may need to meet requirements that are either externally imposed, unknown or both to establish reasonable levels of security. Each of the threat areas examined here essentially contains at least some non-negotiable conditions that must be met on their terms and not on terms established by human actors. These conditions are perhaps most obvious for climate and other environmental systems upon which society depends. However, externally imposed limits can also apply to intergroup related conflicts that can escalate into nuclear or biochemical confrontations or for social and economic systems that can fail in unexpectedly destructive ways. The non-negotiable character of such threats can arise due to society's dependence on natural, economic and social systems. The external and unknown origin of such failures along with their ubiquitous consequences greatly increases the need for cooperation between actors across the globe if we are to successfully address the risks they entail. Competition among actors on the global stage will likely result in a failure to meet these externally imposed conditions. The unpredictable timing and severity of these risks suggest that the global community will also

need to take a long-term insurance-oriented investment strategy to address these challenges.

Finally, the external nonnegotiable character of threats facing society today will require the development of global institutions, international and national cooperation, along with value systems and norms that better support social justice and human rights. Such institutions and norms will better enable society to engage in broad based longer term strategies to address these threats. Critically, since identifying specific causal mechanisms associated with fat-tailed threat is often difficult to accomplish, investing in strategies that can yield multiplicative benefits may be the most productive avenue to establishing more secure, resilient societies. Fortunately, the fact that each type of risk is deeply interdependent with the others raises the likelihood that addressing one area may yield multiple benefits across other areas.

Acknowledgements. We would like to acknowledge the contributions of Eileen Kirk for her editorial and research support as well as of Parth Baxi and Sarah Schulte for their research assistance in the early stages of this project.

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Intelligent Systems and Applications

Incorporating the Cultural and Decisions Factors in Multi-objective Optimization of Air Conditioning Conduit Design Process

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Abstract. Various engineering designs are multi-objective as they contain more than one design goal to be optimized. These design goals theoretically inflict differing requirements on the technical performance of system design. To analyze the trade-offs amongst conflicting design's multi-objectives and to explore respective design options, an optimization problem with multi objectives has been mathematically modeled in this paper. In the present work, multi-objective optimization of air conditioning conduits and nets design is formulated. The design factors also consider the cultural as well as quantifiable, subjective ergonomics constraints and control decision-making factors. The cultural constraints, such as geographical, historical, sociological, and organizational constraints that determine the efficiency of the design of these nets are also incorporated in the objective function. This is reproduced during the option of filtration and selection from the solutions population generated at the locals and other levels, in which influences of cultural factor and of the decisions making factors are reflected in the subjective preferences.

Keywords: Multiple objective optimization · Optimization · Multi-criteria optimization · Modeling · Ergonomics · Design · Decisions making · Mathematical modelling

1 Introduction

The Multi Objective Optimization problems with respect to modelling is challenging research subject as the objective functions, problem parameters and constraints are challenging to model. Optimization and multi-objective optimization both have gathered researchers for mutli domains like engineering and mathematics, to developed solutions for Multi-Objective Optimization Problems. The application of multi-criteria

M. Hoffman (ed.), *Advances in Cross-Cultural Decision Making*,
Advances in Intelligent Systems and Computing 610, DOI 10.1007/978-3-319-60747-4_18

optimization methods on air conditioning systems has been basically aimed at ensuring adequate thermal comfort, indoor air quality and energy savings. Parameshwaran et al. [1]
applied genetic algorithms (GA) and fuzzy logic to conserve energy in systems with variable air supply (VAV). In some research studies [2] a predictive model based on artificial neural networks (ANNs) is shown, which is improved by a particle swarm optimization algorithm that controls the air temperature and the adjustment of the static pressure in the duct is discussed. On the other hand, Bau et al. [3], show a tool for the simulation of adsorption air conditioning systems by multi-criteria optimization combining genetic algorithms and Modelica with MatLab. The use of CAD systems for the design and simulation of fluid (CFD) allows perfecting the configuration of the components of the system [4]. In [5], the research tool RR-PARETO2 is presented, which supports multiple criteria decision-making in the design of HVAC systems according to the selected efficiency indicators. In [6], a detailed simulation method to evaluate the energy consumption is proposed, modifying the service areas and the number of flow drive equipment coupled to the net.

The present research focuses on the design stage of air conditioning networks, as a starting point to achieve its good performance. Starting from the path that the network will follow in building and characterizing the spaces to be serviced, a multi-criteria optimization algorithm will provide an orderly series of design proposals that meet the objective criteria (installation cost, level of conduction losses and noise level in spaces to acclimatize). Few researchers also applied linear convex optimization and DSM techniques to optimize problems where the system was linear and definite precedence was present in the system [7, 8] with multi objective functions targeting one at time. Some research studies on multi-objective optimization on applied engineering problems shows near optimal solutions [9–11] with various approaches.

2 System Analysis

The Computer aided design (CAD) system developed for air conditioning conduits nets design is subordinated to a higher system, devoted to the civil constructions design with its all component elements, which will give service and the designed air conditioning nets as shown in Fig. 1. In such a way, the CAD system under study receives the drawings of the construction and in these, all the constructive details of the locals

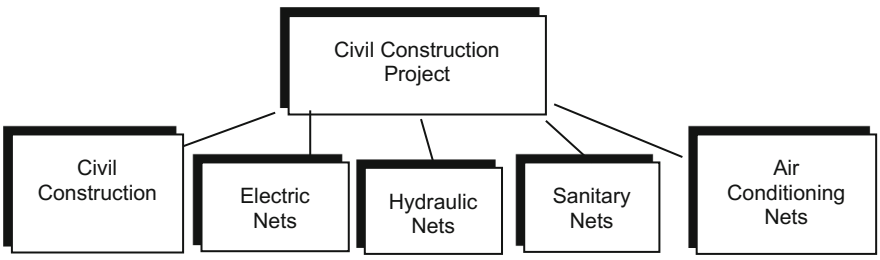

Fig. 1. Civil construction Project and decision making system

are acclimatized. CAPP system should receive from the CAD the indispensable information to plan the production process for the non-standard elements of the air conditioning net [4, 5].

The air conditioning conduits nets design is subordinated to a higher system: the design of civil construction with all its component elements, to which the designed air conditioning nets will lend service. In such a way, the design starts by the graphical information of the construction. Then, the conduits net design task will entail the construction of the air distribution net for each one of the branches that make arrive the fluid to the locals, with all its constructive elements, assuring general efficiency criteria.

2.1 Coordination Variables

These are derived from the more span system and are given by the construction's project. Among the most important variables are:

- Designation of every room i of the branch $j = \varphi_i$ of de networks: $Desig_{i,j}$
- Flow intensity values required for each of the rooms, that are calculated departing from the room constructive and functional characteristics, as well as its orientation: $FluLocR_{i,j}$
- Recommended speed values for the rooms according to their designation: $VelcR(Desig_{i,j})$
- Maximum height in stretch h, room i of branch j determined by the edification: $AltMaxTra_{h,i,j}$

In the projection of air-conditioning duct networks in edifications, predominated as *efficiency indicators* the following:

- Minimal cost of installation considering the expenses of materials and manpower: $\boldsymbol{C}$
- An appropriate charge loss level in the duct when supplying air to the rooms: $\boldsymbol{P}$
- An appropriate level of noise generated by the system: $\boldsymbol{R}$
- Maximum "satisfaction" of the investor and the future users of the net with the network design, (non-quantifiable indicator).

2.2 Decision Variables

The following are the most outstanding *decision variables*:

- Amount of branches in the network: J_t
- Amount of rooms in branch j: I_j
- Branch number to which the room i belongs: φ_i
- Trajectory of the network inside room i, branch j: $Tray_{i,j}\left(CantSal_{i,j}\right)$; $\forall_i \in I_j = \{i/j = \varphi_i\}$; $j = 1, \ldots J_t$
- Stretch h profile in room i, branch j of the network: $Perf_{h,i,j}$; $\forall_h = 1, .., h_t\left(Tray_{i,j}\right)$; $i \in I_j; j = 1, \ldots J_t$

- Duct material in stretch h, room i, branch j: $Mat_{h,i,j}; \forall_h = 1,..,h_t\left(Tray_{i,j}\right)$; $i \in I_j; j = 1,...J_t$
- Type of diffusers that will be used in room i, branch j of the network: $SalLoc_{i,j}; \forall_i \in I_j; j = 1,...J_t$
- Type of accessories in stretch h, room i, branch j: $Acc_{m,h,i,j}; \forall_m = 1,2; h = 1,..,h_t\left(Tray_{i,j}\right)$

3 Conceptual Mathematical Modelling of System

The supposition that the designer determines the amount of branches in the network J_t, the amount of rooms in each $j(\boldsymbol{i}_j)$ branch, the branch number to which each $i(\varphi_i)$ room belongs, the trajectories of the branches to the entrance of every room ($Tray_{i,j}$; for $i = 0$), the ascending and descending direction changes of the trajectory ($DesSup_{h,i,j}$; and $DesInf_{h,i,j}$) constitutes the basis of the following mathematical formalization. So, the values of these variables are already known. Starting from the external analysis exposed previously, we can deduce the following structure of the conceptual mathematical model:

$$\textbf{Minimize} \quad \boldsymbol{Z}(\boldsymbol{x}) = \left\{ \sum_{j=1}^{j_t} \boldsymbol{Z}^{\boldsymbol{j}}\left(\boldsymbol{x}_{\boldsymbol{j}}\right) + \boldsymbol{\varepsilon}_0(\boldsymbol{x})/\boldsymbol{xD} \right\} \tag{1}$$

Where:

$Z(x)$: Objective function v alue as a function of the decision variables$x$.

$\boldsymbol{Z}^{\boldsymbol{j}}\left(\boldsymbol{x}_{\boldsymbol{j}}\right) = \left[\boldsymbol{C}^{\boldsymbol{j}}\left(\boldsymbol{x}_{\boldsymbol{j}}\right), \boldsymbol{P}^{\boldsymbol{j}}\left(\boldsymbol{x}_{\boldsymbol{j}}\right), \boldsymbol{R}^{\boldsymbol{j}}\left(\boldsymbol{x}_{\boldsymbol{j}}\right)\right] \in \Re^3$: Efficiency indicators vector of the j branch of the network design.

$\boldsymbol{\varepsilon}_0(\boldsymbol{x}) = (\Delta \boldsymbol{C}, \Delta \boldsymbol{P}, \Delta \boldsymbol{R}) \in \Re^3$: Efficiency indicators vector increment caused by the entrance intersections to the branches, the need of introducing noise muffling elements, etc. required for integrating the different branches.

$\boldsymbol{x} = (\boldsymbol{x}_1, \ldots, \boldsymbol{x}_{\boldsymbol{j}}, \ldots, \boldsymbol{x}_{\boldsymbol{jt}})$: Decision variables of different branches design vector.

$D_j = \left\{x_j / g_k(x_j) \geq 0; x_j X_j\right\}$:Set of the possible solutions for the design of the j branch of the network.

$\boldsymbol{X}_{\boldsymbol{j}} =$ Set of admissible value for each variable vector $\boldsymbol{x}_{\boldsymbol{j}} = (\boldsymbol{x}_1, \ldots, \boldsymbol{x}_{\boldsymbol{j}}, \ldots, \boldsymbol{x}_{\boldsymbol{jt}})$.

$g_k(x_j) \geq b$: Symbolizes designing restrictions of the j branch.

3.1 Decomposition of the Conduit Nets Design Task and Mathematical Modeling

The conduit nets design task consists on the construction of the air distribution net for all and each of the branches that assure the air flows to the locals, with all its constructive elements, accessories and air exits, satisfying a general efficiency criterion. This way, a hierarchical structure arises which central task consists on the whole net design. In Fig. 2 the structure of the design system of the studied conduits net is

illustrated. For each one of the j branches it is necessary to solve the air-conditioning design of the duct network task for every one of the room associated to the branch. Thus, it is necessary to solve the task:

$$\textbf{Minimize} \quad \boldsymbol{Z^j(x_j)} = \left\{\sum \boldsymbol{Z^{i,j}(x_{i,j})} + \boldsymbol{\varepsilon_j(x_j)/x_jD_j}\right\} \boldsymbol{i} \in \boldsymbol{I_j} \tag{2}$$

Where:

$Z^j(x_j)$: Objective function value of the j branch.

$\boldsymbol{Z^{i,j}(x_{i,j})} = [\boldsymbol{C^{i,j}(x_{i,j})}, \boldsymbol{P^{i,j}(x_{i,j})}, \boldsymbol{R^{i,j}(x_{i,j})}]\Re^3$: Vector of the quantifiable efficiency indicators of i room, j branch$\boldsymbol{\varepsilon_j(x_j)} = (\Delta \boldsymbol{C^j}, \Delta \boldsymbol{P^j}, \Delta \boldsymbol{R^j})\Re^3$: Efficiency indicators values increment of j branch caused by the intersections of entrance to the rooms, the need for noise muffling elements, etc.

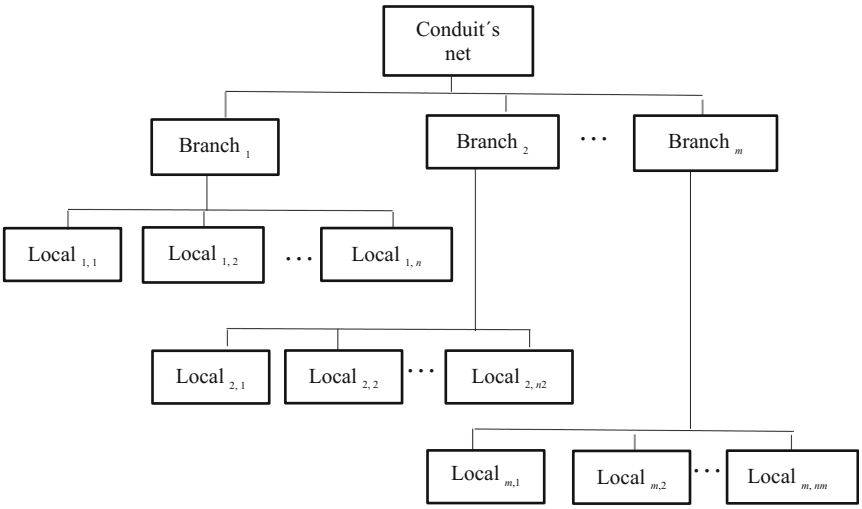

Fig. 2. General structure of the air-conditioned conduit´s net design

$\boldsymbol{x_j} = (\boldsymbol{x_{1,j}}, \ldots, \boldsymbol{x_{i,j}}, \ldots, \boldsymbol{x_{it,j}})$: Vector of decision variables associated to j branch.

$D_j = \{x_j / g_k(x_j) \geq 0; x_j \in X_j\}$: Set of the possible design solutions

X_j : Set of admissible value for each variable x_j

$g_k(x_j) \geq 0$: Symbolizes designing restrictions of j branch.

The variables $x_{i,j}$ correspond, respectively, to $Tray_{i,j}, Perf_{h,i,j}, Mat_{h,i,j}$, $SalLoc_{h,i,j}$, $Acc_{m,h,i,j}$, $DerTra_{h,i,j}, TipoCodo_{h,i,j}(Tray_{i,j})$ adopt entire values associated to different trajectory solutions generated by an empiric algorithm, based on design standards and experience. For each value of the $Tray_{i,j}$ depending on the room dimensions $DisXLoc_{i,j}$, $DisYLoc_{i,j}$ and $DisZLoc_{i,j}$, the stretch amount h, their lengths $LongTra_h(Tray_{i,j})$, the elbow amounts $CantCod_h(Tray_{i,j})$, air exit amounts in the stretch $CantSal_h(Tray_{i,j})$,

and the length of every stretch section of the duct $Long_{k,h}(Tray_{i,j})$ are determined, algorithmically.

The structure of models (1) and (2) is in accordance with the selection of proposals task put forward in Arzola J. [12, 13] for whose solution the discreet optimization method of the same name was developed. The above-mentioned structure allows finding a solution to each of these tasks among the α-optimal solutions. As α-optimal solutions are understood all those solutions that are different from the optimal according to the chosen optimization criterion in no more than a α parameter. By subtasks of task (1) are understood all the j_t optimization subtasks (2) corresponding to each branch of the network. By subtasks of task (2) are understood all the $|i_j|$design optimization tasks of each network of the rooms that belong to the corresponding branch:

$$Min\left\{Z^{i,j}(x_{i,j})/x_{i,j} \in X_{i,j}\right\} \tag{3}$$

For the design of every branch, it is necessary to determine a designs population of every one of the rooms of the branch and for the network design, it is necessary to determine a designs population of every branch. Therefore, in the solution of the optimization task (1) it is necessary to use a double partitioning procedure of the network into branches and of the branches into rooms.

3.2 Internal Analysis and the Cost Function

Estimation of the Network Cost. For each section of the duct *SecCon*, elbow type *TipoCodo*, accessory *Acc*, air exit device *SalLoc*, duct derivation or transformation *DerTra*, the system calculates the total unit costs, $C(SecCon), C(TipoCodo), C(Acc)$, $C(SalLoc), C(DerTra)$, which integrate into stretch, room, branch and network.

$$C = C_S + C_{mje} \tag{4}$$

Where:

C_S : Supplying cost of the branch component elements

C_{mje}: Set up cost of the branch elements.

