The Potential of Pervasive Sensors and Computing for Positive Technology: The Interreality Paradigm

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Abstract. Positive Technology is an emerging field that could be defined as the scientific and applied approach to the use of advanced technology for improving the quality of our personal experience. This discipline effectively combines the purposes of Positive Psychology with the enhancements of Information and Communication Technologies to promote individual and social well-being. Here, we suggest that a further advancement for Positive Technology might be offered by a new technological paradigm, namely Interreality. The value of Interreality Paradigm lies in bridging the gap between virtual and real world by integrating different pervasive sensors and computing technologies to create a hybrid, closed-loop empowering experience for the assessment and treatment actually missing in the traditional research and clinical approach of psychological disorders. Interreality Paradigm uses biosensors, activity sensors and mobile devices (PDAs, mobile phones, etc.) to conduct the continuous assessment throughout the virtual and real experiences. It enables tracking of the individuals' general and psychological status over time in several settings. The information collected during the assessment phase is constantly used to monitor individuals' progress and to precisely calibrate their treatment sessions thanks to a decision support system. Finally, Interreality Paradigm uses advanced simulations (virtual experiences) to transform health guidelines and provision in meaningful and engaging experiences. A recently funded European project "INTERSTRESS – Interreality in the management and treatment of stress-related disorders" will offer the right context to test and tune these ideas.

Keywords: positive psychology, positive technology, virtual reality, interreality paradigm.

1 Introduction

Positive Technology is an emerging field that could be defined as the scientific and applied approach to the use of advanced technology for improving the quality of our personal experience [1,2,3]. This discipline effectively combines the

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purposes of Positive Psychology [4,5,6,7,8] with the incredible enhancements of Information and Communication Technologies (ICTs) to foster positive emotions, to support individuals in reaching engaging and self-actualizing experiences, and to improve social integration and/or connectedness between individuals and groups: in sum, to promote well-being. Since ICTs allow the individual to live positive virtual experiences, an open challenge remains unclear: how can these virtual experiences improve the real world of an individual, and how can his/her real experience affect the virtual world? Here, we suggest that a further advancement for Positive Technology might be offered by a new technological paradigm, namely Interreality. The value of Interreality Paradigm lies in bridging the gap between virtual and real world by integrating different pervasive sensors and computing technologies to create a hybrid, closed-loop empowering experience for the assessment and treatment actually missing in the traditional research and clinical protocol of psychological disorders [9,10,11,12,13]. Starting from the socio-economic context that has led to a new definition of well-being, the paradigm of Positive Psychology will be fully explained. Then, the attention will be focused on Positive Technology and its promising applications. Finally, Interreality Paradigm will be introduced and explained in its technological and clinical advantages.

2 A New Definition of Well-Being

Since the mid-1940s, there has been a shift not only in the definition of the disease, but mainly in that of the well-being. Health was first conceived as a physical state of the body when perfectly functioning and with no evidence of disease, then it began to be conceptualized in a more holistic way, integrating also the social, cultural and psychological aspects. In the 1946, the *World Health Organization* (WHO) defined health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" [14]. The WHO's 1986 *Ottawa Charter for Health Promotion* has enriched this definition highlighting the importance of the health promotion in healthcare:

"*Health promotion is the process of enabling people to increase control over, and to improve, their health. To reach a state of complete physical, mental and social well-being, an individual or group must be able to identify and to realize aspirations, to satisfy needs, and to change or cope with the environment. Health is, therefore, seen as a resource for everyday life, not the objective of living. Health is a positive concept emphasizing social and personal resources, as well as physical capacities. Therefore, health promotion is not just the responsibility of the health sector, but goes beyond healthy life-styles to well-being.*" [15]

The change of cultural paradigm that has led to a multidimensional definition of well-being has also influenced psychology. As underlined by Seligman and Csikszentmihalyi *"the new century challenges psychology to shift more of its intellectual energy to the study of the positive aspects of human experience"* [4]. Before the World War II, indeed, psychology had mainly three missions: curing the mental illness, making individuals more and more productive and identifying high

talent [4]. Gradually, it becomes clear that a disease model may limit psychologists' comprehension of typical and optimal human functioning: this trend has resulted in a change in emphasis toward the study of the factors that allow individuals and communities to flourish - the strengths' perspective [16]. Within this framework, Positive Psychology could be defined as "nothing more than the scientific study of ordinary human strengths and virtues"[17].

