Chapter 3

Imposing Cognitive Load to Detect Prepared Lies: A T-Pattern Approach

Valentino Zurloni, Barbara Diana, Massimiliano Elia, and Luigi Anolli

Abstract

One of the most well-documented claims in the deception literature is that humans are poor detectors of deception. Such human fallibility is exacerbated by the complexity of both deception and human behavior. The aim of our chapter is to examine whether the overall organization of behavior differ when people report truthful vs. deceptive messages, and when they report stories in reverse vs. chronological order, while interacting with a confederate. We argue that recalling stories in reverse order will produce cognitive overloading in subjects, because their cognitive resources are already partially spent on the lying task; this should emphasize nonverbal differences between liars and truth tellers. In the present preliminary study, we asked participants to report specific autobiographical episodes. We videotaped them as they reported the stories in chronological order or in reverse order after asking to lie about one of the stories. We focused in analyzing how people organize their communicative styles during both truthful and deceptive interactions. In particular, we focused on the display of lying and truth telling through facial actions. Such influences on the organization of behavior have been explored within the framework of the T-pattern model. The video recordings were coded after establishing the ground truth. Datasets were then analyzed using Theme 6 beta software. Results show that discriminating behavioral patterns between truth and lie could be easier under high cognitive load condition. Moreover, they suggest that future research on deception detection may focus more on patterns of behavior rather than on individual cues.

Key words Deception, Cognitive load, T-Pattern microanalysis, Theme, Detection, Nonverbal cues

1 Introduction

Deception is an articulated and complex communication act aimed at influencing the beliefs of others [1–3]. There are many kinds of deception, such as lies, fabrications, concealments, misdirection,

This chapter is dedicated to the memory of Professor Luigi Anolli.
Professor Anolli made an effective contribution to the introduction and development of communication psychology in Italy. Focusing on the miscommunication field, he closely examined deceptive communication in its different aspects. Within the communication domain, Professor Anolli also gave special attention to nonverbal communication. As well, he focused on new methodological devices of analysis. In Italy, he introduced the use of "Theme" software for the recognition of hidden patterns in human interaction. His contribution and his effort in the methodological and theoretical approach we have embraced were crucial for the realization of this study.

Magnus S. Magnusson et al. (eds.), *Discovering Hidden Temporal Patterns in Behavior and Interaction: T-Pattern Detection and Analysis with THEME™*, Neuromethods, vol. 111, DOI 10.1007/978-1-4939-3249-8_3,

bluffs, fakery, mimicry, tall tales, white lies, deflections, evasions, equivocation, exaggerations, camouflage, and strategic ambiguity. These forms of deception are common, everyday occurrences in interpersonal, group, media, and public contexts. However, one of the most well-documented claims in the deception literature is that humans are poor detectors of deception. Such human fallibility is exacerbated by the speed, complexity, volume, and global reach of communication and information exchange that current information technologies can afford now, enabling the collection of massive amounts of information—information that must be sorted, analyzed, and synthesized. The interactions and complex interdependencies of information systems and social systems make the problem even more difficult and challenging [4].

A recent meta-analysis reveals that although people show a statistically reliable ability to discriminate truths from lies, overall accuracy rates average 54 % or only a little above chance [5]. Moreover, the average total accuracy rates of professional lie catchers (56 %) are similar to that of laypersons. What is the reason for the near-chance performance of human lie detection? Do liars behave consistently with people beliefs about deceptive behavior?

2 Cues to Deception

Three recent, comprehensive meta-analyses [6–8] which considered above 130 studies published in English examining 158 different cues to deception, including a large variety of nonverbal, verbal, and paraverbal cues, as well as certain content features of deceptive and truthful messages, reveal that many conflicting results have been found.

DePaulo, Lindsay, Malone, Muhlenbruck, Charlton, and Cooper [6] examined around 100 different nonverbal behaviors. Significant findings emerged for 21 behaviors. The cues were ranked in terms of their effect sizes. The highest effect sizes were found in the cues that have not often been investigated, such as changes in foot movements, pupil changes, smiling. Concentrating on the cues that were investigated more often, the largest effect size was found for pupil size (dilation). Compared to truth tellers, liars' pupils look more dilated. Gaze aversion is not a valid indicator of deception. The simple heuristic that liars are more nervous than truth tellers is not supported because many cues of nervousness, such as fidgeting, speech disturbances or blushing, are not systematically linked to deception. However, liars appear tenser, have a tenser voice, have their chin in a higher position, press their lips more, and have less pleasant looking faces. They also sound more ambivalent, less certain and less involved, and make more word and sentence repetitions.

In different studies it was further found that liars make fewer illustrators, fewer hand and finger movements, and fewer leg and foot movements than truth tellers. DePaulo and colleagues [6] showed that the effect for illustrators was small, whereas the effect for hand and finger movements was somewhat more substantial. In those studies where a difference was found, liars typically showed fewer leg and foot movements than truth tellers. However, the effect for leg movements was not significant in this meta-analysis, perhaps because a "no difference" was found in many individual studies. Conversely, hand and finger movements appear to have the strongest relationship with deception. Vrij, Winkel, and Akehurst [9] found that 64 % of their participants showed a decrease in hand/finger movements during deception, whereas 36 % showed an increase of these movements during deception. Finally, most researchers that obtained an effect for shifting position reported that liars change their sitting position more than truth tellers do. In most studies where shifting position was measured, however, no difference between truth tellers and liars was found. It is therefore probably best to conclude that shifting position is not related to deception [8].

Even if research on this topic revealed only a few, and usually weak, relationships between nonverbal cues and deception, police training packages often include nonverbal and paraverbal behaviors as important cues to deception. Lay people and professionals alike have believed that these behaviors are particularly helpful in catching a liar [10, 11]. Although there seems to be no reliable cues, a closer look reveals that some studies have found reliable differences between liars and truth tellers under certain conditions, which may account for the overall inconsistency in findings. An explanation for the contradictory findings obtained across individual studies might be that studies differ regarding experimental method, the type of sample, or the operationalizations used to measure the nonverbal behaviors of interest. A host of moderator variables may blur the association between behavioral cues and deception.

These studies reveal that a sign equivalent to Pinocchio's growing nose has not been found [8]. In fact, most of the nonverbal cues do not appear to be related to deception. However, for some cues a weak relationship with deception emerged. Why only a few and rather weak relationships between nonverbal behavior and deception have been found? Could it be that more nonverbal cues to deception exist than we are aware of, but that researchers so far have overlooked some diagnostic nonverbal cues to deception? And could it be that a combination of nonverbal cues, rather than individual cues, would reveal diagnostic indicators of deceit?