The total cost of stretch h, in room i in branch j of the network can be expressed as:

$$\begin{aligned} &C_{h,i,j} = C(SecCon_{h,i,j}) + C(TipCodo_{h,i,j}) + C(Acc_{h,i,j}) + C\left(SalLoc_{h,i,j}\right) + \\ &C\left(DerTra_{h,i,j}\right) \forall_h = 1,..,h_t\left(Tray_{i,j}\right); iI_j; j = 1,..J_t \end{aligned} \tag{5}$$

The cost of the installation of the net is calculated as:

$$C = \sum_{j=1}^{J_t} \sum_{iI_j} \sum_{h=1}^{h_t(Tray_{i,j})} C_{h,i,j} \tag{6}$$

3.3 Estimation of Charge Losses in the Network and the Noise Function

The calculation of the pressure drop by tracts, locals, brunches and the whole net obeys well-known and complex engineering calculation methodologies, for what they will not exposed here. Estimation of the noise level in the network: The exact calculation of the noise level in the duct can lead, in addition to the achievement of a more favorable acoustic environment, to the decrease of manufacturing costs through the correct selection and allocation of sound attenuating accessories and absorbing material [14] as well as the correct dimensioning of its cross section. For each section of the duct the resulting volume level must be calculated according to the equations shown in [15]. The noise at the fan output is calculated as:

$$R_j = R + \Delta R_j \tag{7}$$

Where:

ΔR_j: Increase of noise resulting from the generation and attenuation caused by the duct elements.

The noise in i room, transmitted through the$j$ branch can be calculated as follows:

$$R_{i,j} = R_j + \Delta R_{i,j} + \sum_{h=1}^{h_t} \Delta R_{h,i,j} \tag{8}$$

Where:

$\Delta \boldsymbol{R_{i,j}}$: Increase of noise resulting from the generation and attenuation from the j branch to the entrance of i room.

$\sum_{h=1}^{h_t} \Delta R_{h,i,j}$: Increase of noise resulting from the generation and attenuation from the $h = 1$ entrance to i room to air way outs located in different stretches of the room.

The total noise level in h stretch, i room, $j$branch of the network can be calculated as:

$$\begin{aligned} R_{h,i,j} = {} & \mathrm{R}(SecCon_{h,i,j}) + \mathrm{R}(TipCodo_{k,h,i,j}) + \mathrm{R}(Acc_{h,i,j}) + \mathrm{R}\left(SalLoc_{h,i,j}\right) + \mathrm{R} \\ & \forall_h = 1, .., h_t\left(Tray_{i,j}\right); i \in I_j; j = 1, \ldots J_t\, k = 1, .., CantCod\left(Tray_{i,j}\right) \end{aligned} \tag{9}$$

When calculating the noise level, not to exceed the levels allowed by the designation of the rooms is intended

4 Methodology for Optimal Multiple Objective Design and Optimization

According to the selection of Proposals algorithm, adequate to the particularities of the studied task, for known Tray_j values for the set of jt branches until the entrance to the local $\boldsymbol{i}$ belonging to the branch $j = \varphi_{\boldsymbol{i}}$ the adopted outline of decision preparation is completed in the following steps:

Step 1. For each one of the locals that belong to the studied branch are generated, by exhaustive search, all possible value combinations of the variables $Tray_{i,j}$, $Perf_{h,i,}$ $Mat_{h,i,j,}$ $SalLoc_{h,\ i,j}$, $Acc_{m,h,i,j}$, $DerTra_{h,i,j}$, $TipoCodo_{h,i,j}$ $\forall m = 1, 2$, $h = 1,\ldots,$ $ht(Tray_{i,j})$. The efficiency indicators and multiple objective function $\beta_{i,j}$ values are calculated for each combination of generated possible solutions for every local.

Step 2. The user eliminates, among the generated solutions those that don´t satisfy his complete preferences system assisting to cultural, ergonomic and other reasons. These reasons will be called, bellow, as subjective character criteria.

Step 3. For the local corridor, and the trajectory $Tray_{\ i,\ j}$, previously built using system's graphic edition tools, all the possible combinations of the values of the variables $Perf_{h,i,j}$, $Mat_{h,i,j,}$ $SalLoc_{h,i,j}$, $Acc_{m,h,i,j}$, $DerTra_{h,i,j}$, $TipoCodo_{h,i,j}$ $\forall m = 1, 2$, $h = 1,\ldots,$ $ht(Tray_{i,j})$ are determined by exhaustive search. The efficiency indicators and the multiple objective value function β_j are calculated for each variables values combination and a solutions population for the corridor is created. The trajectory $Tray_{0,j}$, during the exhaustive search is made in inverse to the airflow direction, contrary to the outline described in Step 1 of this methodology. In each population, a predetermined number of the closer to the optimal solutions is included.

Step 4. The decider eliminates, among solutions population generated, those that don't satisfy its preference system, considering subjective character criteria, and, in this way, the orderly set of local corridor solutions are defined.

Step 5. Between the best solutions chosen by the user for each local including the corridor, the multiple objective value function calculation is made, in order to evaluate the different unions' combinations, applying the selection of proposals methodthe solutions population for the branch is obtained.

Step 6. The decider eliminates, among the solutions generated, those that don't satisfy his preference system, considering subjective character criteria. This way the orderly set of solutions for the studied branch is defined.

Step 7. The procedure described is repeated from steps 1 to the 6 for each of the branches that belong to the studied net.

Step 8. Once selected the solutions population for each net branch, the calculation of the efficiency indicators is made according to the function for evaluating different combinations of unions among the branches and are obtained, applying the method of Selection of Proposals, the final solutions population of the net.

Step 9. The procedure described is repeated from steps 1 to the 8 for each one of the nets that belongs to the studied air conditioning system.

5 Human Machine Interactions and the Design Process

The CAD system developed in this paper for the optimal multiple objective air conditioning conduit nets design with very flexible tools for human-machine interaction. Composite applications are theoretically unable to be solved in a practical amount of

time. So, the researchers are involuntary force to instrument heuristics approach in solving problems that leads to extremely sub-optimal solutions. This article focus on human interaction integrated with decision-making process in order to produce solutions in an appropriate way that improve upon those that are produced by a human or machines.

The design process suggests that in order to evolve human-machine interaction methods; it has to be starts with a human tactic and supplement it with decision-support or starts with an automatic method and augments with human input. We have analyzed in our research a design process by offering an automated interactive procedure that addresses alliance from the onset of the design of conditioning system with the decision-making method. The structure of the automated system developed constitute a component part of a higher one that included the computer aided process planning for manufacturing system (CAPP system). To achieve the demands outlined to the system in graphical documentation was necessary to use Auto LISP of the AutoCAD package as programming language. From the structural point of view, the overall system is compound by the three following modules:

- DPPIPE: For the design of the conduit nets.
- CONDUIT: For the deployed of the elements of the installation.
- DPCORTE: For the distribution of the pieces in the foil and the generation of the CNC program for cutting machines.

Every one of these modules also constitutes an autonomous system, so one could use it in an independent way assisting to the user's necessities and his technological readiness. However, the best results are using it as an integrated package (see Fig. 3) that assure the information flow without errors from the design stage until the planning for manufacturing process.

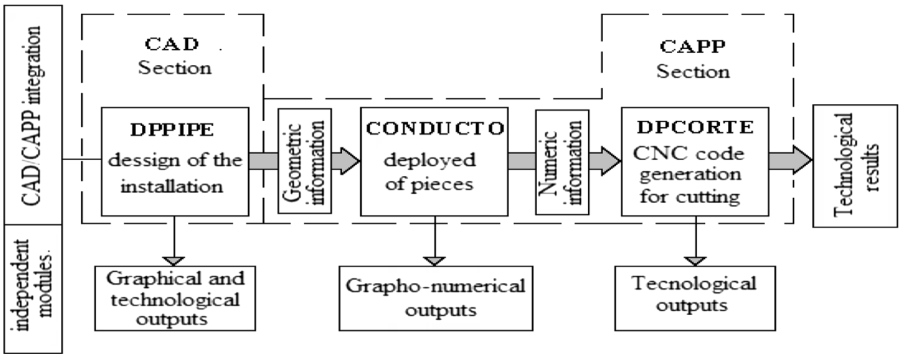

Fig. 3. CAD/CAPP system structure

6 Pattern Recognition and Decision Interactions

Human being are blessed with an extra ordinary ability to recognize patterns with respect to the cluster analysis. Humans can easily recognize similar patterns of behavior and extrapolate to it forecast future behavior in such a sort time frame whereas the machines are not so intelligent. The dependencies and the correlations among decisions are examined before making a concluding final choice in case of human machine interactions. Numerous choices taken by human in similar projects are stored as clusters. The cluster of choice finally contributes in making final decision and also used as input to the automation during human machine interaction.

Interactive evolution approach as discussed in various studies is considered good in this case; an iterative method of decision making processes. At each stage of process the solutions are generated by the computer or machines, human as operators selects the most appropriate solutions to be given to computer or machine to generate new solutions in the next iteration. In this way, optimal solution in conduct and nuts design is approximately achieved.

7 Description of the Modules

7.1 DPPIPE

It is a system for the automated conduits nets design for the air circulation to drops pressures as shown in Fig. 4. It operation principle consists in the definition of the trajectory through a determined info-line. DPPipe allows knowing the characteristics of each pipe tract according the modifications of the installation or the insertion of new tracts. The design task could be as simple as the change of the characteristics of the info-line, in the construction of new info-lines, in the redesign of the conduits net of a local, branch or of the completely air-conditioned net for a design solution defined by the user or being a particular solution from a solutions population generated by the system. The system gives the listing of the materials associated to a solution and offers classified information about each component element and the economic calculations of the investment and in the expedition of orders for materials. The optimization of the net design module uses information existent in the database of the drawing entities. Then, when being approved the optimal design variant, the database of the modified graphic entities is upgraded automatically. For the presentation of the optimization results information is transferred to the graphic edition functions.

7.2 CONDUIT

Facilitates the deployment of the pieces on the plane that are obtained starting from the foil or of tubes.

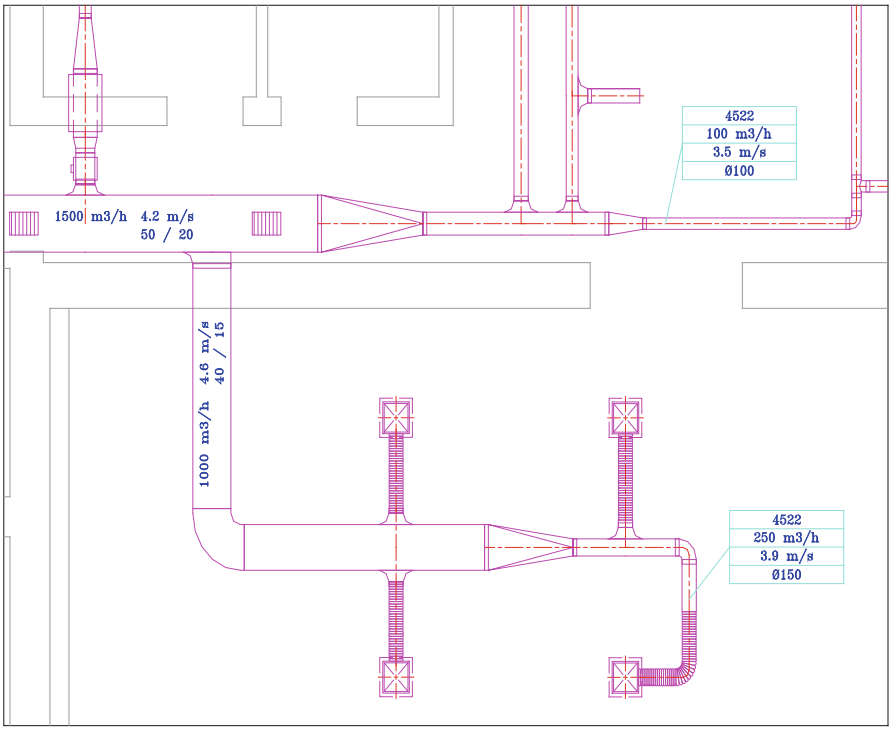

Fig. 4. Pipe section designed by DPPIPE

7.3 DPCORTE

Carries out the optimal distribution of the pieces on the surface of the foil and defines, helped by the user the trajectory of the cutting tool starting from the generated CNC code.

8 Findings and Conclusions

1. In this research, scientific and technical principles that enable the application of multi-objective optimization of the air conditioning duct nets design have been developed.
2. The introduction of multi-objective optimization techniques in the air conditioning networks design allows to increase the efficiency of the solutions found and the level of automation of the design, maintaining the required flexibility in the decision-making process by the designer.
3. Implementation of the described procedure was implemented in a CAD application that allows to obtain air conditioning networks designs, ensuring the best possible compromise between the efficiency indicators for this type of networks, where are applied the exhaustive search and selection of proposals methods, which allow to

obtain a series of α-optimal solutions sorted according to the multi-objective optimality criterion chosen.
4. The approach applied in the developing of the design system presupposes the narrow interaction human-machine with significant influence of the pattern recognition in the complex decisions making processes.

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The Necessity of New Paradigms in Measuring Human-Chatbot Interaction

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Abstract. Our research is carried out in the context of the ongoing process of introducing artificial intelligence in the area of social interaction with people, with a particular emphasis on interactions in the professional sphere. In this paper, we provide an overview of methods used so far in researching human-bot interaction. We describe the methodology behind our experiment using electromyography as well as other psychophysiological data and a detailed set of questionnaires focused on assessing interactions and willingness to collaborate with a bot. Our purpose is to thoroughly examine the character of the human/non-human interaction process.

Keywords: Human computer interaction · Chatbots · Electromyography · Neuroscience · Psychophysiology

1 Introduction

Our project is devoted to social interaction between chatbots and clients of organizations that implement them. Chatbots are a perfect example of the implementation of state-of-the-art consumer-oriented artificial intelligence that simulates human behavior based on formal models.

In order to understand and better explain our complex relationship with information technology in the professional environment, we place an emphasis on the user. Instead of focusing on building and perfecting another technology, we focus on the other side of the "attention economy"—namely, technology's interlocutors (i.e., humans). Essentially, we seek to compare the way people interact with each other and with chatbots that imitate both human ways of interacting and human expertise. In this paper, we seek to assess how those interactions impact the social cognition of individuals (clients).

Thus, we place our research in the context of the ongoing process of introducing artificial intelligence in the area of social interaction with people, with particular emphasis on interactions in the professional sphere (business, strategic management).

M. Hoffman (ed.), *Advances in Cross-Cultural Decision Making*,
Advances in Intelligent Systems and Computing 610, DOI 10.1007/978-3-319-60747-4_19

In doing so, we argue for greater attention to the factors that cause either trust or resistance towards such technological innovations in organizations. Our work, which focuses on the user and his/her declarative and psychophysiological responses to a bot, will fill a gap in the HCI (Human-Computer Interaction) research, where little attention has so far been paid to the socio-cognitive nature of the professional interaction between man and technology in general, and chatbots in particular.

2 Previous Research

To date, only a few experiments directly examining communication between humans and chatbots have been conducted. Wide problematics of human attitudes towards humanoid technologies were first discussed by Mori in The Uncanny Valley Hypothesis [1], who predicted that perceptual difficulty in distinguishing between a humanlike object (e.g., a lifelike prosthetic hand or mannequin) and its human counterpart will evoke negative affect. In fact, Mori observed a heightened sensitivity to defects in near-humanlike forms—an "uncanny valley" in what is otherwise a positive relationship between human likeness and familiarity. Since then, research has focused on affect, but little is known about how humanoid objects are actually perceived. Thus, the eerie feeling elicited by human-looking (vs. mechanical-looking) robots is worth exploring.

Today, we know that many kinds of media are capable of eliciting, to varying degrees, different kinds of social responses, including verbal [2], gestural and visual responses [3]. Nevertheless, both quantitative and qualitative differences emerge, depending on the type of media and how it acts.

One of the more recent studies [4] has hypothesized that a human-looking android may be perceived as uncanny because it elicits a fear of death; the author attempted to verify this through questions designed to measure distal terror management defenses such as worldview protection. The results were favorable. On average, the group exposed to an image of an uncanny robot consistently preferred information sources that supported their worldview relative to the control group. The results, however, only applied to one particular stimulus, so it was impossible to generalize across uncanny stimuli.

In other experiments [4], where participants were presented with short video clips of a wide range of mainly android and humanoid robots engaged in various activities in different settings, the results did not indicate a single uncanny valley for a particular range of human likeness. Rather, they suggested that human likeness is only one of perhaps many factors influencing the extent to which a robot is perceived as being strange, familiar, or eerie.

Yet another experiment, in which the android's responses were identical, showed how human responses to androids varied according to their beliefs. For example, Japanese participants who believed an android was under human control via telepresence showed the same type of modesty, by averting their gaze downward, when interacting with an android as when interacting with a human interlocutor. Thus, recent evidence indicates that androids are generally better able to elicit human-directed norms of interaction than less humanlike robots or animated characters [5].

The notion that the uncanny valley can be escaped through varying factors unrelated to human likeness is consistent with an experiment performed by Hanson [6] using morphs. Although he found that morphing from a mechanical-looking robot to an android produced an uncanny valley in a familiarity scale and in an appealing scale as well as a peak in an eeriness scale, these effects were greatly reduced by tuning the morphs. Thus, without making a given morph more or less humanlike, Hanson was largely able to design around the uncanny valley. The technique he used was to adjust the appearance of the uncanny morphs toward the cuter features of a doll [6].