2.1 Positive Psychology: Three Routes to Well-Being

In 2000, Seligman and Csikszentmihalyi officially announced the birth of Positive Psychology in the first twenty-first century issue of the *American Psychologist* [4]. As suggested also by Gable and Haidt [18], Positive Psychology has a long history starting from the pioneering research on "health mindedness" by William James in 1902, to Maslow's advocacy for the study of individuals' basic universal needs in 1968, to the Cowan's recent investigation on resilience in children and adolescents (e.g., [19]). Within the humanistic approach, Rogers introduced the concept of full functioning as fulfilment of the healthy and creative traits of the individual in a process of continual personal constructive growth: "*Here in this palm like seaweed was the tenacity of life, the forward thrust of life, the ability to push into an incredibly hostile environment*" [20]. These researches have gradually led to a paradigm shift, in Kuhn's terminology, from a psychology aiming at the reparation of deficits to a psychology focused on human potentiality [8]. The incredible value of Positive Psychology lies in having offered a unifying framework for the scientific study of well-being and in providing evidences to promote well-being [21,22]. On these basis, Positive Psychology is the scientific study of well-being to understand human strength and virtues and to promote them to allow individuals, communities, and societies to thrive [4,5,6,7,8]. So defined, a fundamental interest of Positive Psychology is the scientific study of well-being: what is, which factors allow its attainment and which consequences it leads at individual and social levels. Seligman, the father of Positive Psychology, in his book "Authentic Happiness" identified three constituents of well-being or happiness: a) pleasure or positive emotions; b) engagement; and c) meaning [23]. According to Seligman, there are three routes to well-being:

1. *the pleasant life*: achieved through the presence of pleasure and promoted by activities that increase positive emotions;
2. *the engaged life*: achieved through engagement in empowering activities and utilization of own strengths and virtues;
3. *the meaningful life*: achieved by identifying and connecting with something larger than oneself.

The pleasant life is based on a hedonic definition of well-being, which is rooted in Epicurean equation of happiness with pleasure, comfort and enjoyment. Kahneman and Colleagues [24] defined hedonic psychology, one of the two fundamental approaches of Positive Psychology [6], as the study of *"what makes experiences and life pleasant and unpleasant"* [25]. So defined, hedonic approach poses for itself an ambitious target of research and intervention by maximizing

human happiness. Although there are many ways to evaluate the pleasure continuum in human life, most study has used assessment of subjective well-being (SWB) [26], that consists of three components: life satisfaction, the presence of positive mood, and the absence of negative mood. The salience of positive emotions in increasing well-being is recently highlighted by "broaden-and-build model" [27,28]. According to Fredrickson [27], first of all positive emotions provide the organism with undefined action tendencies that may lead to adaptive behaviour: for example, joy is associated to the tendency to explore our surrounding physical and social environment. Secondly, positive emotions could reduce or mitigate the impact of stressful negative emotions: participants who were exposed to "positive films" after the vision of a "negative film" showed more rapid recovery from the cardiovascular activation [29]. Finally, positive emotions have fundamental long-term effects by broadening the thought–action repertoire and by building future physical, psychological, and social resources [28].

The engaged life is based, indeed, on a eudaimonic definition of well-being, that is rooted in Aristotle' ethical doctrine and its advocacy to fully realize our true nature (one's daemon), through the exercise of personal virtues in pursuit of a common good [30]. According to eudaimonic view, the other fundamental approach of Positive Psychology, well-being consists of more than the merely satisfaction of pleasure because it involves instead the actualization of human potential [6]. Ryff & Keyes [31] have introduced the concept of psychological well-being (PWB) that consists of six aspects of human experience: autonomy, personal growth, self-acceptance, life purpose, mastery, and positive relatedness. Self-determination theory [32,33] is an interesting perspective that has embraced the concept of self-realization as a central aspect of well-being specifying what it means to actualize the self and how that can be accomplished. Within eudaimonic approach, Peterson and Seligman [34] identified six universal virtues (wisdom, courage, humanity, justice, temperance, and transcendence) that are favoured by 24 character strengths representing the psychological components of them.