3 The Imposing-Cognitive-Load Approach to Deception

Nonverbal cues to deception are typically faint and unreliable, as confirmed by the studies above mentioned. A contributing factor is that the underlying theoretical explanations for why such cues occur, like nervousness and cognitive load, also apply to truth tellers [12]. In order to explain deceptive communication, Zuckerman, DePaulo, and Rosenthal [13] pointed out that liars show signs of deceit as an outcome of experiencing emotions or cognitive load. However, those assumptions may lead to opposite behaviors. For example, arousal typically leads to an increase in eye blinks whereas cognitive load typically leads to a decrease in eye blinks. Moreover, the emotional approach predicts an increase in certain movements (signs of nervous behavior), whereas the cognitive load approach predicts a decrease in movements during deception as a result of neglecting the use of body language.

Different researches have recently examined whether liars actually do experience these processes more than truth tellers [14, 15], with controversial results. Studies in the past have focused on eliciting and amplifying emotions [16] for example by asking questions, but it is uncertain whether this procedure will necessarily raise more concern in liars than in truth tellers. For instance, Inbau, Reid, Buckley and Jayne [17] pointed out that liars feel more uncomfortable than truth tellers during police interviewing. Conversely, DePaulo and colleagues [6] comprehensive meta-analysis regarding how liars actually behave, and Mann, Vrij, and Bull's [18] analysis of behaviors shown by suspects during their police interviews gave no support for the assumption that liars, above all, appear nervous. DePaulo and colleagues [6] stressed that experiencing emotions is not the exclusive domain of liars. Truth tellers may also experience them and, as a result, may also display nonverbal cues associated with emotion. Moreover both liars and truth tellers gain from being believed, and will attempt to appear convincing [6].

Conversely, only a few efforts focused on unmasking the liars by applying a cognitive lie detection approach [16, 19]. Vrij and his colleagues [12, 16] have recently suggested that lying can be more cognitively demanding than truth telling. First, formulating the lie may be cognitively demanding. Except when the liar deceives by omission (e.g., when he omits to give the addressee some information that he/she thinks or knows is relevant to the addressee's goals), he needs to invent a story and must monitor its fabrication so that it is plausible and adheres to everything the addressee knows or might find out. Moreover, liars must remember what they have said to whom in order to maintain consistency.

Furthermore, liars are typically less likely than truth tellers to take their credibility for granted [12]. As such, liars will be more inclined than truth tellers to monitor and control their demeanor in order to appear honest to the investigator. Such monitoring and controlling is cognitively demanding. They may also monitor the interlocutor's reactions carefully in order to assess whether they appear to be getting away with their lie, and this too requires cognitive resources.

Liars also have to suppress the truth while they are fabricating, and this is also cognitively demanding. While activation of the truth often happens automatically, activation of the lie is more intentional and deliberate, and thus requires mental effort. A single deceptive act can be governed by a plurality of intentions, embedded in each other and hierarchically organized. Such is the case of a prepared (packaged) lie, in which different layers of communicative intentions are at work [20]: (a) a hidden (covert) intention (the speaker intends to deceive the addressee by manipulating the information); (b) an ostensive (overt) intention (the speaker intends to convey the information manipulation to the addressee). This second intentional layer is, in its turn, twofold: (b1) informative intention (the speaker wants to give the addressee the manipulated information as if it were true); (b2) "sincerity" intention (the speaker wants the addressee to believe that what he has said is true, in order to respect the Sincerity Rule of Searle [21]: "I want you to believe that I believe what I am saying to you"). Therefore, deceptive communication appears to require at least a second-order intentional system and in certain cases (especially in prepared lies) a third-order intentional system.

Lying is not always more cognitively demanding than truth telling [22]. Perhaps the reasons given as to why lying is more cognitively demanding could give us insight into when it is more cognitively demanding. For example, lying is likely to be more demanding than truth telling only when liars are motivated to be believed. Under those circumstances it can be assumed that liars take their credibility less for granted than truth tellers and hence will be more inclined than truth tellers to monitor their own behavior and/or the interlocutor's reactions. Moreover, for lying to be more cognitively demanding than truth telling, liars must be able to retrieve their truthful activity easily and have a clear image of it. Only when liars' knowledge of the truth is easily and clearly accessed suppressing the truth will be difficult for them. Obviously, truth tellers also need to have easy access to the truth for the task to be relatively undemanding. If truth tellers have to think hard to remember the target event (e.g., because it was not distinctive or it occurred long ago), their cognitive demands may exceed the cognitive demands that liars require for fabricating a story.

To sum up, the cognitive load of the deceiver (a) arises as a function of the entity and gravity of the deceptive contents, and (b) depends on the context's significance. This raises the distinction between *prepared* and *unprepared lies*. The former is cognitively planned in advance and examined by the deceiver at least in its main aspects, while the latter is spontaneously said, often by an answer to an unexpected question, without any mental planning. Anolli and colleagues [20] introduced a further distinction between *high-* and *low-content lies.* A deceptive act is high-content when it concerns a serious topic, is said in an important context, and is characterized by the presence of notable consequences and effects for the deceiver, for the addressee or even for other people. High-content lies may request previous planning, since they are generally foreseen and prepared. In this case, the liar has to elaborate his best communicative way to convince the partner. He has to be careful in the deceptive message planning, paying attention to its internal consistency and compatibility with the partner's knowledge. Moreover, he has to be as spontaneous as possible in the deceptive message execution in order to be believable [20].

In order to discriminate more effectively between truth tellers and liars, a lie catcher could exploit the different levels of cognitive load that they experience. If liars require more cognitive resources than truth tellers, they will have fewer cognitive resources left over. Cognitive demand can be further raised by making additional requests. Liars may not be as good as truth tellers in coping with these additional requests.

One way to impose cognitive load is by asking speakers to tell their stories in reverse order [12, 16]. The underlying assumption is that recalling events in reverse order will be particularly debilitating for liars—whose cognitive resources have already been partially depleted by the cognitively demanding task of lying—because (a) it runs counter to the natural forward-order coding of sequentially occurring events [23, 24], and (b) it disrupts reconstructing events from a schema [25]. This is analogous to the finding in the cognitive-attention literature that information processing in the primary task is slower in dual-task conditions than in single-task conditions [26].

In an experiment, half of the liars and truth tellers were requested to recall their stories in reverse order [16], whereas no instruction was given to the other half of the participants. More cues to deceit emerged in the reverse-order condition than in the control condition. Observers who watched these videotaped interviews could distinguish between truths and lies better in the reverse-order condition than in the control condition. For example, in the reverse-order experiment, 42 % of the lies were correctly classified in the control condition, well below what is typically found in nonverbal lie detection research, suggesting that the lie detection task was difficult. Yet, in the experimental condition, 60 % of the lies were correctly classified, more than typically found in this type of lie detection research.