A study by Shrammel et al. [7] investigated the effect of self-involvement during social interaction on attention, arousal, and facial expression. Specifically, the study sought to disentangle the effect of being personally addressed from the effect of decoding the meaning of another person's facial expression. To this end, eye movements, pupil size, and facial electromyographic (EMG) activity were recorded while participants observed virtual characters looking either at them or at someone else. In dynamic animations, the virtual characters then displayed either socially relevant facial expressions (similar to those used in everyday life situations to establish interpersonal contact) or arbitrary facial movements. The results show that attention allocation, as assessed by eye-tracking measurements, was specifically related to self-involvement regardless of the social meaning being conveyed. Arousal, as measured by pupil size, was primarily related to the perception of the virtual character's gender. In contrast, facial EMG activity was determined by the perception of socially relevant facial expressions, regardless of whether the virtual characters were looking at the participants or elsewhere.

Work by Boucher et al. [8] sought to determine how human and robot gaze can influence the speed and accuracy of human action. The research provided a robot with the capability to produce appropriate speech and gaze cues in the context of human–robot cooperation tasks, and gaze was manipulated in three conditions: full gaze (coordinated eye and head), eyes hidden with sunglasses, and head fixed. The authors demonstrated the pertinence of these cues in terms of statistical measures of action times for humans in the context of a cooperative task, as gaze significantly facilitates cooperation as measured by human response times.

Finally, a very recent work by Gillespie and Corti [9] used speech shadowing to create situations in which people converse in person with a human whose words are determined by a conversational agent computer program. The method consisted of so-called speech shadowing that involved a person repeating vocal stimuli originating from a separate communication source in real time. Humans shadowing for conversational agent sources (bots) thus became hybrid agents ("echoborgs") capable of face-to-face interlocution. In a series of three studies, the authors noticed that, unlike those who engaged with a text interface, the vast majority of participants who engaged with an echoborg did not sense a robotic interaction. These findings have implications for human–computer interaction, as they show that the human body, as a channel of communication, fundamentally alters the social psychological dynamics of interactions with machine intelligence.

3 Methodology

Our methodology consisted in two distinct phases. During the first phase, we collected various psychophysiological signals that we describe below. Second phase was launched immediately after the experiment consisted in a detailed questionnaire related to the experience of interacting with our bot and overall bot-human collaboration assessment.

We have created a simple reinforcement learning bot, "Ola," intended to provide detailed information about a Central European university as a dedicated service for students and future students. We implemented two experimental conditions, depending on the type of entity taking part in the interaction: (1) interaction with avatars that are graphically very similar to humans, (2) interaction with text chatbots without any avatar image. In all experimental conditions, communication takes place via computer. Because the study is aimed at the discovery of general laws that are applicable to all people, we did not foresee any special procedure for the selection of respondents for the groups aside from balancing the in terms of the basic parameters of gender, age, and education (similar assumptions are made in choosing judges for the Turing Test). We had 31 participants in total (15 in group 1 and 16 in group 2; 18 female).

The groups of participants were asked to talk with the chatbot about the specific topic of enrollment in an academy, and they had to learn some information about the process (in this way, we made the study more objective and comparable). After they finished, they were encouraged to engage in a free chat with the chatbot on a topic of their choice. Afterwards, the tested groups were asked to assess the quality of the chatbot and fill in a questionnaire developed to investigate human–chatbot interactions. During the experiment, electrophysiological data were collected from eyebrow-wrinkling muscles (*musculus corrugator supercilii*) and smiling muscles (*musculus zygomaticus*), in accordance with standard guidelines [10]. Additionally, we gathered information from ECG, respirometer, and electrodermal activity in order to supplement the qualitative data with affective quantitative data (see Fig. 1).

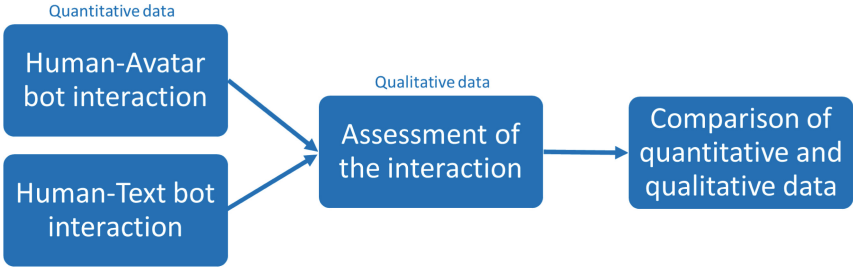

Fig. 1. Experimental scheme.

For the qualitative part of the study, we used several questionnaires [11–13]: the Theory of Planned Behavior survey, which asks about the participants' attitude towards cooperation with chatbots in the future; the Social Presence survey, which checks the

degree to which "the other" in a communication appears to be a "real" person; and the Anthropomorphism scale, which measures the extent to which the chatbot seems human-like.

4 Hypotheses

The main hypothesis of the study was that significant differences in both psychophysiological and declarative responses of study participants would be revealed in relation to the type of bot with which the participants interacted. These differences were expected to depend on the type of the entity with which the tested groups would be interacting. In the analysis stage, the data were included in a series of multivariate analyses (MANOVA) in the mixed scheme, where the assessment of individual human characteristic parameters in chatbots in subsequent attempts was our within-group variable, while the between-group variable consisted of the type of entity present in interactions (human-like avatar/chatbot and text chatbot). In the near future, psychophysiological data from all trials, with each of the conditions (assessment of human-like characteristics (within-group variables) and type of entity present in interactions (between-group variables)) will be compared with each other. We assume that emotional and physiological response will be most intense in the interaction with the human-like chatbot, whereas it will be reduced in the interaction with the text chatbot. Such a result would allow for further study of moderation, where the intensity of the physiological reaction would be a moderator for the relationship between the type of entity present in the interaction (predictor) and the assessment of individual parameters of human traits in chatbots (outcome variable). By adopting this methodology, we will be able to reliably compare quantitative data with qualitative data.

5 Preliminary Results

Thus far, we have analysed the questionnaires, while the psychophysiological data requires a specific protocol to be followed in order to obtain reliable results. The psychophysiological analysis is quite arduous, since it requires hiring competent judges to review the logs of the participants' conversations with the chatbot in order to assess each question and answer with respect to its emotional load.

Nonetheless, the questionnaires reveal several interesting facts. First of all, no differences were observed across gender and education level. The only significant differences we observed between groups; thus, there was a main effect of the type of chatbot with which the participants interacted. In general, the participants were keen to cooperate with the chatbot, even though several of them expressed irritation, or even frustration, in the debriefing session. Nonetheless, both groups had a good opinion about using robots in the workplace, while the opinion was significantly better in the group interacting with a simple text chatbot, $F(1,29) = 5.452$; $p = .027$ (see Fig. 2).

Similarly, the Negative Affect Evaluation factor indicates that participants felt more negative emotions when interacting with the chatbot enhanced with animated avatar and sound, $F(1,29) = 7.621$; $p = .01$ (see Fig. 3).

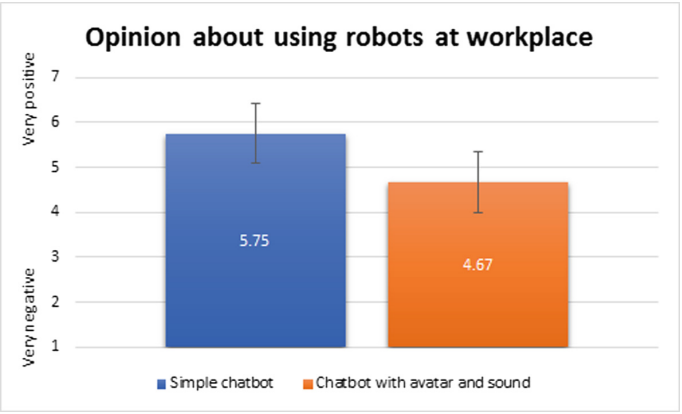

Fig. 2. This chart presents the means of answer to a question concerning the possibility of using chatbots in the workplace. Whiskers represent confidence intervals. The number in the center of each bar indicates the mean answer value on the 7-point Likert scale.

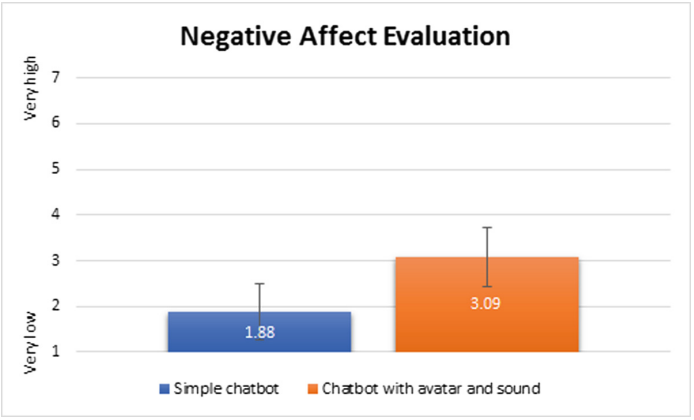

Fig. 3. This chart presents mean answer values to questions about negative affect induced by chatbots. The lower the answer value, the lower the level of negative affect. Whiskers represent confidence intervals. The number in the center of each bar indicates the mean answer value on the 7-point Likert scale.

The next chart presents the mean results of assessing four units in the questionnaire (the chatbot is: devious, embarrassable, jealous, creative), resulting in a factor dubbed Nonsupportive Anthropomorphic Traits. Here, we see again that the simple text chatbot was associated with fewer negative traits, $F(1,29) = 9.224$; $p = .005$ (see Fig. 4).

Next, the Behavioral Traits factor was created out of seven units (aggressive, agile, active, energetic, fearful, lethargic, muscular). The results show that the factor was assessed low in both groups; however, it was significantly higher for the simple text chatbot, $F(1,29) = 6.193$; $p = .019$ (see Fig. 5).

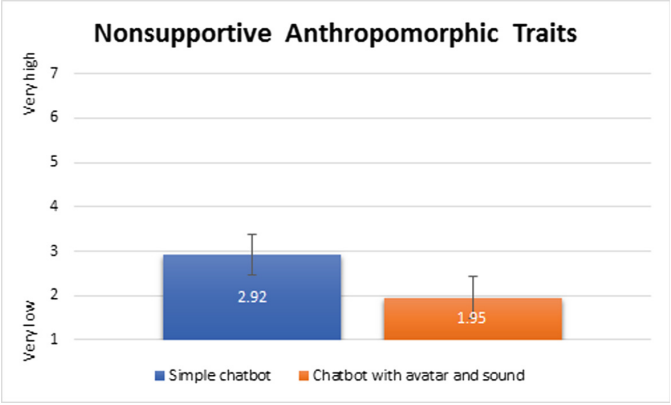

Fig. 4. This chart presents mean answer values to questions connected with negative aspects of the chatbots' anthropomorphism. The lower the answer value, the lower the level of negative traits associated with a chatbot. Whiskers represent confidence intervals. The number in the center of each bar indicates the mean answer value on the 7-point Likert scale.

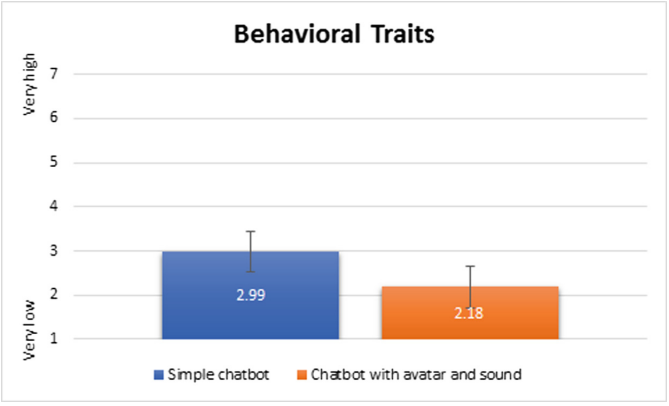

Fig. 5. This chart presents mean answer values to questions connected with behavioral aspects of the chatbots' anthropomorphism. Whiskers represent confidence intervals. The number in the center of each bar indicates the mean answer value on the 7-point Likert scale.

Neither of the chatbots were deemed to be particularly competent. We can see on Fig. 6 that in the group with the chatbot with avatar and sound, the assessment is significantly below the middle point (4 on the 7-point Likert scale), while the assessments of the simple text chatbot oscillate around the middle point. The two groups differ significantly, $F(1,29) = 17.023$; $p < .001$.

The last chart may somewhat explain the differences between the two groups, since it considers questions referring to the uncanny valley effect (a factor consisting of the following characteristics: attractive, strange, familiar, human, friendly). The simple text chatbot is considered significantly "less weird" and less inhuman than the more

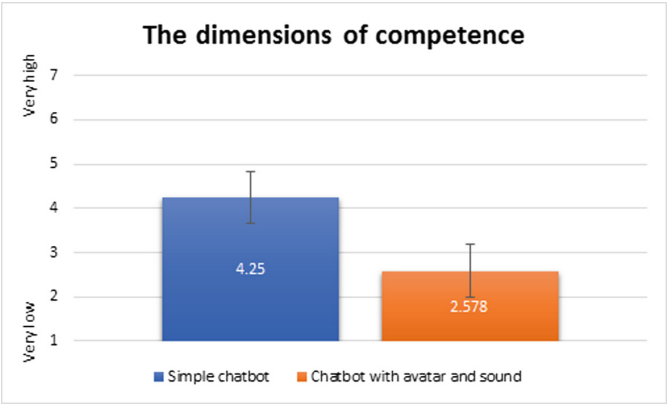

Fig. 6. This chart presents mean answer values to questions connected with the chatbots' competence. Whiskers represent confidence intervals. The number in the center of each bar indicates the mean answer value on the 7-point Likert scale.

enhanced one, $F(1,29) = 8.309$; $p = .007$. Moreover, the data indicates a strong negative correlation between the uncanny valley factor and negative affect evaluation ($r = -.594$, $n = 31$, $p < .001$); this means that the more a chatbot was perceived as inhuman, or "weird", the more it was disliked. Similarly, we observed a strong positive correlation between the uncanny valley factor and the dimension of competence ($r = .654$, $n = 31$, $p < .001$); this means that the more a chatbot was perceived as inhuman, the less competent it seemed to participants (Fig. 7).

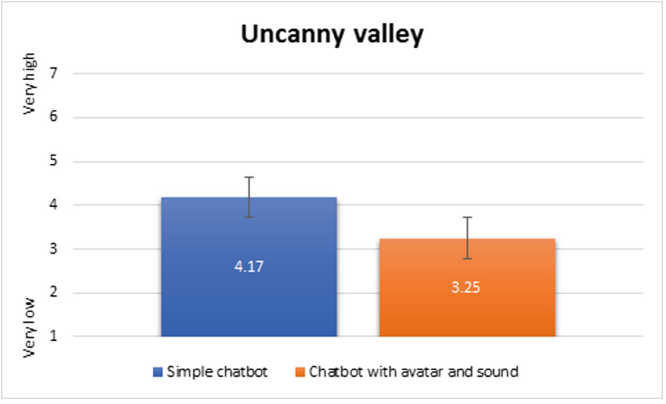

Fig. 7. This chart presents mean answer values to questions connected with the uncanny valley effect. The higher the value, the less "weird" the chatbot was perceived to be. Whiskers represent confidence intervals. The number in the center of each bar indicates the mean answer value on the 7-point Likert scale.

6 Conclusion

Our overall assessment of the questionnaires is that participants enjoyed their interaction with both types of chatbot; moreover, they expressed an expectation of more frequent interactions of that kind in the future, stressing the need to develop bots' communication abilities. The most significant difference between the groups lies, as we expected, in the uncanny valley factor. At the same time, the interaction with the simple text chatbot was more pleasant for participants compared to the interaction with the more enhanced one. These two factors were strongly correlated, as we showed in the analysis section; this naturally indicates, in accordance with previous research, that the "weirder" the bot is perceived to be, the more intense negative affect it causes. This result suggests that chatbots should not be designed to pretend to be human—at least not if they do so ineptly.

7 Future Research

There is a need to gradually test increasingly sophisticated bots and social robots using various methodologies, including ours. This project will be scaling up from the purely non-learning bot designed for the experiment we are currently conducting, to more refined commercial and non-commercial bots based on deep-learning. Simultaneously, our research team has started the process of developing an experimental protocol of comparing chatbots with human help-desk participants, which is a necessary next step in order to reliably present the attitude of the general public towards chatbots.

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Understanding the Social and Economic Factors Affecting Adverse Events in an Active Theater of War: A Neural Network Approach

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Abstract. This study focused on the application of artificial neural networks (ANNs) to model the effect of infrastructure development projects on terrorism security events in Afghanistan. The dataset include adverse events and infrastructure aid activity in Afghanistan from 2001 to 2010. Several ANN models were generated and investigated for Afghanistan and its seven regions. In addition to a soft-computing approach, a multiple linear regression (MLR) analysis was also performed to evaluate whether or not the ANN approach showed superior predictive performance compared to a classical statistical approach. According to the performance comparison, the developed ANN model provided better prediction accuracy with respect to the MLR approach. The results obtained from this analysis demonstrate that ANNs can predict the occurrence of adverse events according to economic infrastructure aid activity data.