The meaningful life, finally, is based on a more complex definition of well-being that integrates individual well-being to social well-being by serving a purpose larger than oneself to promote connectedness between individuals, groups, and communities [35]. Csikszentmihalyi explained that he had realized the need for a positive psychology in Europe during the World War II:

"As a child, I witnessed the dissolution of the smug world in which I had been comfortably ensconced. I noticed with surprise how many of the adults I had known as successful and self-confident became helpless and dispirited once the war removed their social supports. Without jobs, money, or status, they were reduced to empty shells. Yet there were a few who kept their integrity and purpose despite their surrounding chaos. Their serenity was a beacon that kept others from losing hope. And these were not the men and women one would have expected to emerge unscathed. They were not necessarily the most respected, better educated, or more skilled individuals. This experience set me thinking: What sources of strengths were these people drawing on?"[4]

A Positive Psychology should take positive communities and positive institutions into accounts because individual experiences are necessarily embedded in several social contexts [8]. In this framework, Ryff and Singer have embraced these issues by introducing the concept of interpersonal flourishing, which could be defined as the development of positive relations with other people as a key dimension of well-being [36]. More recently, Biswas-Diener emphasized the shift from individual to collective well-being: the individual flourishing could be achieved by including group-level interventions, policies, and social change broadly [37].

3 Three Routes to Well-Being in Practice: Positive Technology

The progressive union of information and communication in technology has led to the field of Information and Communication Technologies (ICTs). Today, the current Golden Age of ICTs is dramatically changing every aspect of our individual and social lives. On one side, in fact, ICTs are becoming more and more popular in daily life because they are user-friendly and low-cost. On the other side, the technological sophistication has allowed the development of increasingly advanced devices. As underlined by Riva and his Colleagues [1], a significant part of the reflections concerning the use of technology starts with the same question: "What is wrong with technology?". The incredible progress in ICT sector and its clear influence in everyday life have led technology developers, designers, and psychologist to reflect about another starting question: "What is right about technology?". In this perspective, Positive Psychology appears to be a promising framework to develop ICTs that foster positive emotions, promote engagement in empowering activities and support connectedness between individuals, groups, and communities. Within this scenario, Positive Technology could be defined as the emerging scientific and applied approach to the use of advanced technology for improving the quality of our personal experience. If Positive Psychology identifies three constituents of well-being, namely positive emotions/pleasure, engagement/actualization and meaning/connectedness, positive technologies could be classified according to their effect in promoting these three features [1]:

1. *Hedonic level*: technologies used to induce and/or enhance positive and pleasant experiences;
2. *Eudaimonic level*: technologies used to support individuals in reaching engaging and self-actualizing experiences;
3. *Social and Interpersonal level*: technologies used to support and improve social integration and/or connectedness between individuals and groups.

For each level, we will try to identify crucial features that could be manipulated to develop different positive technologies (see Fig.1).