4 Discovering Hidden Patterns in Deceptive Behavior

Since no diagnostic cue to deception occurs, it could be that a diagnostic pattern does arise when a combination of cues is taken into account [8]. Senders are able to arrange a set of different signaling systems to communicate and make their communicative intentions public, like language, the paralinguistic (or suprasegmental) system, the face and gestures system, the gaze, the proxemics and the haptic, as well as the chronemics. Among others, Anolli [27] argued that each of these communicative systems bears its contribution and participates in defining the meaning of a communicative act in an autonomous way. However, the generative capacity of each signaling system should be connected to produce a global and unitary communicative action, with a more or less high consistency degree.

Meaning is not connected with a unique and exclusive signaling system but is generated by the network of semantic and pragmatic connections between different systems. Such a process is ruled out by the so-called principle of *semantic and pragmatic synchrony* [27], according to which meaning is originated by a nonrandom combination of different portions of meaning, each of whom produced by a given signaling system. Thus, the meaning of a word, an utterance or a gesture hinges upon its relations to every piece of meaning arising out of each signaling system within the same totality.

Although it sounds reasonable to suggest that looking at a combination of nonverbal and verbal behaviors will lead to more accurate classifications of liars and truth tellers than investigating nonverbal and verbal behaviors separately, researchers rarely investigate both types simultaneously. Vrij and his colleagues [28, 29] examined participants' nonverbal and verbal behavior and obtained the most accurate classification of liars and truth tellers when both the nonverbal and verbal behaviors were taken into account. On the basis of a combination of four nonverbal behaviors (illustrators, hesitations, latency period, and hand/finger movements) they correctly classified 70.6 % of participating truth tellers and 84.6 % of liars, whereas any of these behaviors separately resulted in much more disappointing findings.

Ekman and colleagues found similar patterns of nonverbal behaviors during deception. Up to 80 % of truths and lies could be detected when a trained observer paid attention to micro-facial expressions [30]. When the tone of voice was taken into account in addition to micro-facial expressions, 86 % of the truths and lies could be detected [31]. Other studies have shown that between 71 and 78 % of correct classifications were made when the researchers investigated a cluster of behaviors [28, 32, 33]. In other words, more accurate truth/lie classifications can be made if a cluster of nonverbal cues is examined rather than each of these cues separately.

Clustering nonverbal cues to deception brings out some issues that remain unresolved at present. First of all, which kind of behavior should be clustered? Currently, different researchers examine different clusters of behavior, and it cannot be ruled out that a cluster that is effective in pinpointing lying in one situation or group of participants is not effective in another situation or group of participants [8]. Second, is there a criterion for grouping different behaviors into the same pattern? For example, the temporal distance between one cue and another is decisive. How much time must elapse between two cues to consider them as part of the same pattern? Finally, liars sometimes deliberately attempt to appear credible to avoid detection. For example, able liars, or people who are informed about the operating method on nonverbal behaviors, can successfully employ countermeasures to conceal nonverbal cues to deception. If it is known amongst terrorists, spies and criminals which lie detection tools will be used to catch them, they may learn more about these tools and attempt to beat them. If they succeed in doing so, the tools are no longer effective.

Of course, people can easily control only those patterns that are manifest and have a macroscopic nature, easily readable from the outside time by time. However, patterns in behavior are frequently hidden from the consciousness of those who perform them as well as to unaided observers [34]. As Eibl-Eibesfeldt [35] argued, "behavior consists of patterns in time. Investigations of behavior deal with sequences that, in contrast to bodily characteristics, are not always visible". Order alone is not a valuable criterion to detect hidden recurrent behavior patterns because deceptive strategies are characterized by a large complexity and by a great variability in the number of behaviors occurring between the liar and his interlocutor.

One approach is to include the element of time in the analysis of nonverbal deceptive behavior. Neural networks have been used frequently over the last few decades for static pattern recognition and pattern recognition in time. Discovering the real-time multilayered and partly parallel structure of even the most common dyadic verbal and nonverbal interactions remains a formidable challenge where clues to deception may be hidden to unaided observers in anything from the tiniest of details to intricate aspects of temporal structure.

A mathematical approach that may be particularly suitable for defining and discovering repeated temporal patterns in deceptive behavior is T-pattern sequential analysis. T-pattern detection was developed by Magnus S. Magnusson [34, 36, 37] to find temporal and sequential structure in behavior. The algorithm is implemented in the software THEME [38]. T-pattern analysis focuses on determining whether arbitrary events *e1* and *e2* in a symbolic string of {*ei*} events sequentially occur within a specified time interval at a rate greater than that expected by chance. In this way, it detects repeated patterns of intra- or inter-individual behavior coded as events on one-dimensional discrete scales. This kind of analysis has been used in a wide variety of observational studies, including microanalysis of *Drosophila* courtship behavior [39], cooperative behavior between humans and dogs when constructing an object [40], patient-therapist communication in computer assisted environments [41], and analysis of soccer team play [42]. The common feature in all of the above studies is the need to identify repeated behavioral patterns that may regularly or irregularly occur within a period of observation.

Since human behavior is highly organized, in this chapter, rather than concentrating on individual nonverbal cues of lies, our aim is to observe and describe the overall organization of behavior patterns which repeat over time. In particular, we focused on the display of lying and truth telling through facial actions. Research on single cues to deception has highlighted that facial displays are not reliable indicators of deception. They have great communicative potential (e.g., eye contact is used to persuade others) and, as a result, people are practiced at using and, therefore, controlling them [8]. We were interested in verifying the presence of significant and systematic differences in the organization of facial patterns when participants tell the truth or lie, both in the condition of imposed cognitive load and that of no cognitive load manipulation, in order to detect regularities in the temporal patterns of individuals belonging to the same condition.

5 The Present Study

5.1 Method

5.1.1 Participants

Participants were 12 students, all females, aged from 20 to 26 (mean age 23.25 ± 2.4), all native to the same geographic area. They were recruited at the faculty of Psychology from the University of Milano-Bicocca. After being recruited, all participants gave their informed consent both to audio and video recording.

5.1.2 Materials and Setting

The present study was carried at the University of Milano-Bicocca in an audio-isolated laboratory room equipped with four cameras, set to video-record participants' full-lengths and close-ups. The cameras were connected to a two channel quad device (*split-screen* technique).