Keywords: Infrastructure aid activity · Adverse events · Artificial neural networks · Multiple linear regression

1 Introduction

In 2002, Afghanistan was socioeconomically among the ten bottom countries and there was no human capital to build on, then the international community promised over $5 billion in aid and started the work of helping to rebuild Afghanistan [1].

After 9/11 attacks, the U.S. government signed agreements with the energy-rich countries bordering Afghanistan. The main objectives of these agreements were to increase economic liberalization and attract investments from foreign capital. The total amount of U.S. assistance was categorized into four portions [2]. The main portion since 2001 is approximately 56% of the total amount was given to the Afghan Security Forces Fund (ASFF). This portion includes the training of Afghanistan security forces and their equipment.

The second largest amount is composed of economic, social, and political development efforts, and it comprises approximately 31% of the total amount. A third portion of assistance, humanitarian aid, was implemented mainly through the United States Agency

M. Hoffman (ed.), *Advances in Cross-Cultural Decision Making*,
Advances in Intelligent Systems and Computing 610, DOI 10.1007/978-3-319-60747-4_20

for International Development (USAID) and international organizations; it constitutes about 4% of the total aid provided since 2001. The last portion of the aid program is counter-narcotics, and it comprises approximately 9% of the total aid provided.

The impact of these infrastructure developments remains scarcely explored and the relationship between infrastructure development and 'terror' is not clear cut [3]. A recent survey was conducted for the northeastern region of Afghanistan between 2005 and 2009 [4]. They tested the effect of aid in conflict zones and concluded that participants that felt already secure were more likely to feel positively about aid. However, nation-building was not so successful from 2001 through August 2009, when the second presidential election occurred. In this period, there was a negative relationship between the number of military forces and safety in Afghanistan, as the number of terrorism events tripled between 2002 and 2007 and endured through the summer of 2009 [5]. A quantitative study was conducted by using district-level data over the period 2002–2010 [6]. They concluded that the influence of projects was so small on the number of security incidents for most cases. However, these economic and reconstruction efforts are part of the irregular warfare missions which are followed by today's military. To support these efforts, the U.S. military has encouraged various programs to understand the effect of social and cultural factors on human behavior especially to the domain of human, social, cultural, and behavioral (HSCB) modeling.

HSCB models are increasingly being considered during the development of current and future operational requirements [7–9]. For instance, these models are designed to characterize the behavior and structure of organizational units at both the macrolevel and the microlevel [10]. In order to handle complexity, illness, and uncertainty, one must pay particular attention to apply soft computing techniques. There are different kinds of modeling approaches to the data that are being developed for this purpose and so far none have widely been accepted. Spatial and temporal analysis to analyze only terrorism events have been studied by several authors [11–15]. Some studies focused on several aspects of terrorist incidents by predicting patterns [16, 17]. However, sociocultural data integrated with terrorist incidents has not been addressed. In order to be able to understand the relationship between adverse events and infrastructure development in an active war theater, it is important that a study based on soft computing techniques be conducted to assess the effects of infrastructure development on occurrence of adverse events and examine the differences in adverse event outcomes due to infrastructure development over time. In addition to a soft-computing approach, a multiple linear regression (MLR) analysis was also performed to evaluate whether or not the ANN approach showed superior predictive performance compared to a classical statistical approach. Unlike the previous studies [18–20], this study uses all 89 input values in ANN model construction and compares it with regression model on the same basis.

2 Methodology

2.1 The Dataset

This study uses data describing adverse events and infrastructure aid in Afghanistan provided by HSCB program management. The adverse event data set includes

information regarding the date of event, incident type, death/wounded/hijacked count, and the location information in terms of latitude and longitude coordinates.

The infrastructure aid dataset has population density, location information, project types and respective allocated budget information. The collected dataset was processed by text processing techniques and analytics to generate a suitable set of data to be used in the content of an HSCB project. A total of 89 inputs and 4 outputs reflecting the adverse events were considered in this study. The data was represented based on the format in Table 1. Data used for this study was limited to incidents and projects occurring between 2004 and 2010. The data were partitioned into two data sets such as training (the years between 2004 and 2009) and testing (the year 2010). In other words, a total number of 28800 pieces of data were selected as training sets, and the remaining 4800 records were used for the purpose of testing.

Because each region contains a different number of provinces and districts, training and testing information for each region is collected in separate files to be ready for the regional analysis. The following main steps of this paper are:

- Step 1: Data migration to include a single database representing the variables of adverse event numbers in "Witsgeo" data, project budgets and aid number in "USAid" data and population information in "AISCS" data are considered in this study.
- Step 2: Input and output selection to represent the variables for infrastructure development, population density and adverse events.
- Step 3: Represent data on district and monthly bases for the years 2004–2009 (for model training), and year 2010 (for model testing).
- Step 4: Divide the data into seven regions for regional analysis.
- Step 5: Apply ANN for each region and whole Afghanistan.
- Step 6: Apply regression analysis for each region and whole Afghanistan.
- Step 7: Perform prediction accuracy by using Mean Absolute Error (MAE).
- Step 8: Compare ANN and regression models based on MAE values.

2.2 Evaluation Criterion

Several performance metrics are existing to calculate the errors in the model. The mean absolute error (MAE) would be considered as the most natural measure of average error [21]. Thus, the model performance was calculated according to the MAE values for comparing the model performance values of ANN and MLR approaches.

The following Eqs. 1 and 2 were used for this calculation:

$$e_i = (P_i - O_i) \quad i = 1, 2, 3, \ldots\ldots, n \tag{1}$$

$$MAE = \frac{1}{N}\sum_{i=1}^{N}|e_i| \tag{2}$$

Table 1. Performance comparison of ANN and regression models

Region	Dependent variable[a]	# of neurons in a hidden layer (best configuration)	MAE	
			ANN	Regression
Afghanistan	(1)	5	0.6666	0.7072
	(2)	24	1.0069	1.0354
	(3)	39	0.1981	0.2125
	(4)	40	0.6587	0.6852
Central	(1)	29	0.4091	0.4485
	(2)	2	0.8834	0.9574
	(3)	4	0.1091	0.1241
	(4)	32	0.4991	0.5236
Eastern	(1)	4	0.2829	0.3124
	(2)	33	0.9493	0.9947
	(3)	47	0.2867	0.3145
	(4)	27	0.5648	0.6012
North Eastern	(1)	1	0.3812	0.4125
	(2)	23	0.5957	0.6385
	(3)	30	0.1368	0.1741
	(4)	27	0.3794	0.4025
Western	(1)	18	0.5357	0.5874
	(2)	43	0.5370	0.5763
	(3)	30	0.3154	0.3552
	(4)	12	0.6590	0.6744
South Eastern	(1)	14	0.8006	0.8456
	(2)	19	1.1218	1.2115
	(3)	2	0.2016	0.2632
	(4)	3	0.8021	0.8574
South Western	(1)	40	1.7292	1.8114
	(2)	18	2.2486	2.3526
	(3)	48	0.1569	0.1785
	(4)	16	1.1228	1.1875
North Western	(1)	29	0.2167	0.2985
	(2)	45	0.3833	0.4332
	(3)	7	0.2136	0.2445
	(4)	43	0.4303	0.4661

[a](1): Number of people killed; (2): Number of people wounded; (3): Number of people hijacked; (4): Total number of adverse events

3 Results and Discussion

3.1 Descriptive Statistics

We provided some descriptive statistics for all variables and mean number of events by district in each region took place between 2004 and 2010. All variables were the lowest

in 2004 and the highest in 2010. Between 2004 and 2010, there was an increasing trend, in general. The corresponding mean by district values varied between 0 and 30. The south-western region had the highest mean by district values than other regions and the whole of Afghanistan for all variables. On the other side, the north-western region had the lowest mean by district values than other regions and the whole of Afghanistan for all variables. When we compared the variables against each other, the number of people hijacked had the lowest values in total and average by district than the other variables.

3.2 ANN Model Development

Artificial neural networks (ANNs) (Fig. 1) are basic models of the biological structure which is based on the function of human brain [22, 23]. Real-world and complex problems are simply modeled and solved using ANNs [24]. The weight of an artificial neuron gives an idea of how important the regarding input is. The weights are updated by learning/training unit and the sum is transformed using the activation function *f*. The proper selection of neural network architecture is a crucial decision for accurate prediction [25]. We performed several feed forward neural network models with a different number of neurons, up to fifty, in a hidden layer that aimed to minimize MAE values.

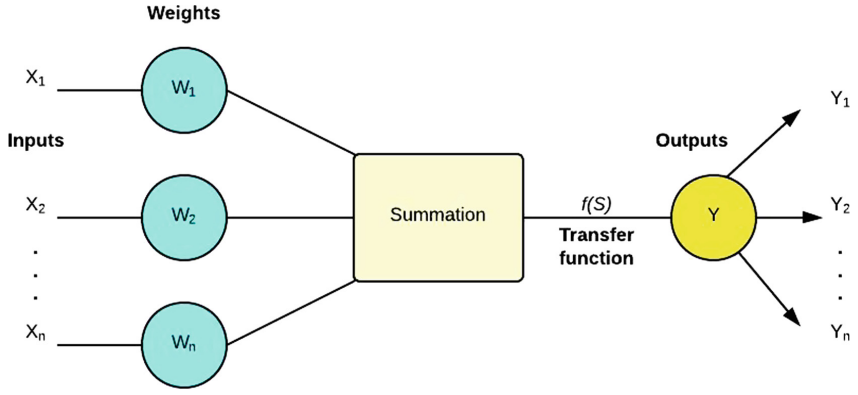

Fig. 1. Illustration of an artificial neural network

We employ a Levenberg-Marquardt (LM) training algorithm to train the neural network. The Levenberg-Marquardt (LM) algorithm, classified as higher-order adaptive algorithms, is good for decreasing the mean square error (MSE). LM algorithm has an important advantage, which "it defaults to the gradient search when the local curvature of the performance surface deviates from a parabola", which is so common in neural network approaches [26].

The hyperbolic tangent functions are used in the output nodes and input data are normalized in the range of −1 and 1. The LM training algorithm can be summarized in following equation:

$$X_{n+1} = X_n - \left[J^T J + \mu I\right]^{-1} J^T e \tag{3}$$

where X_n is the current weight matrix, X_{n+1} is the new weight matrix, e is the network error, J is a Jacobian matrix that contains the 1st derivative of the network error with respect to the current weights and biases, I is the identity matrix, and μ is the learning rate.

In this work, the log-sigmoid function for hidden nodes and the hyperbolic tangent function for output nodes were considered as transfer functions.

Number of neurons in a hidden layer varied from 1 to 50 and the best model was selected among them. Momentum coefficient and learning rate were selected as 0.7 and 0.2 respectively. ANN computations were performed using Matlab R2016b (Mathworks Inc, Natick, MA). The model summary of input and output values are represented in Fig. 2.

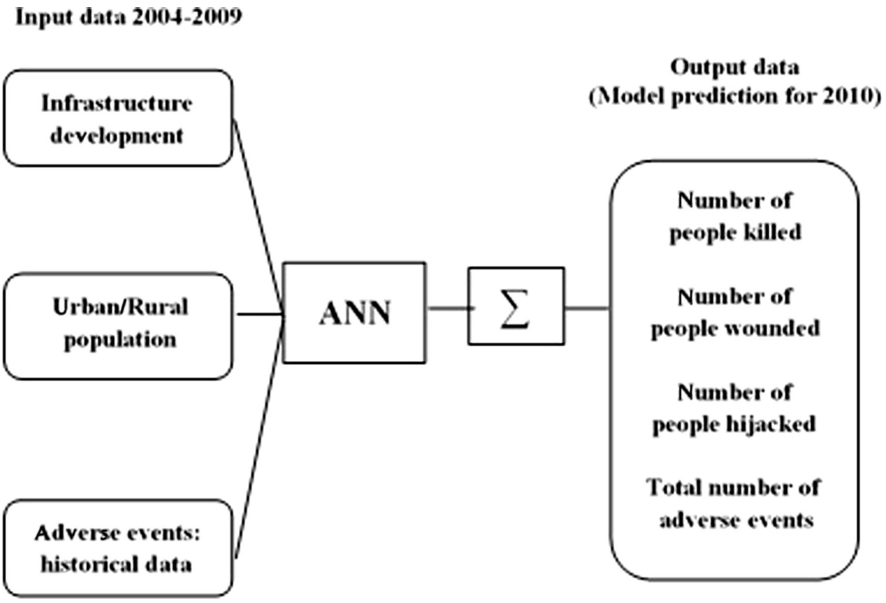

Fig. 2. The model summary of input and output data

3.3 MLR Model Development

MLR analysis is performed to predict the relationship among variables including a dependent variable and one or more independent variables. More specifically,

regression analysis tries to explain variations in the dependent variable y through movements in the k explanatory (independent) variables such as X_1, X_2, ……, X_k.

The general form of the MLR model is:

$$\begin{aligned} y_i &= f(x_{i1}, x_{i2}, \ldots\ldots\ldots, x_{ik}) + \in_i \\ y_i &= \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots\ldots\ldots + \beta_k x_{ik} + \in_i \end{aligned} \tag{4}$$

In this study, a total of 89 inputs and 4 outputs reflecting the adverse events were considered to develop MLR model and compare on the same basis with ANN approach.

3.4 Performance Comparison of ANN and MLR Models

In this study, all models were compared with each other based on the MAE values to determine the most accurate model between two approaches performed. The minimum MAE values were highlighted and it provides information about the best ANN model among alternative configurations (Table 1). According to the obtained results, the MAE values of dependent variables varied between 0 and 1 for most regions and both models. The developed ANN model provided better prediction accuracy for all dependent variables with respect to the MLR approach.

For number of people killed, the best performance was observed in the northwestern region with the MAE value of 0.21. On the other side, the worst performance was observed in the southwestern region with the MAE value of 1.72. Similarly, in regression model, the best performance was observed in the northwestern region with the MAE value of 0.29. On the other side, the worst performance was observed in the southwestern region with the MAE value of 1.81.

For number of people wounded, the best performance was observed in the northwestern region with the MAE value of 0.38. On the other side, the worst performance was observed in the southwestern region with the MAE value of 2.24. Similarly, in regression model, the best performance was observed in the northwestern region with the MAE value of 0.43. On the other side, the worst performance was observed in the southwestern region with the MAE value of 2.35.

For number of people hijacked, the best performance was observed in the central region with the MAE value of 0.11. On the other side, the worst performance was observed in the western region with the MAE value of 0.31. Similarly, in regression model, the best performance was observed in the central region with the MAE value of 0.12. On the other side, the worst performance was observed in the western with the MAE value of 0.35.

For total number of adverse events, the best performance was observed in the northeastern region with the MAE value of 0.38. On the other side, the worst performance was observed in the southwestern region with the MAE value of 1.12. Similarly, in regression model, the best performance was observed in the northeastern region with the MAE value of 0.40. On the other side, the worst performance was observed in the southwestern region with the MAE value of 1.18.

4 Conclusion

In this study, the soft computing methodology of ANNs were applied to model the relationship between infrastructure development projects and adverse events for Afghanistan and its specific geographical regions. In addition to a soft-computing approach, a multiple linear regression (MLR) analysis was also performed to evaluate whether or not the ANN approach showed superior predictive performance compared to a classical statistical approach. According to the performance comparison, the developed ANN model provided better prediction accuracy with respect to the MLR approach. For further studies, some of ANN parameters should be optimized to reduce inconsistency and the computation time. ANNs usually need more data for better training and this provides the more accurate results in testing data. For further studies, more training data should be included to improve the ANN model performance.

Acknowledgments. The authors are grateful for the support of the Office of Naval Research (ONR) under Grant No. 1052339, Complex Systems Engineering for Rapid Computational Socio-Cultural Network Analysis, and the helpful guidance of ONR Program Management and the technical team.

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Human-Machine Interactions and Tools

Designing Culturally Appropriate Responses to Culturally Influenced Computer Usage Behaviors

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Abstract. Cultural variables impact across a wide range of behaviours when interacting with computers. The Diamond Model provides an organizing structure for these variables and their instances from specific territorial cultures. Instances of cultural factors in Jordan impact at several levels on computer usage. Where such impact is adverse, culturally appropriate responses are required. Such responses need to be at the appropriate level from individual user behaviors, via organizational IT and work policies, national educational and economic policies, and global IT practices. We present examples of adverse interactions between cultural variables and computer users' behaviors in Jordan and propose a range of culturally appropriate responses at the individual, organizational, national and global level.

Keywords: Culture · Arabic language · User interface design · IT policies

1 Introduction

Culture shaping of human behaviour has many aspects. To understand its main meaning, Kroeber, and Parsons [1] define culture as a "transmitter and created content and patterns of values, ideas, and other symbolic meaningful systems as factors in the shaping of human behaviour and the artefacts produced through behaviour".

Culture is to a human collective what personality is to an individual. Personality has been defined by Guilford [2] as "the interactive aggregate of personal characteristics that influence the individual's response to the environment". Culture could be defined as the interactive aggregate of common characteristics that influence a human group's response to its environment, but terms such as 'structure', 'system' and 'pattern' are preferable to "aggregate". There are common relationships between aspects of cultures. For example, there is a direct relation between policies and religion in Muslim country such as the regulation in courts which are part based on religion.