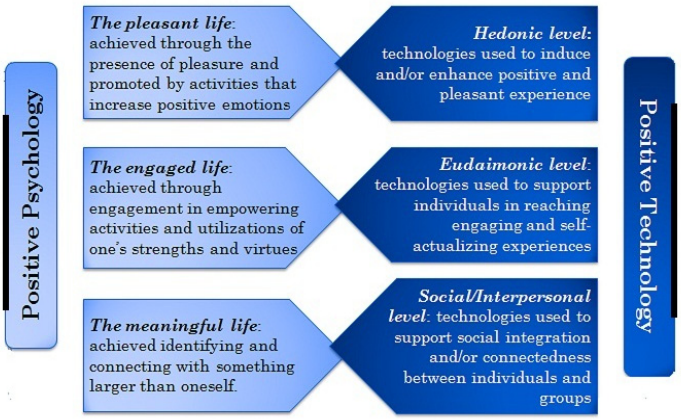

Fig. 1. From Positive Psychology to Positive Technology

3.1 Hedonic Level: Using Technology to Foster Positive Emotions

The first level of Positive Technology concerns how to use technology to foster positive emotions, such as joy and relaxation. There is a long history of researchers trying to induce affective states in experimental and clinical settings. On the basis of Russell's model, it is possible to modify the affective quality of an experience by manipulating the "core affect", a neurophysiological state corresponding to the combination of hedonic valence and arousal that endows individuals with a sort of "core knowledge" about the emotional features of their emotional experience [38]. Several procedures for the induction of mood states have been developed to investigate individuals' emotional responses [39,40,41]. Although it's not particularly recent, an interesting categorization of mood induction procedures (MIPs) is given by Gerrards-Hesse [39]. In that review, the authors proposed to classify them according to the stimuli used to affect participants' states: for example, Velten's mood induction technique [42] used self-referent statement describing positive or negative sensations to be repeated by the participants with the added instruction to get into the advocated mood state. Another category comprises the mood induction procedures built on the exposure of emotion-eliciting materials, such as pictures [43], music [44,45] or films [40,46]. Recent researches showed that Virtual Reality (VR) could be effective to induce positive emotions. The potential advantages of using VR technology in inducing positive emotions are essentially the following:

- *Interactivity*, to motivate participants, including video and auditory feedback;
- *Manipulability*, to allow the therapist and/or the researcher to tailor the sessions focusing on the specificity of individual as well as to increase task complexity as appropriate.

Riva and Colleagues tested the potentiality of Virtual Reality (VR) in inducing specific emotional responses, including positive moods [47]. Results suggested the efficacy of VR as an affective medium: the relaxing virtual environments induced relaxation. Villani and Colleagues compared the efficacy of structured experiences provided through different technologies (video, audio and VR) for inducing relaxing states: results showed a significant reduction of anxiety and a significant improvement in emotional states, assessed through psychological self-report and physiological parameters, but no difference among media conditions [48,49]. Within EMMA Project (Engaging Media for Mental Health Applications), some VR environments (Emotional Parks) were developed to induce positive states [50,51,52]. Emotional Parks combined different Mood Inductions procedures, such as Velten's self-statement [42], affective images from IAPS [53], and music to induce positive mood state within several virtual environments.

More recently, some studies explored the potentiality of emerging mobile devices in inducing positive emotions. Grassi and Colleagues [54] that showed relaxing narratives supported by multimedia mobile phones are effective to enhance relaxation and reduce anxiety in a sample of commuters. Villani and Colleagues [55] demonstrated the efficacy of a stress management protocol supported by the use of mobile phones in reducing anxiety levels in a sample of oncology nurses.

The advantages in using a mobile mood induction procedure could be potentially several both in research and clinical setting: first of all, a mobile platform can be multifunctional, exploiting the possibility of using more complex and combined stimuli (e.g., images, music, mobile application created ad hoc). Secondly, the use of a mobile device increases the ecological validity of the experiment: although the laboratory study maintains its status as the "gold standard" of controlled observation and concise testing of hypotheses, ubiquitous mobile platform offers the possibility to study user's experience in everyday environment.

3.2 Eudaimonic Level: Using Technology to Support Engaging and Self-actualizing Experiences

The second level of Positive Technology investigates how technologies can be used to support individuals in reaching engaging and self-actualizing experiences. This field of investigation includes, in turn, two sublevels:

- technologies that allow individuals to reach the state of flow [56];
- technologies designed to enhance individual self-efficacy [57].

The theory of flow [58] provides a useful framework to define what is an "engaging and self-actualizing experience". Flow, or optimal experience, is a positive state of total involvement of consciousness characterized by a perceived balance between high environmental opportunities for action (challenges) and adequate personal resources in facing them (skills). Additional features are deep concentration, clear rules in and accurate feedback from the task at hand, loss of self-consciousness, control of one's actions and environment, positive affects, and intrinsic motivation. The theory of flow has been deeply used to take into account

the user experience with ICTs [59] in order to investigate the factors that influence its occurrence [60] and to study its specific consequences in different computer mediated communication activities (e.g., [61,62,63]).

Recent research showed the potentiality of VR in supporting the emergence of flow state because it offers the immediate opportunity for action, the possibility to create increasingly challenging tasks due to its manipulability, and the opportunity to calibrate the appropriate and multimodal feedback [64,65,66]. In addition, some researchers have draws parallels between the experience of flow and the sense of presence, conceived as the subjective perception of "being there" in a virtual environment [67]. Both experiences, indeed, have been described as absorbing states, marked by a merging of action and awareness, loss of self-consciousness, and high involvement and focused attention in the ongoing activity [68,69]. On these premises, Riva and Colleagues suggested the use of VR for a new class of applications in mental health based on the strategy of the "transformation of flow" [66,70], which could be conceived as an individual's ability draw upon an optimal experience induced by technology, and use it to promote new and unexpected psychological resources and sources of involvement. For example, Gaggioli and Colleagues [71,72] developed and tested on 9 post-stroke patients the VR Mirror comprising a three computer-enhanced mental practice sessions per week. Results showed a good acceptance of this system by patients, giving support to the introduction of virtual reality technology into mental practice interventions.