5.1.3 Experimental Procedure

Participants were asked to report two autobiographical episodes, the first being a simple night out with friends, the second being about the last time they went to a restaurant with relatives. They were asked to lie about several elements of one (and only one) of the two reports; 15 min were given to recall the events (for the truth condition) and prepare a story (for the untruthful report), considering that they then would have to tell these reports to a confederate who didn't know which one was untruthful. In a first condition, participants had to report the story in chronological order, while in the second, they had to report it in reverse order (starting from the end of the story and going back to the beginning). Each story had to last around 5 min, marked by audio signals.

5.1.4 Experimental Design

A 2 × 2 experimental design was carried out. Included independent variables were:

– Content (1 = truth; 2 = lie).
– Cognitive load (1 = normal—chronological order; 2 = induced—reverse order).
– Nonverbal cues (Fig. 1) were the measured dependent variables.

5.1.5 Manipulation Check

To establish the ground truth and verify cognitive load manipulation and motivation, we asked the subjects to complete a questionnaire after the experiment was finished. Later, we watched the video recordings with the participants and asked them when they lied (veracity status).

5.2 Data Analysis

The coding grid was built basing on literature review of facial displays (gaze and facial micro-movements) in lie detection [6, 8, 43, 44] (Fig. 1).

We coded 2 min of each report, using a frame-by-frame video coder (Theme coder). Each behavior occurrence was considered as

ITEM	DESCRIPTION	ITEM	DESCRIPTION
b	begin of the event type	au20	Lip Stretcher
e	end of the event type	au23	Lip Tightener
		au24	Lip Pressor
ACTOR		au25	Lips part
actor1	participant	au28	Lip Suck
		au41	Lid Drop
FACE		au43	Eyes Closed
au1	Inner Brow Raiser	au45	Blink
au2	Outer Brow Raiser		
au4	Brow Lowerer	***GAZE***	
au5	Upper Lid Raiser	gazeup	
au6	Cheek Raiser	gazedown	
au12	Lip Corner Puller	gazeleft	
au14	Dimpler	gazeright	
au17	Chin Raiser		

Fig. 1 Coding grid

a punctual event (no duration). The occurrences of each behavior (event types) form the "T-dataset".

To assess inter-rater reliability of the T-dataset, Cohen's Kappa was calculated on 10 % of the same video materials independently coded by two coders, using a "blind" coding procedure. Although differing through categories, inter-coder reliability was found to be good to satisfactory (ranging from 0.79 to 0.91; $p < 0.05$). When disagreements were identified or the agreement was not perfect, the specific cases were discussed and agreed by both coders.

Datasets were then analyzed using Theme 6 XE3 beta software. A first analysis was conducted, aimed to explore the effects of the independent variables on the organization of nonverbal behavior in each condition, identifying their most significant patterns. We had a theme project file for each condition (normal/truth, normal/lie, reverse/truth, reverse/lie). Individual datasets were joined together through the "concatenate into a multi sample file" function.

We then conducted a second analysis, exploring the specific qualities that characterize truthful and untruthful behaviors within the "normal" and "reverse" conditions through the aforementioned concatenate into a multi sample file function.

5.2.1 Detection Procedure

Theme detects statistically significant time patterns in sequences of behaviors. The term T-pattern stands for temporal pattern; it is based on the timing of events, relative to each other. T-pattern detection [36, 37, 45] was developed for finding temporal and sequential structure in behavior. The algorithm implemented in the software detects repeated patterns of intra- or inter-individual behavior coded as events on one-dimensional discrete scales. T-patterns are repeated occurrences of two or more event types such that their order (allowing also for concurrence) is the same each time and the distances between them are significantly fixed as defined by a statistically defined and detected critical interval relationship. A minimal T-pattern consists of two event types. An event type is a category of observable behavior whereas an event is an instance of behavior occurring at a particular time unit without a duration [36]. The search naturally stops when no more patterns can be found and the result of such procedure is the discovery of patterns occurring more often than chance and embedded within the raw data stream in a nonintuitive manner.

By means of relevant options, the program allows the experimenter to set specific search parameters. Parameters set in present study were: critical interval type (free), significance (0.0001), minimum occurrence (5), lumping factor (0.90), minimum % of samples (100), packet base type (off), types of randomizations (shuffling and rotation), number of runs per type (20).

5.2.2 Selection Procedure

In the first analysis, complex T-patterns were considered, since they are regarded as the most interesting, due to their potential meaning and the (low) likeliness to be detected using other definitions and algorithms [36, 38]. However, instead of ignoring less complex patterns (e.g., simple two event type patterns), we selected those presenting a demonstrated behavioral relationship, basing our choices on literature review.

In the second analysis we used the function of Theme "selection – multi-sample file selection—statistical". Theme select patterns that appear significantly more often in samples selected than in the multi-sample file as a whole. The level of significance was 0.05.

5.3 Results

5.3.1 First Analysis

Qualitative Assessment

We compared the number of patterns detected (Fig. 2) and the mean of their lengths and number of levels (Fig. 3) among the four experimental conditions.

Behavioral Patterns

Within the first condition (truth when cognitive load is normal), most relevant patterns included a combination of different eyes movements with blinking (au45) and eyes closed (au43), a combination of different action units (au1 + au4; au1 + au2), and spontaneous smile (au6 + au12).

Analogous patterns were detected in the second condition (lie when cognitive load is normal). In particular, significative patterns included a combination of different eyes movements with blinking (au45) (e.g., Fig. 4), chin raised (au17) and spontaneous smile (au6 + au12), and a combination of different action units (au1 + au2).

Within the third condition (truth when cognitive load is induced), lots of patterns included a combination of different eyes