Culture shapes most human behaviour, including interaction with computers. In much Human-Computer Interaction (HCI) research, culture is assumed to impact design preferences. However, many cultural variables identified in the general literature

M. Hoffman (ed.), *Advances in Cross-Cultural Decision Making*,
Advances in Intelligent Systems and Computing 610, DOI 10.1007/978-3-319-60747-4_21

have no clear link to design preferences. For this reason, we developed a new model, the Diamond Model [3], to help designers, and developers to understand users' culture in better ways through identification of the cultural variables that impact usage most, which is tied to users' behavior that is affected by culture.

The Diamond Model also can act as a tool for field studies, providing a structure for identifying and organizing instances of Jordanian cultural variables. It also later supported compact communication of these variables and instances via a novel representation, the Dramatic Sketch [4].

The balance and range of cultural variables in the Diamond Model suggests that culture should have impact beyond design preferences (as often assumed when considering the impact of culture on user interface design), and should also influence how users react to, explain and evaluate difficulties when using computers. Some of these difficulties can be addressed by user interface design, but others require responses from users, internal services (IT), organizations, governments and the IT industry. In this paper, we report on a new application of the Diamond Model, based on data from field studies in Jordan, that supports the identification of culturally appropriate responses to adverse behaviors and experiences of computer users.

2 Culture and HCI

This paper builds on our previous research on the impact of territorial culture on computer usage in Jordan and how this shapes users' responses to the problems during usage. Territorial cultures are ones that are geographically coherent due to pervasive political, economic and sociocultural influences. They co-exist with other cultures in a territory, for examples ones associated with age, gender, occupation, status or wealth, but can reasonably be expected to shape how other cultural factors operate across a territory such as a city, nation or wider geographical region. We use the term 'territorial factors' to refer to the combination of cultural and other differences for a specific geographical area that are influential across a range of users who may differ considerably in terms of temperament and competence. For example, through our studies we discovered cultural variables that led users in Jordan to have different experiences of computer usage to those from other cultures such as the USA: self-reported anxiety and frustration differed between users in a US study and ours in Jordanian, as revealed by repeating a questionnaire and triangulating the results with interviews with a range of stakeholders [5].

Much of the overt frustration recorded in western studies may be much less evident elsewhere. We should not assume that what is a usability problem in the USA will be one in Jordan, not only in its severity, but also whether it is viewed as a problem at all. Our views on the value of usability in the West are much based on the negative emotional impact of poor usability, yet in other cultures, these associations may not hold as much, even at all. Effective localisation guided by software quality needs to consider this. It is not just that the same feature may be judged differently by the same quality criterion, but that quality criteria themselves may be radically different.

For example, Jordan users do not get angry with their computers, even if they have experience of using IT. If they face any problem, they often do not know if the problem

comes from the computer or from them. Therefore, the last thing that users may think are that the problem is from computer itself. If this is so, then they will not be angry with their computer.

Jordanian computer users were thus shown to respond differently to similar usage problems when compared with UK users and US. However, in some contexts, Jordanian users' responses to similar usage problems were similar to those reported in the mainstream literature on Human-Computer Interaction (HCI). In addition, Jordanian users experienced problems that are not typically reported in European and American studies, which are related in the Diamond Model to specific cultural variables.

Usage problems in Jordan may thus be different from or similar to those reported for Europe and America. Different problems require culturally specific responses, as do similar usage problems that have culturally different responses. In this paper, we focus on these areas of difference and propose a range of culturally appropriate sociotechnical design responses.

3 Jordanian Users' Experiences with Computer Usage

In field studies [3], Jordanian users reported some common difficulties that face them such as the English language, which some find hard to read or write, therefore they prefer an Arabic version if one is available. However, sometimes there are quality problems with Arabic software, for both locally developed software and localisations of English language software.

However, some users use English software to learn words and improve their English language. One user in our studies suggested including both Arabic and English in the same software by having the meaning of an English word in Arabic appear when the mouse is over it.

Another source of problems that affect computer usage is a lack of training. This is often due to cost problems, because some users cannot afford a specific training program, or their company cannot afford to pay for training because of the cost.

The example behaviours and experiences above are related to cultural variables that have been discussed in detail during the development of the Diamond Model [3]. Another problem discussed in the context was users who could not trust the internet to buy or sell products, which limited the development of e-commerce. Overall, a wide range of cultural variables were seen to be influencing the behaviours and experiences of Jordanian computer users in our studies. These cultural variables included:

1. Degree of familiarity and competence with the *English language*.
2. *Economic* contexts.
3. Access to, and *Experience with, Technology*
4. Individualistic and *collectivist* behaviors
5. *Family* obligations (Nepotism) that result in many employees who are free much of the time and do not experience pressure at work.
6. *Attitude to Time*, evidenced by situations where a user's computer was faulty, delaying work with it, but there is other work that does not depend on their

computer, but they don't switch to that but enjoy their time by sitting and having a rest until someone comes and fixes their computer.

7. *Power distance and authority*, for example, when a computer is faulty in some way (hardware or software difficulties), an employee will not try to fix it because the employee will be worried by their manager's reaction if they damage it more. Employees can be limited in solving computer problems because they are afraid to cause further 'damage' to the computer, as the employee will be responsible for any damage happen when they solve the problem. In our studies, users often interpreted usage difficulties as being due to their computer being 'damaged', and not to difficulties of operation.

Some of the difficulties above, such as those associated with the English language, can be addressed via user interface design, but others require interventions at the level of internal services (IT), organisational policies, national programmes and even global IT industry practices. There can thus be long causal chains, mediated by cultural variables, between user behaviours and experiences and their effective root causes.

Furthermore, there are differences between users in Jordan and we cannot generalize all of them into an identical user stereotype. For example, students in our studies took deadlines more seriously than employees, and were thus more frustrated by usage difficulties than employees. Even so, there are some common territorial factors that have similar impacts on different users in Jordan. Users in Jordan continue to have different needs that have steadily reduced in western countries such as the US and UK, but were more apparent in the 1980s and 1990s when computers started to spread through the workplace and then homes.

4 Jordanian Usage Experiences and Some Proposed Responses

Some common problems face both users in Jordan and users in western country, but on the other hand, there are difficulties that face users in Jordan that the western users do not typically encounter. The first group relate to the English and Arabic Languages

- Users in Jordan would like to have special emoticons to express their special Jordanian emotions when they chat with friends or family such as, for common phrases that only Jordanians say for example when they say "Hi" to each other the users like to have their own way of say and express their emotion of saying greeting by having special word that mean "Hi", or just a symbol that means "Hi". One example of a Jordanian specific emotion could be to have a famous Jordanian cartoon character (Abu Majoob) say "Hi" in Arabic language (and if spoken, with a Jordanian accent).
- Users in Jordan need better support from English software, which does not use their first language. Some company policies force employees to use English software rather than an Arabic version, creating the need for users to develop their English language competences. Some users in Jordan suggested the use of Arabic tool tips in the software to help them translate the word from English to Arabic, as in Fig. 1.

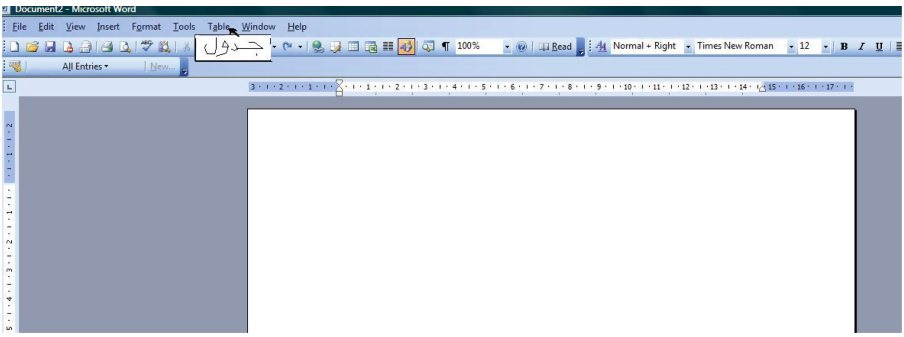

Fig. 1. Suggested provision of Arabic tool tips shown for Microsoft Word.

- Usage difficulties arise due to translating from English to Arabic because sometimes localisations translate a word too directly from English, changing the meaning of the word. Sometimes, a word will be reversed. Writing in Arabic runs from right to left, which is the opposite direction to English; therefore sometimes a translation from English to Arabic will be reversed (word will be miswritten from left to right) which change the word and it will be unknown for the reader. For example, see Figs. 2 and 3 below.

Fig. 2. Example Google translate from English to Arabic, writing Arabic in the wrong direction.

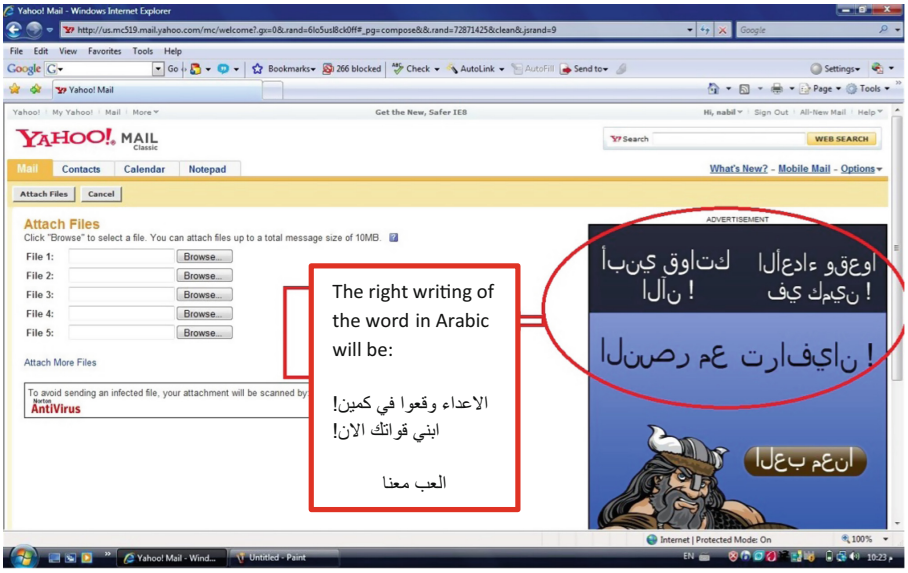

Fig. 3. Example of reversed Arabic word.

- Help messages in some localised Arabic software are not as supportive as they should be; because help messages in Arabic may lack the full details of the English ones, only part of the help text may be translated. Worse still, in some Arabic versions of software, the operational interface will all be in Arabic but help messages will stay in English, which is not helpful for users with weak English.
- Generally, Jordanian users need more context in help messages. It is not enough to simply fully translate from English. More detailed help is needed.
- *Diagrammatic Help* could be better than text help messages, because it could show the solution of a problem step by step by showing pictures or sketches of how to solve a problem, reducing or even avoiding language problems.
- Keyboards with both Arabic and English alphabets cause some problems for users because sometimes they forget to press the 'change from Arabic to English' button therefore users get confused when they realise that the keyboard has not changed from Arabic to English or vice versa. Keyboard modes should be more salient, either through hardware cues such as lights (as on some caps lock keys) or screen reminders (as when caps lock is on during password entry).

Arabic tooltips, more salient language modes (Arabic versus Roman writing systems), higher quality translations, and enhanced Arabic help text (more explanation, perhaps with diagrammatic support) place increasingly higher demands on software localisation. Appropriate responses here rely on the global IT industry improving hardware features and restricting localisation to tool tips and help, but with the latter going beyond simple translation. Local responses are less likely to be effective.

Another set of difficulties that require responses from global IT industries concerns cybercrime:

- Viruses are a common problem for computer users all over the world, and in Jordan they are also a big problem because they damage users' trust when computer hackers compromise their computers, or when a virus damages a user's computer. Therefore, global IT industries need to provide strong protection against hacking and viruses for all computers, and not just the more recent operating systems that require expensive hardware. Low cost or free protection is needed for countries with aging hardware and limited economic resources.

Studies also revealed some specific problems with web interfaces:

- High bandwidth internet connection are still high cost for regular users in Jordan, which makes them use low bandwidth connections, therefore it would be much better if web designers minimize uses of pictures and large colour images in websites to make the website open quicker and faster than one fully loaded with pictures.
- Simplifying the web user interface, especially for government websites, because users across different work sectors will have different levels of education, and computer experience.

Unlike the first two sets of difficulties, culturally appropriate responses to the two difficulties above can be local, with Arabic web pages designed with slow internet connections and low IT literacy in mind, especially for government web sites where there is no alternative (commercial customers can find a better web site, citizens can't as there is typically only one).

The final two sets of problems require appropriate responses at organisational and national levels. Employers and governments have a role to play in reducing the difficulties that Jordanian users face with computers (even if these difficulties rarely annoy them relative to Western users). Desirable interventions here include:

- IT support should be available for users when they need any help, such as having a call centre or help desks in any company or establishment using computers. Support should go beyond 'repairing' 'damaged' computers to developing users' competences so that they can become more independent.
- At the same time, IT services need to restrict users' authority to limit their ability to 'damage' their computers.

Organisations, and especially internal IT services have an important role to play in improving Jordanian users' experience of computers. However, some difficulties are best addressed at government level, whether local, regional or national:

- Training is the key issue for effective usage, when users are trained, the possibility of problems will impact users less, and users will have more experience, which will support their work and knowledge.
- Governments could provide free courses for teaching the principles of computer skills, how to use new technologies, and what to do when they face problems how to deal with computers, with award of certificates for different levels of computer skills. This does not appear to be a focus for international aid programmes, but could be.

5 Conclusions

Identifying and understanding cultural variables that impact on computer usage experiences is an important first step towards improving user experiences across a wide range of territories worldwide. However, the important step requires these understandings to be translated into actions.

Culturally appropriate responses to factors that result in adverse user experiences in computer usage are often seen as being restricted to user interface design. At the levels of language in all its manifestations, user interface design can offer valuable effective responses to current difficulties. However, both hardware and software responses may be needed, and even high quality translation and compatibility with different writing systems may not be enough. For features such as help, instruction and guidance needs to be culturally appropriate, and not just linguistically complete and correct. Conversely, it can be better to not completely localise a user interface, to support the development of English language competence across the world. Adequate responses here require the involvement of global IT industries. Computer security for everyone is a high priority here.

Responses at the individual, departmental, organisational, governmental (local, regional, national) or international (aid programmes) are needed to complement efforts by global IT industries to deliver good user experiences worldwide. Web site design can be readily addressed at relatively local scales. Training and education can develop individual competences, supported by organisations, especially their IT support departments. Growth in users' competence needs to be supported, with some becoming local experts who can take some of the load off IT support. At the same time, the opportunities for inadvertent harm to a computer system need to be reduced at a local level as well as through the actions of global IT industries.

A wide range of insights has been presented above, with recommendations on culturally appropriate responses. This range goes beyond that common for studies of localisation and user interface factors. By developing broad and high level perspectives in our field research through a mixed methods approach across multiple studies [5], we were able to span a wide scope of responses from the individual to the international. At the same time, we were able to collect detailed instances of cultural variables in action in our field research, as well as some co-created responses (i.e., some of our proposed responses above were proposed by respondents in studies). This exposes the complexity of computer user experience and its relation to territorial factors. Reducing digital divides worldwide requires a range of initiatives at all scales from the individual to the global. Everyone has a part to play here.

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Comparative Study of Design by Culture Reference: Design Examples

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Abstract. Design by culture reference is a well-known design methodology for inputting culture resources into design processes and approaches. This paper explores the essence of culture reference design methodology based on three case studies focused on chairs, which are: China chair, Proust chair and Louis ghost chair which reference different historical cultural combinations of modern design methods. With the hypothesis of modern culture reference methodology focusing on culture reference resource as data input, design thinking was considered for data interaction, and simplicity, while symbolism, sustainable design as data output for methodology. Comparing this approach with problem-solving methods of traditional design methodology, the design by culture reference helped increase product value, meanwhile it helped in the adaptation to the humanity and technique development design methodology.

Keywords: Culture reference · Design methodology · Case studies · Comparing technique

1 Introduction

1.1 Background

In modern product design, designers hardly ever start from scratch, but design by modifying existing products [1], many products are created through the transfer and revision from other products, which is called reference design way.

The way in which reference is studied nowadays is inspired by ideas originated between the end of the 19th century and the beginning of the 20th century, particularly the works of Gottlob Frege, in 1892 Gottlob Frege proposes that signs such as names, set of words, or any other written signs should be seen as designating something—that is reference.

Culture can be taken as reference signs and resource, it is referred to as a pattern that signifies human activity manifested by the arts, music, sculpture, theatre, dance, film, fashion, design, food and architecture [2].

In fact, it has been well evidenced that culture plays influential roles over almost all aspects of human life [3], and it is assumed that the realm of product design is not exempt from these pervading cultural effects. Culture as reference resource in product design has already been widely propound by a number of researchers and designers,

M. Hoffman (ed.), *Advances in Cross-Cultural Decision Making*,
Advances in Intelligent Systems and Computing 610, DOI 10.1007/978-3-319-60747-4_22

Those extensive literature supports the notion that cultural reference plays a noteworthy role in the effective products design [3].

This paper focuses on how design is carried out by culture reference to research how culture reference occurs, meanwhile research the difference between culture reference design methodology and traditional modern product design methodology.

1.2 Purpose

The relationship between design and culture takes many twists throughout the last centuries [4]. Design is affected by culture, and at the same time is shaped by culture [4]. Despite the fact that culture influence and input product design, there as clear lack of in-depth research for appropriate design cultural methods. Also there is no solid theoretical framework linking product design and cultural resource [4].