The second sublevel regards the use of emerging ICTs in promoting self-efficacy as a crucial key in health promotion [57]. Within this perspective, self-tracking is a fast-growing trend in the field of e-health that consists in the "regular collection of any data that can be measured about the self such as biological, physical, behavioural or environmental information. Additional aspects may include the graphical display of the data and a feedback loop of introspections and self-experimentation" [73]. This approach is enabled by the increasingly convergence between ubiquitous computing and wearable biosensors, which allows personal health data to be collected, aggregated, visualized, collated into reports and shared [74,75]. Self-tracking is rooted into the experience sampling approach, a paper-and-pencil methodology developed by Csikszentmihalyi and Larson [76] that requires participants to fill out multiple brief questionnaires about their current activities and feelings by responding to random alerts throughout the day. As underlined by Ebner-Priemer and Trull [77], several terms have been used to refer to real-time assessment of psychophysiological data: Ambulatory Assessment [78], Ecological Momentary Assessment [79], Experience Sampling Method [80], and Day Reconstruction Method [81]. These assessment methodologies, although arose from different research paradigms, have in common the continuous recording of psychological and physiological data or indices of behavior, cognition or emotions in the daily life of individual. On these basis, Gaggioli and Colleagues developed and tested the use of PsychLog (www.psychlog.com), a mobile experience sampling platform that allows the collection of psychological, physiological and activity information in naturalistic settings [82,83]. PsychLog consists of

three main modules: the survey manager module, the sensing/computing module and the visualization module. The survey manager module allows configuring, managing and administering self-report questionnaires to collect participants' feedback on his/her quality of experience in its various cognitive, affective and motivational dimensions randomly during a day.

The sensing/computing module (figure 2) allows continuously monitoring heart rate and activity data acquired from a wireless electrocardiogram (ECG) equipped with a three-axis accelerometer. The wearable sensor platform includes a board that allows the transduction, amplification and pre-processing of raw sensor signals, and a Bluetooth transmitter to wirelessly send the processed data. The PsychLog application extracts QRS peaks through a dedicated algorithm [84] and R-R interval time series.

Finally, the visualization module (figure 3) allows plotting in real time ECG and acceleration graphs on the mobile phone's screen.

In this perspective, mobile self-tracking could be conceived as a persuasive technology [85] that allows individuals to accurately monitor their health and check their progress with encouraging and motivating feedback enhancing self-efficacy [57].