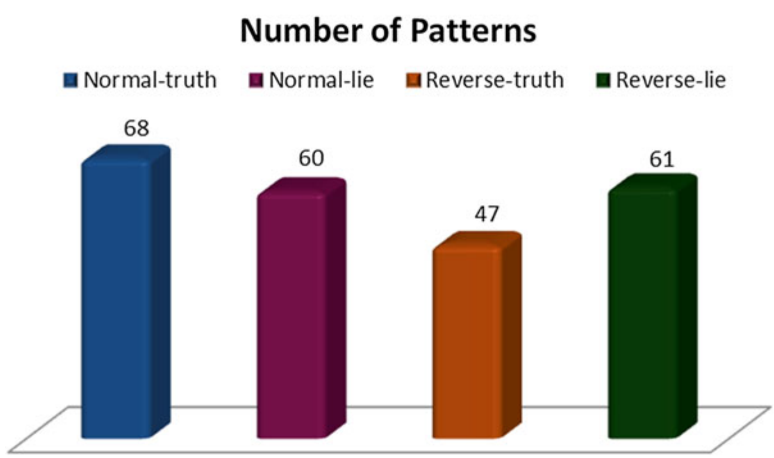

Fig. 2 First analysis: number of patterns in different conditions

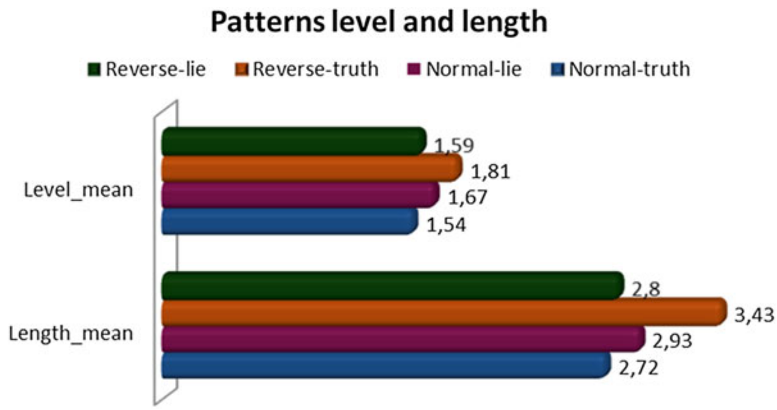

Fig. 3 First analysis: patterns' level and length in different conditions

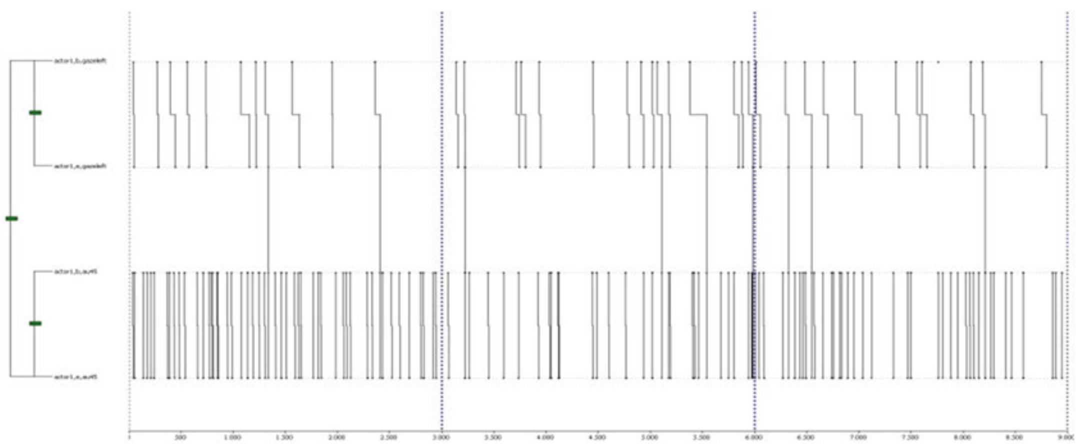

Fig. 4 A T-pattern in normal-lie condition: combination of eyes movements with blinking (au45)

movements with blinking (au45), and spontaneous smile (au6 + au12) (Fig. 5). Most patterns were composed of the repetition of a single event type.

In the fourth condition (lie when cognitive load is induced), most relevant patterns included a combination of eyes movements with blinking (au45) and eyes closed (au43), a combination of different action units (au17 + au23), and fake smile (au12 + au25) (Fig. 6). Lots of patterns were composed of one repeated event type.

5.3.2 Second Analysis

Qualitative Assessment

We compared the number of patterns detected (Fig. 7) and the mean of their lengths and number of levels (Fig. 8) between two experimental conditions (the two levels of the independent variable "cognitive load").

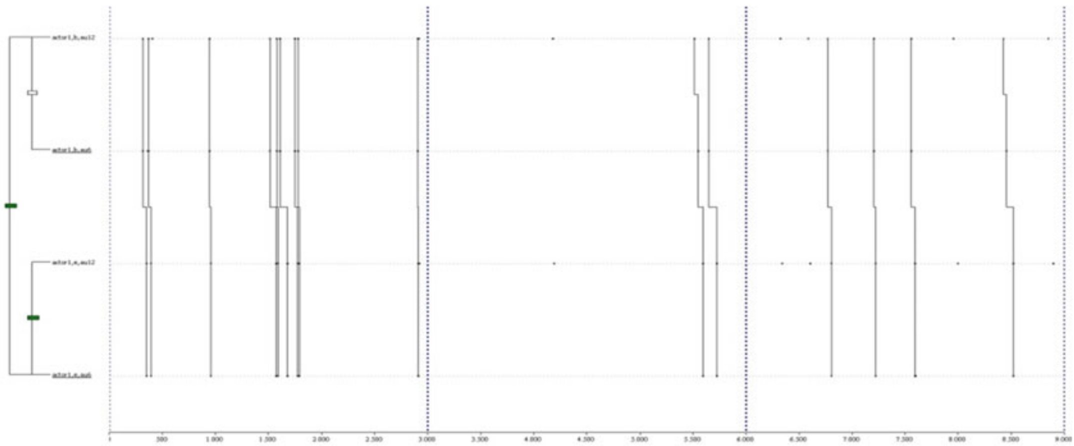

Fig. 5 A T-pattern in reverse-truth condition: spontaneous smile (au6 + au12)