The purpose of this paper is to investigate how culture as reference resource provide inputs for product design, and define the differences between culture reference design methodology and traditional product design methodology.

1.3 Definition of Product Design Terminology

In order to analyze culture reference design methodology comprehensively, this paper provides three modern product design terminology as criterias.

Produce Design Process. In 1991, Koberg, J, & Bagnell J developed the design process in advanced design process from the points of designers thinking activities, showing in the following Fig. 1 [5].

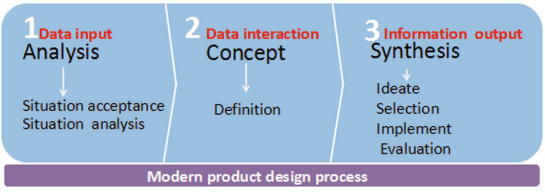

Fig. 1. Modern design process. This shows the contents of each design phase process

Produce Design Approach. The modern product design mainly focuses on intelligent manufacturing design approach, high-technical function, smart appearance, ecological design guidance [6]. In the product design, there are two kind of approaches one is creative social design approach and another one is logical engineering design approach, showing in Fig. 2.

To be more specific point, Fig. 3 shows the exact four kinds of creative design approaches:

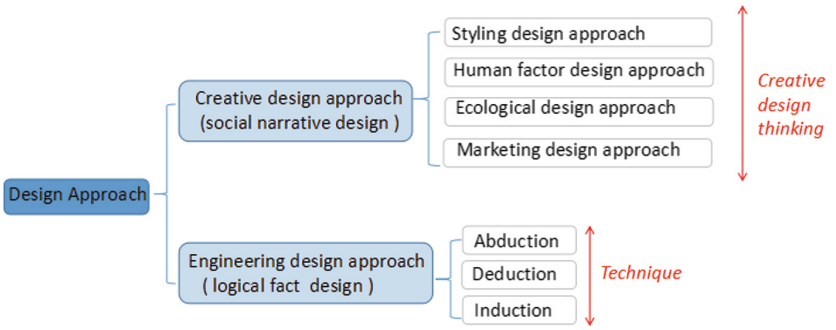

Fig. 2. Design approach. This shows two types of design approaches and their content

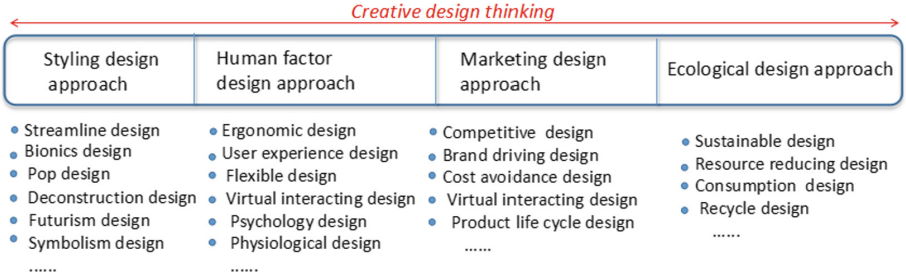

Fig. 3. Creative design approach. This shows the contents of creative Design approach

Component Design. Roozenburg defined product component design as the process of devising and laying down designers' plans that are needed for the manufacturer (1995). This manufacturer constitutes industrial design part and engineering design part. The two parts are overlapped with product component design [7] (Fig. 4).

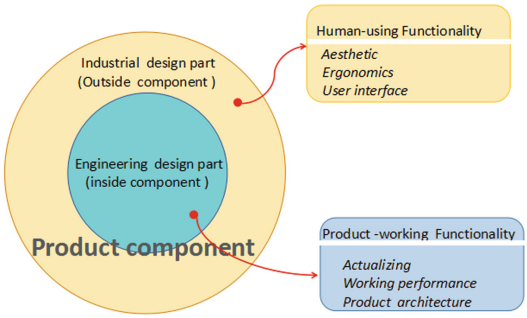

Fig. 4. Product component design. This shows two types of product component design

2 Method

1. Literature review: Consulting and reviewing relevant books and material about the following contents: design theory, design philosophy, engineering design, design thinking and so on.
2. Comparative analysis: one comparison is among three chair case studies about their culture reference similarity and difference. The other one is the comparison between culture input design methodology with traditional modern design methodology.
3. Summarizing analysis: Sum up the features of culture reference design methodology, inductive experience of suggestion about how designers apply culture reference in future product design.

3 Process

3.1 Case Choosing and Reasons

This paper starts from three chair case studies, they are China chair, Proust chair, and Louis Ghost chair. The reasons for choosing them are owning their different social background, design principle and design style.

1. Social background: The creation of China chair is under the circumstance of the construction period of the second World War in Denmark in 1944. Local designer developed the Scandinavian Design, that softened and changed modernism design to organic modernism. The Proust chair is designed in Italy in 1987, the whole world experiences high economy development period, providing open atmospheric for free and diversity design creation. The Ghost chair design is designed by French designer in 2002 under the social background of normal application of new technology. Designers boldly try new techniques to improve design.
2. Design principle: The China chair is designed in the guidance of Scandinavian organic design theory. Alessandro Mendini design Proust chair applies recreational and restoring history context design principle, while the Louis Ghost chair follows the principle of high quality design.
3. Design style: The China chair is the typical functionalism organic modern design style, The Proust chair presents Memphis post Modernism Design style vividly, while The Louis Ghost chair is the simplism modern design style.

These differences show in Table 1 it can clearly see that even though there are apparently difference in these three chair design, designers spontaneously use culture reference design methodology.

3.2 Case Choosing and Reasons

Analysis of China Chair. The China Chair was designed by Danish designer Hans J. Wegner in 1944, it referenced Chinese Ming-style round-backed armchair which dated from 17th and 18th centuries into modern design chair.

Table 1. The background of three chair design. The difference of their background

Contrast items / Chair	Country	Time	Designer	Social background	Design principle	Design style
China chair	Denmark	1944	Hans J. Wegner	Construction period of World War II	Functional and humanized design	Functionalism organic modern design
Proust chair	Italy	1978	Alessandro Mendini	Economy rapid development after World War II	Recreational and restoring history context design	Neo-Duchampian Post Modernism Design
Ghost chair	France	2002	Philippe Starck	High-tech development period	High quality design to create a better life	Simplism modern design

Design Process. The design process of China chair was based on exquisite Danish furniture manufacturing skill and designer Hans J. Wegner's keen design insight. First Hans J. Wegner got this design inspiration from one photo in which a Danish businessman sat on a Ming-style round-backed armchair, this was the outside information input phase, he decided to merge Danish excellent furniture manufacture technique with the Ming-style round-backed armchair culture together, which was belonged to data interacting process, in this interacting process, In the information output phase, Hans J. Wegner changed Ming-style round-backed armchair's complicated structure into simplified modern cohesion structure using modular and standardized joints (Fig. 5).

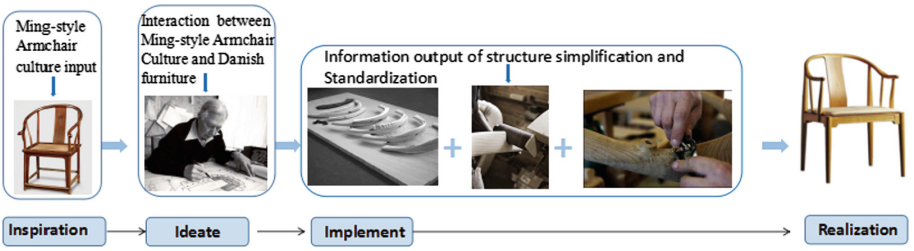

Fig. 5. The design process of China chair. Each different design phases

Design Approach. Hans J. Wegner applied human factor design, styling design, ecological design in creative design approach, and Danish furniture technique design approach. The human factor design approach mainly presented in the proper amplitude bent in backrest and handrail, changed the harsh backrest of Ming-style armchair. The styling design approach mainly reflected on its smooth, nature shape modeling to finish its organic shape. The choice of material wood is the environmental friendly ecological design approach (Fig. 6).

Component Design. In China chair inside engineering component design, Hans J. Wegner applied modern furniture manufacturing technique to create China chair get more solid structure and easy mass production. In the outside industrial design component design, Hans J. Wegner mainly aimed to actualize its simplistic smooth

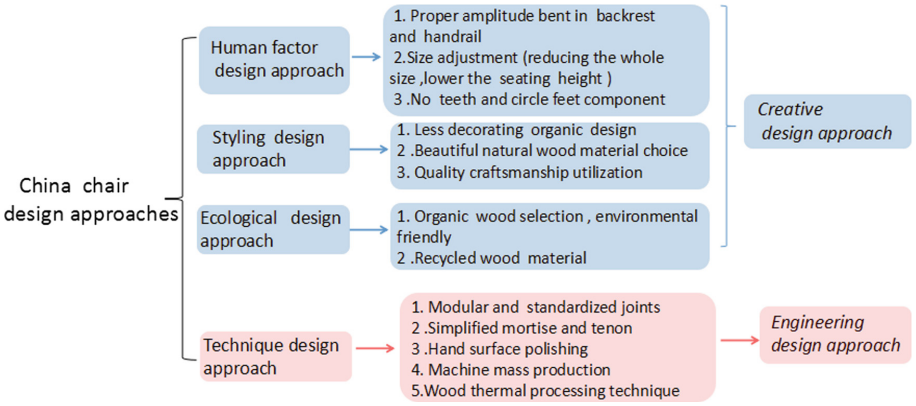

Fig. 6. The design approach of China chair. The concrete content of each design approaches.

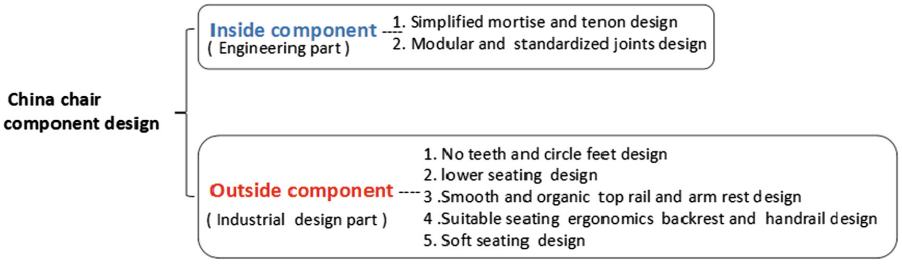

Fig. 7. The component design of China chair, its inside and outside component design

organic form design and comfortable user seating experience. Specific component design showing in Fig. 7.

Analysis of Proust Chair Design. Proust chair was designed by Italian designer Alessandro Mendini in 1978. This chair referenced three culture sources, French writer Proust's novel, Neo-Impressionist painter Paul Signac's dot painting and Louis XV period Rococo chair.

Design Process. Proust chair design originated from one textile company's requirement. After that Alessandro Mendini went to one of his favorite novelists—French writer Proust's house, he wanted to reshape the writer's life scene through one chair. And one day, in the street, he happened to see one antique imitation Louis XV period rococo chair. His chair idea was lighted by this rococo chair, this is data input process. And in the following data interaction process Alessandro Mendini chose Neo-Impressionist painter Paul Signac's dot painting as chair decoration way, because of the reference and combination of three-dimensional culture and two-dimensional culture. In the final information output phase, Alessandro Mendini chose hand-carved and hand-painted wooden frame to construct the whole chair (Fig. 8).

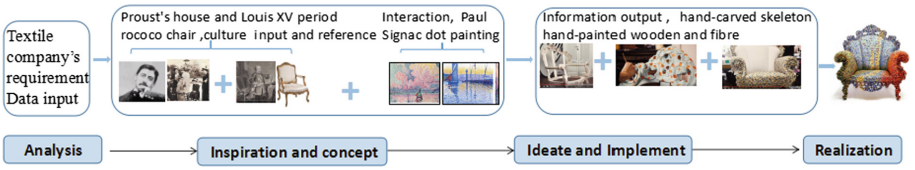

Fig. 8. The design process of Proust chair design. This shows each different design phase

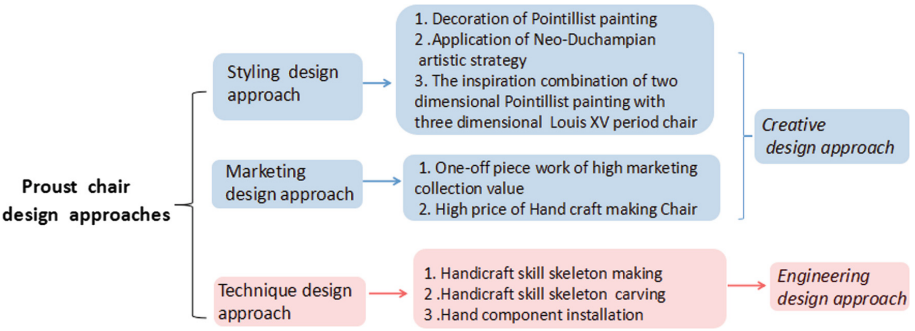

Fig. 9. The design approaches of Proust chair design. This shows each design approach content

Design Approach. Alessandro Mendini applied styling design approach, marketing design approach and technique design approach, the Fig. 9 described them in detail.

Component Design. In Proust chair component design, the inside component parts, Alessandro Mendini applied handicraft of standardized skeleton. In outside component design part, he used hand pointillist painting to decorate all the fiber covering and wood skeleton (Fig. 10).

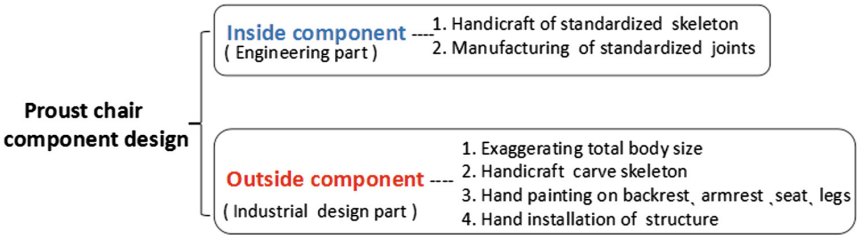

Fig. 10. The component design of Proust chair design. This shows the two types of its component design

Analysis of Louis Ghost Chair Design. Louis Ghost Chair was designed by French designer Philippe Starck in 2002. He playfully referenced 18th Louis XVI Queen chair in his work.

Design Process. Before Philippe Starck design Louis Ghost Chair, he designed one transparent chair named La Marie, but it failed in marketing, Philippe Starck designed Louis Ghost Chair in this background. So in Louis Ghost Chair design process, Philippe Starck took the failure of La Marie chair into consideration, and came out the culture reference design methodology. There are two parts in data input phase, one is the former chair analysis, another one is the reference of Louis XVI period Queen chair, Philippe Starck tried to combination the historical Queen chair essential with modern design and manufacturing, and finally applied colorful injection–moulded polycarbonate technique to implement Louis Ghost chair (Fig. 11).

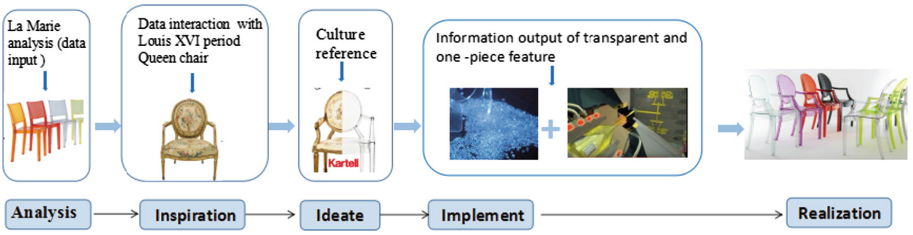

Fig. 11. The design process of Louis Ghost chair design. This shows its each phase of design process

Design Approach. Philippe Starck applied four kinds of design approaches in Louis Ghost Chair design, they were injection–moulded polycarbonate technique approach, transparent styling design approach, ergonomic human factor design approach, mass production marketing design approach and sustainable ecological design approach respectively, the detail showing in Fig. 12.

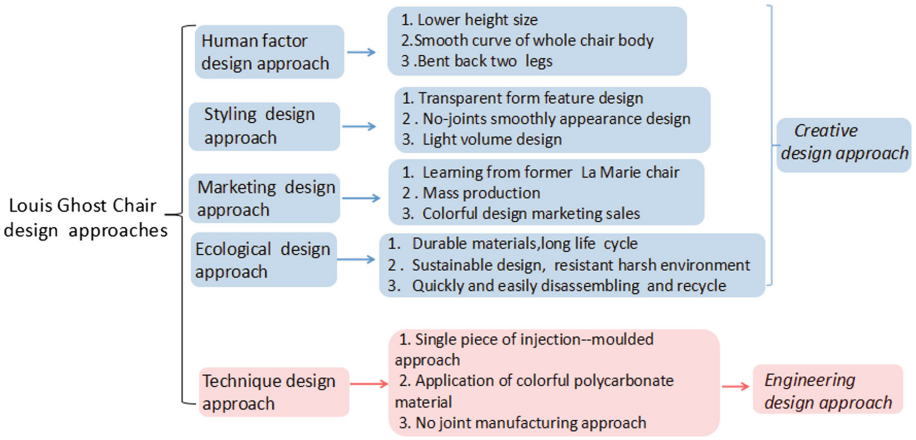

Fig. 12. The design approaches of Louis Ghost chair. This shows the concrete content of each design approach

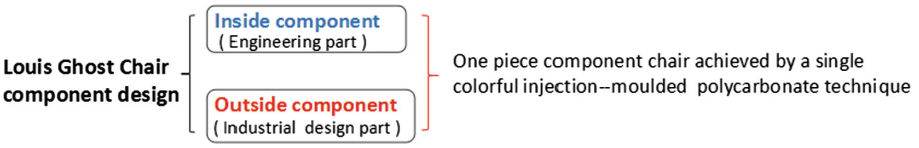

Fig. 13. The component design of Louis Ghost chair. This shows the same inside and outside component design.