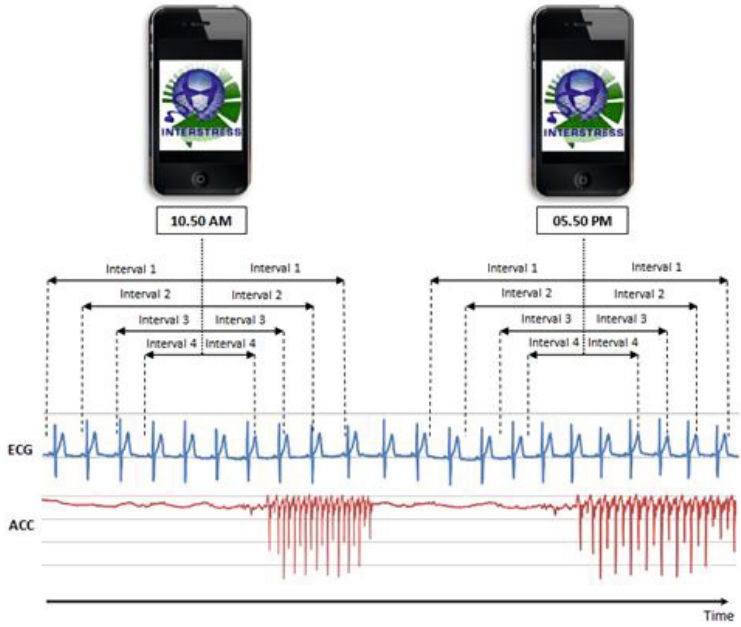

Fig. 2. PsychLog: The sensing/computing module

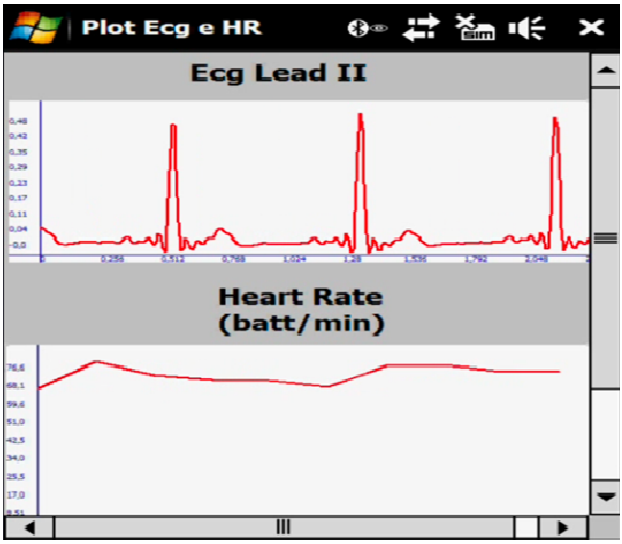

Fig. 3. PsychLog: The visualization module

3.3 The Social and Interpersonal Level: Using Technology to Promote Social Integration and Connectedness

The third level of Positive Technology regards the use of technologies to support and improve the connectedness between individuals, groups, and communities. The crucial question is to understand how to use ICTs to create a mutual sense of awareness and a strong sense of community at distance. Short and Colleagues defined social presence as the *"degree of salience of the other person in a mediated communication and the consequent salience of their interpersonal interactions"* [86]. The incredible progress of ICTs has allowed to enhance the social presence in several mediated activities, such as online learning [87] and healthcare (eg., [88]). Riva and Colleagues [89] recently suggested that an individual is present within a virtual group if he/she is able to put his/her own intentions (presence) into practice and to understand the intentions of the other group members (social presence). The technology has to provide the virtual group with the possibility of expressing itself and of understanding what each individual member is doing [90]. In this perspective, a virtual group is able to achieve a social optimal experience (networked flow state) in which the actions of the individuals and of the collective are merged and guided by "we-intentions", and the group acts as an autonomous, self-organizing entity [91]. In this perspective, social networking sites and pervasive computing technologies appears to be powerful tools for bringing people with shared interests to support and improve the connectedness between individuals, groups, and communities. As underlined by Swan, in addition to general social networking websites (for example, Facebook or Twitter), more specific purpose-driven social networks are dramatically emerging [73]. Morris developed and tested the use of a technological platform measuring phone calls

and visits to derive public displays of social interactions with relatives and friends to reduce feelings of social isolation and depression in elderly individuals [92]. These ambient displays, which reflect data on remote and face-to-face interaction gathered by wireless sensor networks, are intended to increase awareness of social connectedness as a dynamic and controllable aspect of well-being. In the same direction, within the Nostalgia Bits Project (NoBits), Morganti and his Colleagues developed a web-based platform where tangible artefacts (for example, photos, stories, and personal documents) of an elderly person's life can be uploaded and become a significant resource for use by other generations, and a means for connecting the elderly users with members of their own generation [93]. NoBits aims at fostering social interaction between the elderly and their family and increasing cross-generational interactions and mentoring. Another interesting example in this area is PatientsLikeMe (http://www.patientslikeme.com/), a health social network where patients may be able to find and share health information and emotional support [94].

4 Interreality Paradigm: Bridging Real and Virtual World

Currently, positive technologies for improving well-being and promote strengths and resilience in individuals and communities could be classified at three different levels: hedonic level, eudaimonic level and social/interpersonal level. The concept of "personal experience" is what unites these three levels [1]. According to the Merriam Webster Dictionary [95] it is possible to define "personal experience" both as ''a) direct observation of or participation in events as a basis of knowledge'' and ''b) the fact or state of having been affected by or gained knowledge through direct observation or participation.'' These definitions clearly underline the two sides of personal experience: if we can intentionally control the contents of our personal experience, its contents define our future intentions. As underlined by Riva [1], we both shape and are shaped by it. The examples presented showed that emerging technologies could be used to manipulate the quality of our personal experience in three separate, but related ways [1]:

- *by structuring it* using a goal, rules, and a feedback system to provide individuals with a sense of purpose focusing his/her attention and orienting his/her participation in the experience;
- *by augmenting it* to achieve multimodal, mixed and interactive experiences;
- *by replacing it* with a synthetic one using VR system to simulate physical presence in a synthetic world that reacts to the action of the individual as if he/she was really there.