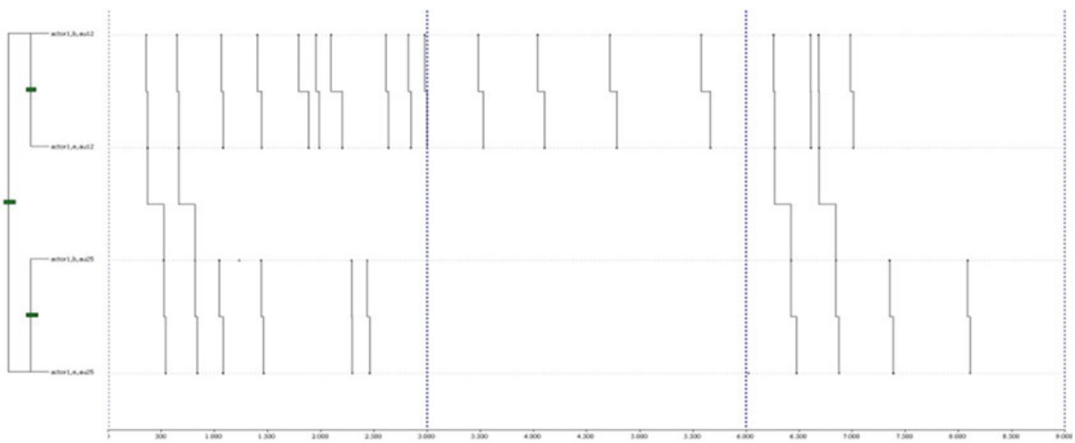

Fig. 6 A T-pattern in reverse-lie condition: fake smile, e.g., au12 + au25

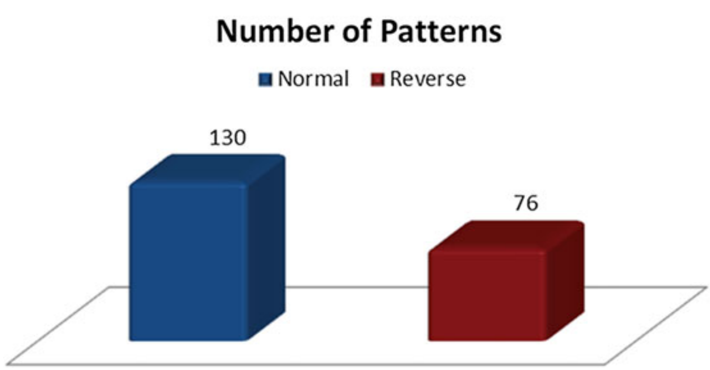

Fig. 7 Second analysis: number of patterns in different conditions

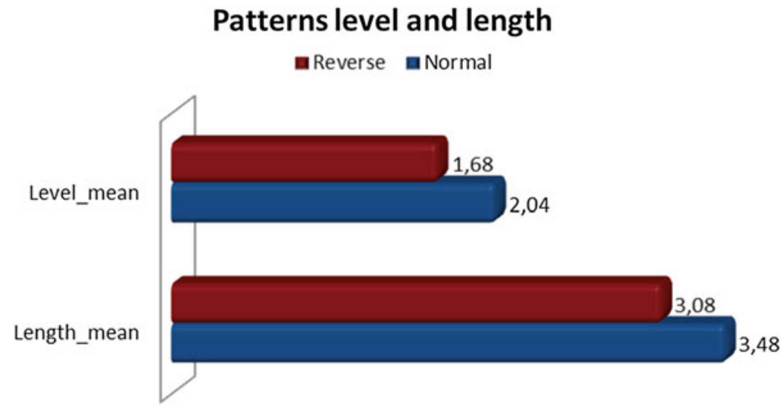

Fig. 8 Second analysis: patterns' level and length in different conditions

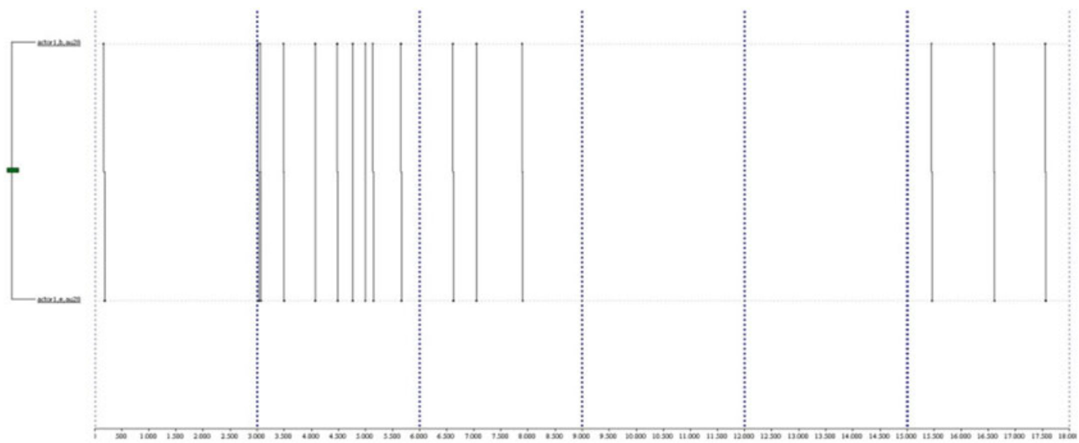

Fig. 9 A significantly distinctive T-pattern of truth in normal condition: au28

Behavioral Patterns

In the condition where the cognitive load was normal, the truth had only one significantly distinctive pattern compared to the entire dataset. It was composed only by the repetition of a single action unit (au28) (Fig. 9).

The lie instead had five significantly distinctive patterns compared to the entire dataset, most were composed by event types belonging to different eyes movements (gaze up, gaze down, and gaze right).

In the condition in which cognitive load was induced (reverse), the truth had four significantly distinctive patterns compared to the entire dataset. Patterns more relevant contained the spontaneous smile, present in three different patterns.

The lie had three significantly distinctive patterns compared to the entire dataset. They concerned the simultaneous presence of gaze up and gaze down (e.g., Fig. 10).

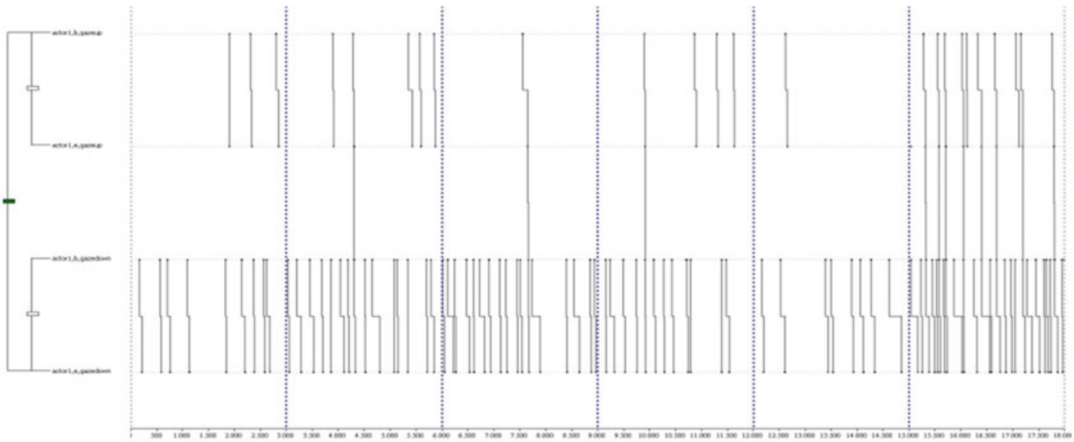

Fig. 10 A significantly distinctive T-pattern of lie in reverse condition: gaze up and gaze down

5.4 Discussion

Research on detection of deception mostly focused on identifying cues to deception, while few studies observed the sequential and temporal structure of deceptive behavior [8]. Through T-pattern analysis, our results showed repetitive temporal patterning among the different experimental conditions.