Component Design. In Louis Ghost Chair component design, its inside and outside component design merged into one step by a single injection–moulded polycarbonate technique (Fig. 13).

3.3 Research Questions

Questions about Design Process. The first question is what are the common points among these three chairs design process. In the data input analysis phase, all of these three chair design process have historical chair information input process. in the following concept of data interaction phase, designers refine these data by their own judgment and design principle according to the social background at that time. Also designers chose different items as culture reference resource based on designer's starting point and criteria. In the final implement of information output phase, all of these three chairs take use of technique, there still some difference, the China chair and Louis Ghost chair mainly used modern advanced technique, but Proust chair mainly used handicraft which made it original design art and aesthetic. So in this design implement both the modern technique and traditional handicraft can generate valuable meaning.

The second question is what are the difference between these three chair design process and traditional modern design process. In The traditional design process, designers should do the analysis work in first step, figure out what design problem might be. Proust chair and Louis Ghost chair design had this kind of analysis phase, but China chair design has no this kind of analysis.

Question about Design Approach. What approaches did these three designers choose?

All of these three chairs applied technique approach, and styling design approach. In the choice of concrete approach, these three designers chose ones based on their design knowledge and technical level they lived in. Among them, Hans J. Wegner chose standardized joints to simplify chair's structure and organic styling design approaches, Alessandro Mendini chose hand carve and painting to realize his post modernist aesthetic philosophy. Its original and hardly copied value of handicraft reflected in Proust chair. In Louis Ghost chair, Philippe Starck made high use of advanced manufacturing technique to realize its transparent design aesthetic according to 2000s technique. In the human factor design approach, all the three designers did

some adjustment in pattern and size comparing with the origin referencing chairs. And also Proust chair and Louis Ghost chair applied marketing design approach, the difference is Proust chair applied one-off piece work of high marketing collection policy comparing with the mass-production of Louis Ghost chair. In the ecological design part, China chair chose recycled wood material, and Louis Ghost chair chose durable, sustainable long life cycle material.

Question about Component Design. What are the common points among these three chair component design and the difference with traditional product component design?

Generally speaking the inside (industrial design part) and outside (Engineering design part) component design are separated, just as the China chair and Proust chair design did. but Louis Ghost chair is one special case, its inside and outside component design were finished in one procedure. So in which situation, designers finish them one time or two times.

4 Research Result

4.1 Research Results of Design Process, Design Approach and Component Design of Culture Reference Design

1. The design process of culture reference design methodology directly occurs from designers' desire motivated by culture resource, culture resource plays the inspiring role to push the design process forward, While the traditional design process is the problem solving motivation design process. Culture reference design process is inclined to designers' subjective judgement. But the design process of traditional one closely focuses on the product problem definition and solution points.
2. The design approaches apply in culture reference methodology are based on the technique and marketing background designer lived in and their design thinking philosophy. These culture reference design approach mainly focuses on simplicity, symbolism styling design, human factor design, competitive marketing design, sustainable ecological design and standardized approaches (Fig. 14).
3. The component design in culture reference design methodology almost abides traditional component design way. But in some cases, these two parts can be merged into one. The component changes from the referenced culture object are based on the design development tendency mainly in aesthetic and ergonomics development.

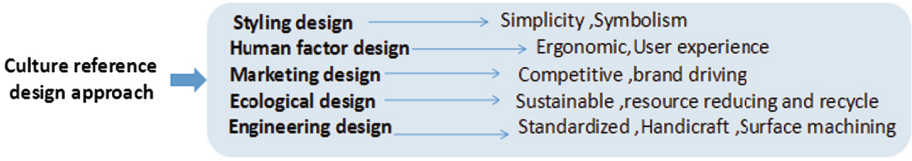

Fig. 14. Culture reference design approach. The main design approach of culture reference design

4.2 Hypothesis of Culture Reference Design Methodology

According to the above research results, here gives propose of culture reference design methodology. The culture reference resource as data input, designer carries out the design thinking taking the use of the knowledge of styling, marketing, ecology, human factor, technique. These knowledge interacts with designers' thinking to push designers do some combining work with other design resource. These resource can be both two dimension and three dimension, that comes out the product embryonic form, in order to make reality of embryonic form, Comparing with the traditional design methodology, this culture reference design methodology is much more focusing on the culture reference resource to build on design embryonic form and take the simplicity, symbolism design approaches, which is flexible comparing with problem-solving traditional design methodology (Fig. 15).

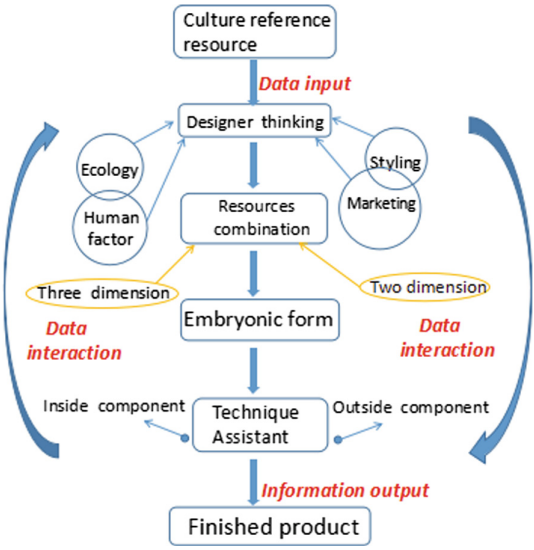

Fig. 15. Hypothesis of culture reference design methodology. This shows how the culture reference design methodology work and the process

5 Discussion

5.1 The Reason of Different Culture Reference Design Process and Traditional Design Process

The main difference between them are the traditional design process are the problem–solving process, and reference design is the designers mind inspiration from reference resource and design knowledge process. But is that process always like this, the answer maybe not absolute. In this question, is that culture reference design process totally has

no relationship with product problem-solution process, so following research should laugh in this part.

5.2 The Criteria of Approach Choice of Culture Reference Design

In the both creative design and engineering design approach, how designer to choose the proper ones to fulfill culture reference design idea? if there is criteria for that choice work, this part discussion is meaningful. But until now, this part haven't been mentioned in this paper. In the following research, author should do deep research to find out the approach choice criteria.

5.3 The Feasibility and Scientific Approach of the Hypothesis of Culture Referenced Methodology

The methodology author gives out is just based on these three chair design situation. Even though author does some comparing analysis and conclusion, the methodology cannot cover all the culture reference design situation, so this point is also this paper's limitation. So this culture reference design methodology should be deeply tested and evaluated.

6 Conclusion

This paper discusses how designers consider culture reference in product design, considering the three case studies, the author gives out the hypothesis of culture reference design methodology. This methodology support the consideration of culture resource to support in data input, interaction and information output design process, it also gives out two suggestions for future designs, one is as the high value of culture reference design methodology, the pluralistic application of exposing designers various cultural inspiration situation and extending designer's thinking can help designers to from a multitude of design thinking perspectives. The other case in design should apply advanced techniques widely. These pluralistic applications of culture reference resource and advanced technique application can help culture reference design methodology operate efficiently in the future product design.

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Analyzing Various Functions of Prefrontal Cortex (PFC) in Decision Making via Brain Imaging Techniques

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Abstract. With the advent of noninvasive medical imaging techniques, neuro scientists have acquired the ability to examine functional activation of human's brain in different environments, especially infants and elderly patients, an approach which was difficult until recently with introduction of with non-invasive neuro imaging methods. One innovative new neuro-imaging technique is the functional Near-infrared spectroscopy (fNIRS) which obviously compensate much limitations, and an elucidation of this technology being implemented and gathered attention of modern social and neuro imaging researchers. Most of the Near-infrared spectroscopy (NIRS) research falls into two main categories: Analyzing the brain's social and biological information in academia, and its clinical applications making neuroimaging particularly advantageous. Moreover, Near-infrared spectroscopy (NIRS) allowed researcher to investigate different cultural and behavioral interaction with human and the behaviors in which these interaction changes effect brain. One of the behavioral interaction is the decision-making process and its study on human brain region known as Prefrontal Cortex Region (PFC). Most decision-making processes takes place in prefrontal cortex region of brain, functional neuro imaging techniques like functional Near-infrared spectroscopy (fNIRS) and functional magnetic resonance imaging (fMRI) and are considered as an optimal medium to investigate these processes. This study also offer further investigation as to how to the use of medical imaging techniques to answer questions of decision making in PFC trigon of human brain.

M. Hoffman (ed.), *Advances in Cross-Cultural Decision Making*,
Advances in Intelligent Systems and Computing 610, DOI 10.1007/978-3-319-60747-4_23

Keywords: Near-Infrared Spectroscopy (NIRS) · Functional Magnetic Resonance Imaging (fMRI) · Medical Imaging Techniques · Noninvasive Brain Imaging · Prefrontal Cortex Region (PFC) · Brain · Decision Making

1 Introduction

Over the past two decades, research in neuro imaging methodologies entered into various new dimensions like measuring the cognitive behavior and different socioemotional interactions of humans with environment. The most important are the non-invasive methods like electroencephalography (EEG) and functional magnetic resonance imaging (fMRI), and recently optical neuro-imagining method functional Near-infrared spectroscopy (fNIRS) has taken attention of various social and neuro science researchers. On the other hand, with the advent of optical brain imaging techniques like Near-infrared spectroscopy (NIRS) most of limitations encountered in the other neuro imaging techniques have been overcome. The main advantage of fNIRS is its low cost, portability, less effected by the motion artefacts, noninvasive, and more temporal resolution as compared with MRI and more spatial resolution compared with EEG. The advantages make fNIRS a good alternative. Most of the behavioral and emotional cognitive functions are processed in the prefrontal cortex region (PFC) of the brain. Modern brain imaging techniques able to detect different brain functions but have some limitations and tradeoffs over each other. The techniques like Computed tomography (CT) and MRI both require very huge setting and large space to perform different functions and measure the images of brain. These techniques also carry huge amount of cost in performing tests and entail patient to be in motionless state which is difficult. EEG of the other hand is easy, portable and less costly but its spatial resolution is very less which makes its detection approximation somewhat less accurate. With the arrival of neuroimaging techniques like EEG, positron emission tomography and magnetic resonance imaging, a great of mapping information on the human brain has been collected.

Most of the brain mapping methods are performed on young adults because the constraints involved in the MRI and PET are not suitable for infants and very elderly persons. No radioactive material is involved in the testing fMRI but very tight motion constraints and maximum individuals feels stressful. To further explore our understandings into brain functions, a new optical neuroimaging method that is totally noninvasive and does not require strict motion constraint is Near-infrared spectroscopy-fNIRS. One of the old neuro imaging method is EEG and it has been in use over the past 50 years. Different studies on human brain with EEG are surprising in terms of how brain react with different stimuli in the social environment. MRI and recently fMRI again is a non-invasive technique of measuring the brain patterns and getting its images by placing the human head in the MRI scanner. Although the size of fMRI has considerably reduced over the period of time but still required different huge protocols that restricts patient's movements and settings.

Various studies have shown that emotional variations in turn change the requirement of the blood oxygenation level in the blood that can be easily monitored in the PFC. The oxygenated and de oxygenated hemoglobin level changes and these changes

can be measured with fNIRS equipment. Various decision making process are also measured as cognitive function in the PFC. Different decision requires different amount of oxygen in the hemoglobin and which in detected in the optical probe of fNIRS. Same are obvious in various studies in fMRI.

2 Brain Tissues and Near-Infrared (NIR) Light Propagation

Brain tissues are much transparent to near-infrared (NIR) region light, thus this region is named as "biological optical window" [1]. In optical window the NIR light is mostly not observed in the brain tissues and most if it is scattered and can be detected via detectors with the brain optical imagining techniques like near-infrared spectroscopy (NIRS) technique is non-invasive measurement of brain's tissue oxygenation concentration. Noninvasive optical measures of brain functions were discussed in various studies since the last 3 decades and their advantages and limitations make then suitable for various settings [2–5]. Applications of NIRS in measurement of brain hemodynamic changes associated with functional activation in the (PFC) brain's region are highlighted in various studies of Hoshi, Hoshi is among very few researchers who investigated the application of fNIRS in measuring the hemodynamic behavior [3, 6, 7]. The technique emerged as investigation of measurement of hemodynamic with NIR light. Apart from hemoglobin, there are other substances present in blood such as water and it does absorb light but the absorption increases after 900 nm region. So, in NIR region the light is mostly scattered out after interaction with hemoglobin. When some change in requirement of oxygen occurs in blood hemoglobin as a result of some neuro process like emotion or thought or decision, the more oxygen is supplied to hemoglobin making oxygenated hemoglobin more active as compared to deoxygenated. This process takes about few seconds and this change is also measure with NIRS equipment.

NIRS technique induce NIR signal with source LEDs into scalp of human head, the light in the range from 650 nm to 900 nm has minimum absorption in the brain tissues

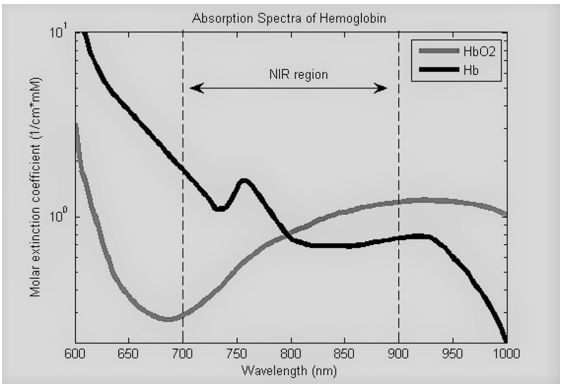

Fig. 1. Absorption properties of various brain tissues. Boxed region from 700 nm to 900 nm in the near-infrared spectral region called "biological optical window" where most of the light in NIR region is reflected and scattered back at detectors.

so most of it is scattered and reflected back at NIRS detectors, it measures concentration changes in oxygenated hemoglobin (oxy-Hb signal) and deoxygenated (deoxy-Hb signal). Since there is variance in absorption coefficients between oxy-Hb and deoxy-Hb and is dependent on the wavelength of light and NIRS utilize this property to measure the change in concentration [5, 6] (Fig. 1).

3 Blood Oxygenation Level-Dependent (BOLD) and Optical Tomographic Spectroscopic Signals

The NIRS deoxy-Hb signal are similar to blood oxygenation level-dependent (BOLD) signal in that are measured in functional magnetic resonance imaging. BOLD signals can be understood as signature of the functioning brain thru its metabolic activities incessantly moderating the blood flow, its blood content, and oxygen level of the blood in the brain tissues. In the experiments performed by various researchers [8–10] concluded few deductions that showed that Both BOLD and NIRS deoxy-Hb signal have similar signal-to-noise ratio and the correlation between distance between the scalp and the brain of these two signals is strong. This spatial imaging maps produced from functional magnetic resonance imaging (fMRI) and fNIRS have been found in such experiments, generally spatial domain, fMRI has much edge over the fNIRS due to deep penetration of magnetic resonance as compared to 2.5 cm depth penetration of fNIRS signals but the path formed by scattered photon between the emitter and detector in fNIRS is much like ellipse shaped (depth is about 2–2.5 cm) which is correlated with the BOLD signals [11, 12]. Blood flow in the brain is highly dependent on the neural activity. The neural activity changes the requirement of oxygen and carbon dioxide in cortical tissue. When a specific region is activated as a result of some neural activity in cortex, a response is generated a small amount of oxygen from the local capillaries is consumed resulting in initial drop of oxygenated hemoglobin and an increase in carbon dioxide (CO_2) and deoxygenated hemoglobin. As a result, a after a lag of 2–5 s, cerebral blood flow (CBF) increases and delivers a surplus oxygenated hemoglobin to neurons, and wash way CO_2 this in turn is visible as BOLD signals (local tissue oxygenation) in MRI readings.