In order to manipulate and enhance the features of our personal experience, Positive Psychology appears to be a promising framework to develop ICT that foster positive emotions, promote engagement in empowering activities and support connectedness between individuals, groups, and communities. Since ICTs allow the individual to live positive virtual experiences, an open challenge remains unclear: how can these virtual experience improve the real world of an individual,

and how can his/her real experience affect the virtual world? For instance, Virtual Reality has been widely used to carry out exposure-based treatments for anxiety disorders (e.g., [96,97,98,99]). As suggested by Repetto and Riva [9], although the virtual reality-based therapy has showed good efficacy in the treatment of anxiety disorders, the virtual experience in clinical settings remains separate from emotions and behaviors experienced by the patient in the real life world. The behavior of the patient in VR has no direct consequences on the real-life experience and the emotions and problems experienced by the patient in the real world are not directly addressed in VR exposure. To overcome these limitations, we suggest that a further advancement for Positive Technology might be offered by a new technological paradigm, namely Interreality. Interreality paradigm creates a hybrid environment within a closed-loop empowering experience for improving well-being [9,10,11,12,13]. The incredible value of Interreality Paradigm lies in bridging the gap between virtual and real world by integrating different technologies to develop assessment and treatment protocols actually missing in the traditional research and clinical fields of psychological disorders. The potential advantages offered by Interreality Paradigm will be explained and discussed in the following paragraphs.

4.1 Interreality Paradigm: From the Technology to Clinical Rationale

- From a technological viewpoint, Interreality Paradigm is based on the following integrated devices/platforms:

- *3D individual and/or shared Virtual Reality worlds:* They allow a controlled exposure, an objective psychophysiological assessment, and the provision of motivating and engaging feedbacks;
- *Personal Digital Assistants and/or mobile phones (from the virtual world to the real one):* They allow the possibility to conduct a real-time psychophysiological assessment and to deliver psychological interventions during daily activities;
- *Personal Biomonitoring System (from the real world to the virtual one):* It allows a pervasive psychophysiological assessment through wearable biosensor both in clinical and ecological settings and a decision support system for treatment.

These technological devices are integrated around two subsystems: the *Clinical Platform* (inpatient treatment, fully controlled by the therapist) and the *Personal Mobile Platform* (real world support, available to the patient and continuously connected to the therapist). These two platforms allow:

- *an objective assessment of psychophisiological data using pervasive biosensors and behavioral analysis:* monitoring of the patient's behavior and both his/her general and psychological status, early detection of symptoms and timely activation of feedback in a closed-loop approach;

- *a Decision Support System for treatment planning trough data fusion and detection algorithm:* monitoring of patient's responses to treatment, management of the treatment and the provision of support for clinicians in making therapeutic decisions;
- *the provision of warnings and motivating feedbacks to improve patients' compliance and self-efficacy:* the sense of presence allowed by this approach affords the chance to deliver behavioral, emotional and physiological self-regulation training in engaging and motivating experiences.

Thanks to this powerful integration, Interreality paradigm bridges the gap between real and virtual world in the assessment and treatment of psychological disorders:

- the assessment is conducted continuously throughout the virtual and real experiences. It enables tracking of the individuals general and psychological status over time in several settings;
- the information collected during the assessment phase is constantly used to monitor individuals' progress and to precisely calibrate their treatment sessions thanks to a decision support system.