If we look at the overall pattern frequencies by group, in the normal condition the number of occurrences, lengths and levels between lying and truth telling is very similar. In contrast, in the reverse condition the number of occurrences was higher in lying than in truth telling, while lengths and levels were higher in truth telling than in lying. If we take a look at significant patterns, it can be seen how, within the normal condition, patterns were very similar among lying and truth telling. Moreover, they were difficult to interpret due to a combination of different eyes movements and different action units. Conversely, very regular patterns are more significantly present in the reverse condition, both in the lie and truth conditions (most patterns contain sub-patterns with repetition of event types). Since patterns in the reverse condition are more recurrent, regular and simpler than the ones seen in the normal condition, it is easier to assign a meaning to them. Besides, being the patterns in the reverse—truth condition quite different from the ones in the reverse—lie condition, it could be easier to discriminate nonverbal behaviors between liars and truth tellers in the reverse condition, than doing it in the normal one.

As Vrij stated [8], certain behavioral patterns are associated with honesty and likeability, such as directed gaze to a conversation partner, smiling, head nodding, leaning forward, direct body orientation, posture mirroring, uncrossed arms, articulate gesturing, moderate speaking rates, a lack of –ums and –ers, and vocal variety

[46–49]. Some people show such demeanor naturally even when they are lying (e.g., *natural performers*) [50]. These natural performers are likely to be good liars because their natural behavior is likely to allay suspicion. DePaulo and colleagues [6] examined around 100 different nonverbal behaviors. Significant findings emerged for 21 behaviors. The cues were ranked in terms of their effect sizes. The highest effect sizes were found in the cues that have not often been investigated, such as changes in foot movements, pupil changes, smiling.

In all conditions, except for the reverse-lie one, there are patterns containing event types ascribable to the spontaneous smile [47] (au6 + au12). This behavior is associated to truthful communication in literature [47] and it could be helpful to discriminate lying and truth telling in the reverse condition.

Patterns with a combination of different gaze movements were disclosed in all conditions. Even blinking (au45) does not seem to be significantly discriminative for the different conditions. However, when we compared truth and lies in the reverse condition, gaze movements (e.g., gaze up and gaze down) were significantly more present in lying than in truth telling. Moreover, there is a higher presence of closed eyes (au43) in both normal truth and reverse lie conditions than in other conditions. A number of researchers have linked excessive gaze aversion with increased cognitive load [51, 52]. During difficult cognitive activities, we often close our eyes, look up at the sky, or look away from the person we're talking to [53]. The fact that this behavior is present in the reverse lie condition and not in the normal lie or in the reverse truth could confirm this hypothesis, emphasizing the effectiveness of the reverse order as a method to induce cognitive load and to emphasize the differences between lying and truth telling.

6 Conclusion

Our data seems to support our objectives and proposals, even though it is clearly subject to some limitations. The most important limit, related to the use of self-reports and autobiographical episodes, is a *ground truth bias*. Can we really trust truth tellers? Did the liars lie for real? There is no legal way to assess the veracity status of most of our participants' statements; for example, lie tellers may also give socially desirable versions of their stories, violating the instructions we gave them [52].

In addition, we cannot be sure that participants are perfectly able to fully recall target events, even during the truthful conditions. Moreover, all participants who had to report (truthfully or not) their story in reverse order, experienced serious difficulties in recalling (and even telling) the events in that modality.

There are some factors that had to be excluded from this preliminary study, that we plan to explore in our next studies; we confined our studies to young females participants only, but it is a certain fact that this method should be applied to a wider sample, variable in gender and age range.

Future developments of this research will also take into account interactions between lie/truth tellers and their interlocutor, due to the importance of interpersonal processes involved in deceptive communication, which is created and ruled by a reciprocal game between communicators [27].

References

1. Bond CF, Omar A, Pitre U, Lashley BR, Skaggs LM, Kirk CT (1992) Fishy-looking liars: deception judgment from expectancy violation. J Pers Soc Psychol 63:969–977
2. Buller DB, Burgoon JK (1996) Interpersonal deception theory. Commun Theory 6:203–242
3. Kaplar ME, Gordon AK (2004) The enigma of altruistic lying: perspective differences in what motivates and justifies lie telling within romantic relationships. Pers Relationships 11:489–507
4. Burgoon J, Nunamaker J (2004) Toward computer-aided support for the detection of deception. Group Decis Negot 13:1–4
5. Bond CF Jr, DePaulo BM (2006) Accuracy of deception judgments. Pers Soc Psychol Rev 10:214–234
6. DePaulo BM, Lindsay JJ, Malone BE, Muhlenbruck L, Charlton K, Cooper H (2003) Cues to deception. Psychol Bull 129:74–118
7. Hartwig M, Bond CF Jr (2011) Why do lie-catchers fail? A lens model meta-analysis of human lie judgments. Psychol Bull 137:643–659
8. Vrij A (2008) Detecting lies and deceit: pitfalls and opportunities. Wiley-Interscience, New York, NY
9. Vrij A, Winkel FW, Akehurst L (1997) Police officers' incorrect beliefs about nonverbal indicators of deception and its consequences. In: Nijboer JF, Reijntjes JM (eds) Proceedings of the first world conference on new trends in criminal investigation and evidence. Koninklijke Vermande, Lelystad, pp 221–238
10. Breuer MM, Sporer SL, Reinhard MA (2005) Subjektive Indikatoren von Täuschung. Zeitschr Sozialpsychol 36:189–201
11. Granhag PA, Strömwall LA (2004) The detection of deception in forensic contexts. Cambridge University Press, Cambridge
12. Vrij A, Granhag PA, Mann S, Leal S (2011) Outsmarting the liars: toward a cognitive lie detection approach. Curr Dir Psychol Sci 20:28–32
13. Zuckerman M, DePaulo BM, Rosenthal R (1981) Verbal and nonverbal communication of deception. Adv Exp Soc Psychol 14:1–57
14. Vrij A, Semin GR, Bull R (1996) Insight into behavior displayed during deception. Hum Commun Res 22:544–562
15. Caso L, Gnisci A, Vrij A, Mann S (2005) Processes underlying deception: an empirical analysis of truth and lies when manipulating the stakes. J Invest Psychol Off 2:195–202
16. Vrij A, Mann SA, Fisher RP, Leal S, Milne R, Bull R (2008) Increasing cognitive load to facilitate lie detection: the benefit of recalling an event in reverse order. Law Hum Behav 32:253–265
17. Inbau FE, Reid JE, Buckley JP (2011) Criminal interrogation and confessions. Jones & Bartlett Learning, Gaithensburg, MD
18. Mann S, Vrij A, Bull R (2002) Suspects, lies, and videotape: an analysis of authentic high-stake liars. Law Hum Behav 26:365–376
19. Vrij A, Leal S, Granhag PA, Mann S, Fisher RP, Hillman J, Sperry K (2009) Outsmarting the liars: the benefit of asking unanticipated questions. Law Hum Behav 33:159–166
20. Anolli L, Balconi M, Ciceri R (2002) Deceptive miscommunication theory (DeMiT): a new model for the analysis of deceptive communication. In: Anolli L, Ciceri R, Riva G (eds) Say not to say: new perspectives on miscommunication. Ios Press, Amsterdam, pp 75–104
21. Searle JR (1979) Expression and meaning: structures and theory of speech acts. Cambridge University Press, London
22. McCornack SA (1997) The generation of deceptive messages: laying the groundwork for a viable theory of interpersonal deception.