The main reason fMRI is intelligent enough to detect these changes lies in major difference of paramagnetic properties of oxygenated hemoglobin (Oxy-Hb) and deoxygenated Hb (De Oxy Hb). The deoxygenated Hb is paramagnetic and detected as BOLD signal. The theory behind the fNIRS detection of Oxy-Hb and De-Oxy Hb and their change in concentration make much similarity between the fNIRS and the BOLD signals. The correlation between change in concentration of deoxy hemoglobin and BOLD signal is strong. The results in research [13] also shows that the direct correlation of reciprocal BOLD signals with Oxy Hb to is strongest and most robust to DPF variation which again dependent on the paramagnetic properties of Oxy Hb, it is with De-Oxy Hb to be weakest, and lastly with total Hb to be intermediate in correlation strength but quite robust to DPF changes. The values of oxygenated and deoxygenated Hb is with modified Beer-Lambert derived. These findings remained unaffected by the inclusion of scalp, skull, and inactive brain tissues in the calculation of the average BOLD signal response [9, 11]. Although constraints imposed by fMRI settings are

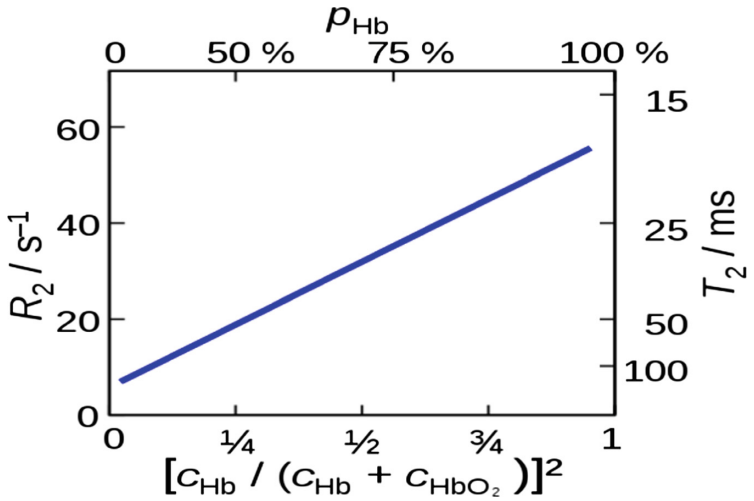

Fig. 2. Blood oxygenation level dependent (BOLD) signals: the transversal relaxation rate, R2, of blood increases linearly with the square of the concentration of deoxygenated hemoglobin adapted from Thulborn KR et al., Oxygenation dependence of the transverse relaxation time of water protons in whole blood at high field.

stressful in the clinical applications as compared to fNIRS. But the deep skin penetration and detection of oxygenated hemoglobin in the PFC area makes fMRI spatial resolution and accuracy much better then fNIRS, which is why despite few limitations BOLD MRI detection is preferred over fNIRS detection and its applications in clinical use (Fig. 2).

4 Regions of Prefrontal Cortex (PFC) and Decisions Making Process

During societal and economic decisions, the human brain compares causes with interest and resolve conflict among them. There are different regions of brain [14, 15].

- Prefrontal Cortex (PFC) region,
- Motor association Cortex region,
- Primary somatosensory Cortex region,
- Sensory association region,
- Visual association region,
- Visual Cortex region,
- Wernicke's region,
- Auditory association region,
- Auditory Cortex and Broca's region

and each portion is responsible for carrying out different functions like problem solving, emotion, thoughts perception is carried out in PFC. These Prefrontal areas

have good networks with limbic structures like amygdala and hippocampus, which intercede processes like memory, learning, decisions, emotional, drive, and motivation [16–18]. The prefrontal cortex (PFC) area of the brain play a pivotal role in this conflict management and decision making processes. Likewise, PFC also is further divided into sub regions and each with different functions [19, 20]. Each of these sub regions takes contribution from a wide-ranging set of causal, rostral and cortical areas, with an idiosyncratic input pattern. These include:

- Medial PFC
- Dorsolateral PFC
- Ventromedial PFC (VMPFC)
- Orbital PFC areas.

Working memory functions in humans processed in the areas called ventrolateral and dorsolateral, these areas are somewhat different in their networks with more posterior portions of the cerebral cortex. Among these regions, Ventromedial PFC (VMPFC) is part of PFC that becomes more active during incorporation of benefits in the chase of social goals [20]. Similar results are obtained in research on prefrontal cortex (PFC) with fNIRS [5]. In making the choices like whether to donate for some cause; (VMPFC) ventromedial PFC and dorsal Anterior Cingulate Cortex (ACC) showed some activation and is evident various research findings [14, 20].

Evidence of decision-making have been found in several brain regions specially research on PFC shows strong correlations with decision making process. Generalized method is used in various studies to quantity tuning curves that shows linkage between mentally accumulated evidence and neural responses, so as to differentiate decision variables in prefrontal cortex and posterior parietal cortex [17, 21, 22]. The activity in this region ACC is also involved conflict resolution, balanced decision between pro-social motives and self-interest. The Dorsolateral Prefrontal Cortex (DLPFC) plays an significant part in decisions involving social predilections and outcomes [1, 14, 15]. These studies suggest that processing of decision processes occurs in ACC and DLPFC but the involvement in decisions concerning different situations. As shown in Figs. 3 and 4 all the regions of PFC are exposed to emotional stimulus. It is believed in the research findings that some external stimuli can also alter the emotional processing in

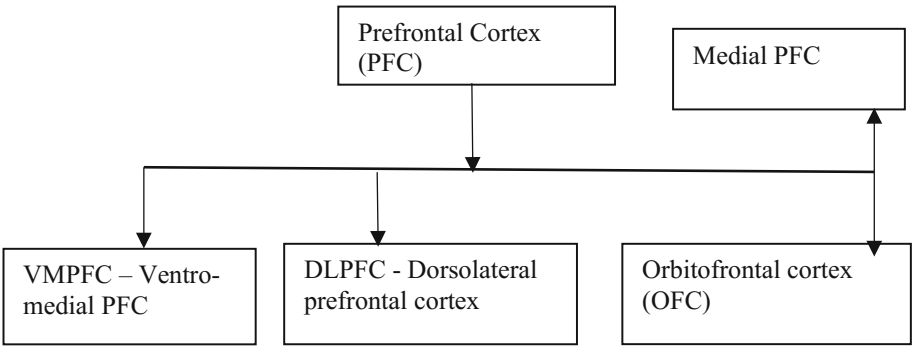

Fig. 3. Different regions of brain's - prefrontal cortex region and its sub region linkages

the PFC if given as a light or electrical impulse spike in that region. Some researchers also suggest that major emotions processing from 2–3 cm deep in PFC area enabling fNIRS to measure hemodynamic changes in that region [4, 5, 23].

4.1 Emotional and Decision Processing Medial and Ventromedial Prefrontal Cortex

As NIRS only can see neural activation from cortical structures about 2–3 cm deep into the skin, skull and brain, neural activation in limbic system (deeper than 3 cm), an area traditionally associated with deep emotional processing cannot be accessed with NIRS. But as PFC neural activation contains emotional processing, thinking and reward decision making, so many cognitive neuroscientists investigating the influence of emotions on cognition still rely on with fNIRS [5, 9, 16]. fMRI can thus investigate quite deeper in emotional and behavioral processing in brain. Numerous parts of the brain in cognitive behavior revealed in neuro imaging studies and research attempts to predict preference and decision-making have increased in past one decade. Few fNIRS studies shows reverence to human's predilection, examination of prefrontal areas recognized the activation patterns in (medial PFC) MPFC in retort to varying levels of predilections [15, 20, 22].

The involvement of VMPFC in moral judgment and emotional processing, human preferences and inclination is revealed in many studies of decision making. This research hypothesis that a precise area of PFC i.e., VMPFC holds a decision and it is made on comparison and quality. Findings provide explanation as PFC might be used to make comparisons among diverse categories and make choices. Brain uses a common region of VMPFC in different decision for every stimulus [1, 5, 7, 21]. We find evidence in neuro imaging research suggests that this VMPFC region contains many neurons with similar properties and so they have capability to encode stimuli signals that are easily compared while making decision. These studies were based in fNIRS and fMRI shows that activity in VMPFC is directly correlated with generous donations and final decisions [8, 9, 17, 18]. The decisions involving charity and generous donations requires processing in VMPFC according to research. The brain decides the final outcome based on the present spending. The donations and the motional feeling associated with them also plays their part in these types of decisions. These studies revealed that emotional procession in the PFC is easily measured with fNIRS which detects hemodynamics changes from 2–3 cm deep skin in PFC area. fMRI goes a further step ahead to localized the sub region like VMPFC as its spatial resolution is much better then fNIRS. These PFC areas are not solely devoted in processing of social partialities, somewhat, VMPFC studies also suggests comprehensive part being played by this specific region in integrating benefits with emotional feelings, irrespective whether these selections contain a specific worth.

4.2 Dorsolateral Prefrontal Cortex (DLPFC) and Neuro Cognitive Processing

Neural activity can be accompanied by similar changes in the blood oxygen enrichment mode can also be detected by near-infrared light. Methods for brain imaging like fNIRS and fMRI also measures relative changes in oxidized (oxy-Hb) and deoxygenated (deoxy-Hb), hemoglobin related with neuronal activity. The neuro imaging studies show that the DLPFC plays a vital part in accurate decision support and good choice selection. When we encounter trade-off between the short term and the long-term benefit, a DLPFC permit decision towards long-term benefit [1, 9, 12, 19]. The long-term benefit is again a difficult decision and hard to decide as the brain inclination towards the instantaneous rewards seems more promising. The short term instantaneous processes are processed quickly as brain major portions inclined towards instantaneous rewards. Long term benefits are more difficult but processed in DLPFC.

The DLPFC activation offers cognitive regulation of the emotional decision to discard the unfair proposals. DLPFC action decrease the regulation of the neuro-impulse signals and so as to upsurge the refusal rate and increase [14, 20]. According to literature [5, 20, 21], the activity in DLPFC directly correlated with the appetitive range of values, DLPFC inversely correlated with the aversive range of values. These finding shows that DLPFC is involved in controlling the neuro signals that push us away from accepting unfair offers [1, 19, 24]. Interestingly, all these studies are tested via fMRI and fNIRS research is much limited in these regions specially regions like DLPFC that affects behaviors and fairness decisions. The regions highlighted in Fig. 4 as dark gray regions is DLPFC. VMPFC and OFC is adjacent to DLPFC so these all regions neurons works in a synchronized fashion contributing towards a decision processes. Decision was assumed to a choice with or with rewards. But modern studies show that there is lot of processing involved in the PFC sub regions before taking some decisions and that decision is surely effected by short term as well as the long-term benefits as well as the amount of effort involved as a consequence of that decision activity. In certain amount of culture or regions also have their effects on decision processing. It is believed that certain amount of communities in certain culture selects specific choices and other people in some other cultures or communities shows different choice selection and decisions. So decisions and choice selection is cross cultural dependent phenomena as well as the experience after selecting a particular choice. In literature, this is refereed as experienced utility where the experience after the decision utility is taken into consideration [1, 15, 22]. The experienced utilities are also examined with fMRI scanners where blood oxygenation dependent signals are examined. The research on experienced utilities is limited as the restriction imposed by different fMRI protocols entails restrictions on subject's movement less and other real life actual environmental effects could not be incorporated in the labs.

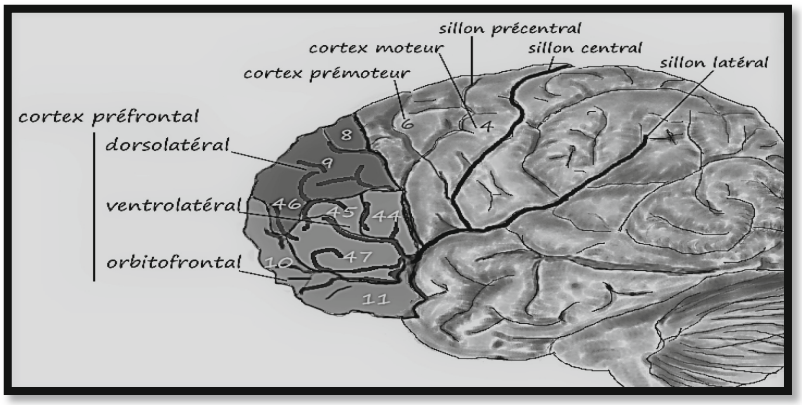

Fig. 4. Different regions of Human brain with DPFC as dark gray

5 Findings and Discussion

Numerous fNIRS studies have investigated deep insights into the neural mechanisms under lying various cognitive functions like emotions. Due to applications of functional Near-infrared spectroscopy (fNIRS) it various behavioral and social cognitive sciences, it achieved wide recognition among cognitive neuroscientists, specifically, the studies on emotions, neruo decision making, benefit analysis may also get advantage from fNIRS applications [3–5]. These studies on PFC regions like orbitofrontal cortex (OFC) involved in emotion processing like predilection, recompense recognition has established much deliberation over the past few years. As discussed DLPFC and VMPFC also have their roles in decision making, so as OFC involved in the decision-making processes. All these regions of PFC do contribute their parts, neural activity in one region also do activate neuron activity in the adjacent regions of PFC.

Various studies conducted with fMRI [8, 9, 12] shows the predilections activation of neurons are mostly activated in orbitofrontal cortex (OFC) and medial prefrontal cortex (MPFC) areas. These are the regions are involved in cognitive reasoning during decision-making. As discussed earlier the VMPFC and DLPFC are activated and the networks among them participated in regulating the decision processes. As evident is fMRI findings, non-invasive brain stimulation can change neural processes and social predilections. These stimulations may initiate neural activity. Neural activity last for few milliseconds do incite the requirement of oxygen in the hemoglobin of brain which in turn change the concentration of oxygenated and deoxygenated hemoglobin in the PFC. This change in concentration is measured as fNIRS and fMRI BOLD signals. These studies strengthen the idea that the VMPFC and DLPFC prefrontal cortex regions are involved in the harmonizing and pondering social predilections and decision outcomes [1, 2, 10, 12].

Multiple fMRI researchers showed a strong indication signals activation in ventral medial prefrontal cortex (VMPFC) at the time of choice in the in modest decisions concerning primary or secondary rewards [15, 23]. The OFC neurons function in

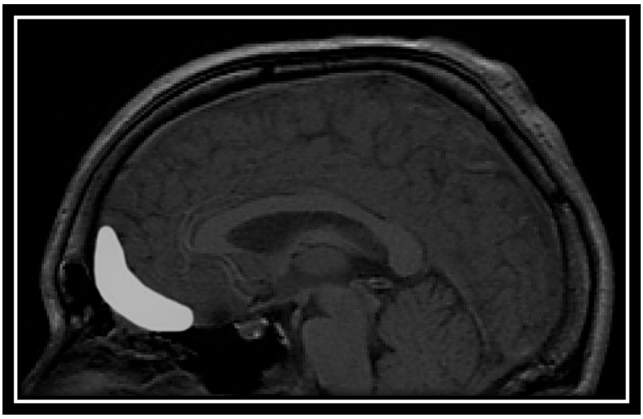

Fig. 5. Orbitofrontal cortex (OFC) - prefrontal cortex (PFC) region in the front portion of brain involved in the cognitive processing of decision-making. (Adapted from Author: Paul Wicks Source: obtained from 1.5T GE MRI Scanner in 2003. White region area is the location of the orbitofrontal cortex).

similar fashion as other neurons different regions of PFC [17]. Research shows that OFC has a different role by each sub region; specifically, OFC involved in stimulus-reward reversals. The lateral OFC (lOFC) and the medial OFC (mOFC) are collectively involved in response to the reward and punishing values [1, 15]. The mOFC responds to any sorts of value irrespective of experienced rewards or merely potential future rewards. The sub regions of OFC are evident in Fig. 5. These sub regions are also responsive to the induced non-invasive stimulus. Similarly change the oxygenated and deoxygenated hemoglobin level which in turn changes the absorption of NIR light.

Lateral PFC used in encoding behavioral responses and sensory information. On the other hand, OFC involved in encoding the potential outcomes toward which our behavior is directed. It is involved in information encoding as a value signal, that ensures that overall results may gratify requirements and accept behavioral precedence [5, 16, 19]. During reward recognition, diverse types of values are encoded as decision value then outcome value finally goal value. As discussed above that functional modules associated with decision-making are maintained by distributed neural systems as evident in fMRI research, these network connections are separate but mostly overlapping, and linked [23, 24]. The overall aim of this research review endeavor is recognition of behavior and can be associated with decisions and involvement of various regions of PFC.

Difference between these regions of PFC lies in the different information encoding processes in each region. Studies shows that OFC plays vital part in dispensation of reward processing: by integrating several information sources of return result to derive a decision value signal. These decision value signal narrates only to the decision result and not to the procedure to attain that result. To summarize all the discussion and functions of different regions of PFC in decision making process we conclude that the decision value signals are detained in working memory, where they are used by lateral PFC to propose and establish behaviors in gaining the final decision. The medial PFC

used to assess the complete process in terms of its accomplishment and the struggle that is essential to obtain. Thus, after reviewing all the research on PFC and its examination through various neuro techniques like fNIRS and fMRI we could achieve an important finding that all these regions of PFC work together in synchronized fashion, to ensure our behavior directed towards a good decision process [1, 14, 16, 19, 20].

6 Conclusion

The main motive behind this research study on the neuro-decision making is explore the functioning of PFC in decision utilities and improve our ability to understand and predict our behavioral involvements that may affect the over decisions and accomplish decision drives. This paper focused on neuroimaging techniques and their applications insight into neuro-decision making research on intertemporal choice and social predilections.

Previously neuroeconomic studies were implemented with EEG, PET MRI and CT, but those technologies also carry a lot of limitations and restrictions. So, new functional tools as fMRI and fNIRS that support examination of neuro-decision making could be done with less limitations and restrictions. Though the fNIRS is in its early phases of development in the decision support process yet many researchers working to reach optimal data acquisition and better understanding of choices and decisions. The goal of this paper was to discuss and present and overview of various studies generally dealing with the basic understanding of neuro imaging methodologies in investigating the roles of PFC and its different regions in decision support process. special research review and emphasis on the optical brain imaging mainly fNIRS and also some fMRI methods that offer understanding of PFC via neuro decision making research in effort to reach the explore optimal decisions process.

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M. Hoffman (ed.), *Advances in Cross-Cultural Decision Making*,
Advances in Intelligent Systems and Computing 610, DOI 10.1007/978-3-319-60747-4