In: Greene JO (ed) Message production: advances in communication theory. Routledge, New York, NY, pp 91–126

23. Gilbert JAE, Fisher RP (2006) The effects of varied retrieval cues on reminiscence in eyewitness memory. Appl Cogn Psychol 20:723–739
24. Kahana MJ (1996) Associative retrieval processes in free recall. Mem Cognit 24:103–109
25. Geiselman RE, Callot R (1990) Reverse versus forward recall of script-based texts. Appl Cogn Psychol 4:141–144
26. Briggs GE, Peters GL, Fisher RP (1972) On the locus of the divided-attention effects. Atten Percept Psychophys 11:315–320
27. Anolli L (2002) MaCHT-miscommunication as chance theory: toward a unitary theory of communication and miscommunication. In: Anolli L, Ciceri R, Riva G (eds) Say not to say: new perspectives on miscommunication. Ios Press, Amsterdam, pp 3–43
28. Vrij A, Akehurst L, Soukara S, Bull R (2004) Detecting deceit via analyses of verbal and nonverbal behavior in children and adults. Hum Commun Res 30:8–41
29. Vrij A, Edward K, Roberts K, Bull R (2000) Detecting deceit via analysis of verbal and nonverbal behaviour. J Nonverbal Behav 24:239–263
30. Frank MG, Ekman P (1997) The ability to detect deceit generalizes across different types of high-stake lies. J Pers Soc Psychol 72:1429–1439
31. Ekman P, O'Sullivan M, Friesen WV, Scherer KR (1991) Face, voice, and body in detecting deceit. J Nonverbal Behav 15:125–135
32. Davis M, Markus KA, Walters SB, Vorus N, Connors B (2005) Behavioral cues to deception vs. topic incriminating potential in criminal confessions. Law Hum Behav 29:683–704
33. Heilveil I, Muehleman JT (1981) Nonverbal clues to deception in a psychotherapy analogue. Psychother Theory Res Pract 18:329–335
34. Magnusson MS (2006) Structure and communication in interactions. In: Riva G, Anguera MT, Wiederhold BK, Mantovani F (eds) From communication to presence: cognition, emotions and culture towards the ultimate communicative experience. Festschrift in honor of Luigi Anolli. IOS, Amsterdam, pp 127–146
35. Eibl-Eibesfeldt I (1970) Ethology. The Biology of Behavior. Holt, Rinehart and Winston, Inc., New York, NY
36. Magnusson MS (2000) Discovering hidden time patterns in behavior: T-patterns and their detection. Behav Res Methods 32:93–110
37. Magnusson MS (2005) Understanding social interaction: discovering hidden structure with model and algorithms. In: Anolli L, Duncan S Jr, Magnusson MS, Riva G (eds) The hidden structure of interaction. From neurons to culture patterns. IOS, Amsterdam, pp 3–22
38. Magnusson MS (2004) Repeated patterns in behavior and other biological phenomena. Evol Commun Syst 7:111–128
39. Arthur BI, Magnusson MS (2005) Microanalysis of Drosophila courtship behaviour. In: Anolli L, Duncan S Jr, Magnusson MS, Riva G (eds) The hidden structure of interaction. From neurons to culture patterns. IOS, Amsterdam, pp 99–106
40. Kerepesi A, Jonsson GK, Miklosi A, Topál J, Csányi V, Magnusson MS (2005) Detection of temporal patterns in dog–human interaction. Behav Processes 70:69–79
41. Riva G, Zurloni V, Anolli L (2005) Patient-therapist communication in a computer assisted environment. In: Anolli L, Duncan S Jr, Magnusson MS, Riva G (eds) The hidden structure of interaction. From neurons to culture patterns. IOS, Amsterdam, pp 159–177
42. Camerino OF, Chaverri J, Anguera MT, Jonsson GK (2011) Dynamics of the game in soccer: detection of T-patterns. Eur J Sport Sci 12:216–224
43. Burgoon JK, Guerrero LK, Floyd K (2009) Nonverbal communication. Allyn & Bacon, Boston, MA
44. Ekman P, Friesen WV (1978) Facial action coding system: a technique for the measurement of facial movement. Consulting Psychologists Press, Palo Alto
45. Borrie A, Jonsson GK, Magnusson MS (2002) Temporal pattern analysis and its applicability in sport: an explanation and exemplar data. J Sports Sci 20:845–852
46. Buller DB, Aune RK (1987) Nonverbal cues to deception among intimates, friends, and strangers. J Nonverbal Behav 11:269–290
47. Ekman P (2001) Smiling. In: Blakemore C, Jennett S (eds) Oxford companion to the body. Oxford University Press, London
48. Ekman P (2009) Telling lies: clues to deceit in the marketplace, politics, and marriage. WW Norton & Company, New York, NY
49. Tickle-Degnen L, Rosenthal R (1990) The nature of rapport and its nonverbal correlates. Psychol Inquiry 1:285–293
50. Ekman P (1997) Deception, lying, and demeanor states of mind: American and post-Soviet perspectives on contemporary issues in psychology. Oxford University Press, Oxford, pp 93–105

51. Beattie GW (1981) A further investigation of the cognitive interference hypothesis of gaze patterns during conversation. Br J Soc Psychol 20(4):243–248
52. Ellyson SL, Dovidio JF, Corson RL (1981) Visual behavior differences in females as a function of self-perceived expertise. J Nonverbal Behav 5(3):164–171
53. Doherty-Sneddon G, Bruce V, Bonner L, Longbotham S, Doyle C (2002) Development of gaze aversion as disengagement from visual information. Dev Psychol 38(3):438–445