4.2 Interreality Paradigm in Practice: INTERSTRESS Project

According to Cohen and Colleagues [100] "Psychological Stress" occurs when an individual perceives that environmental demands tax his/her adaptive capacity. In this perspective, stressful daily experiences could be conceptualized as a continuous person-environment transaction in which individual isn't able to effectively cope with a challenge that is perceived to exceed his/her skills [10,101]. Every day, in fact, individuals are continually invited to deal with several situations or circumstances (for example, being fired from work or having trouble with parents or partner) that provoke anxiety and psychological discomfort. The Cochrane Database of Systematic Reviews identified in the Cognitive Behavioral Therapy (CBT) the best-validated approach for stress management [102,103]. CBT aims to influence dysfunctional emotions, behaviors and cognitions through a goal-oriented, systematic procedure to change cognition and to encourage individuals to proactively respond to daily stressors by reducing their negative thoughts and by optimizing his/her use of personal and social resources. Typically, this approach may include both individual and structured group interventions (10 to 15 sessions) interwoven with psychoeducational materials, experiential exercises and out-of-session assignments (practicing relaxation exercises and monitoring stress responses).

Even if CBT is the "gold standard" for the treatment of psychological stress, there is still room for improvement. In particular, there are three major issues to solve:

- the therapist is less relevant than the specific clinical protocol used;
- the protocol is not customized to the specific characteristics and needs of the patient;
- the therapy is more focused on the top-down model of change (from cognition to emotions) than on the bottom-up (from emotions to cognitions).

To overcome the above limitations, within a recently funded European project, "INTERSTRESS – Interreality in the management and treatment of stress-related disorders", we proposed a stress management protocol based on the Interreality paradigm. INTERSTRESS Project aims at helping individuals to effectively manage psychological stress through the acquisition of techniques of relaxation and coping strategies within six weeks treatment supported by advanced pervasive sensors and computing.

INTERSTRESS platform is based on the following technological devices:

1. *3D individual and shared Virtual Reality worlds:*

   Individual 3D Virtual Reality worlds offer the opportunity to deliver controlled and tailored VR-based exposure sessions in clinical setting according to the specific characteristics and needs of the patient (figure 4). These virtual environments are used in clinical setting and are fully controlled by the clinicians. These virtual worlds exploit the sense of presence provided by the engaging virtual experience to practice several stress management exercises: relaxation techniques, VR biofeedback, assertiveness training, time management training, and problem-solving training.

Fig. 4. INTERSTRESS: A VR-based stressful situation

On the other hand, in order to support connectedness between individuals for health promotion and medical education, shared 3D worlds appears to be promising technological devices. In particular, Second Life (SL) is a virtual three-dimensional platform that has been extensively used for medical education [104]. Within INTERSTRESS Project, Riva and his team developed the Learning Island, a Second Life platform aims at exploiting the motivation and the engagement provided by a shared virtual experience to teach the users about how to improve their stress knowledge and management skills

also beyond a clinical setting [105]. In the Learning Island (figure 5), individuals can learn a) what is stress, what is stress; b) which are the fundamental stressors that occur in daily life; c) which problem-focused (e.g. resource optimization and better planning) and emotion-focused (e.g. relaxation training, use of emotional support) coping strategies could be used to cope with stress.

Fig. 5. INTERSTRESS: The Learning Island

2. *Personal Digital Assistants and/or mobile phones (from the virtual world to the real one).*

In INTERSTRESS Project, a patient's activity in the virtual world has a direct link with his/her life through a mobile phone. The mobile phone allows the possibility to deliver real-time psychological experience sampling assessment [76] and psychological interventions during daily activities [106]. On one side, the mobile phone permits to accurately analyze real-time interaction between environmental demands and individual adaptive capacity and to precisely detect stressful events during the daily life situations [82].

This mobile experience sampling approach opens a "window into a daily life" [74] since participants are invited to provide self-reports of their momentary thoughts, feelings and behaviour across a wide range of daily situations in ecological contexts. On the other hand, the mobile phones could became a true Personal Digital Assistant that provide warnings, motivating feedbacks, and psychological interventions during daily activities as a consequence of critical participants' psychophysiological state. In the field of mobile interventions, Riva and his team has recently showed the efficacy of

mobile biofeedback in reducing anxiety in a sample of GAD patients [107,108]. Within INTERSTRESS Project, a mobile Heart Rate Variability (HRV) biofeedback will be developed to help participants in managing and coping psychological stress. Recent research, in fact, demonstrated that low HRV is associated with a wide variety of medical and psychological health problems, such as cardiovascular diseases, metabolic syndrome, depression, anxiety and psychological stress [109,110,111].

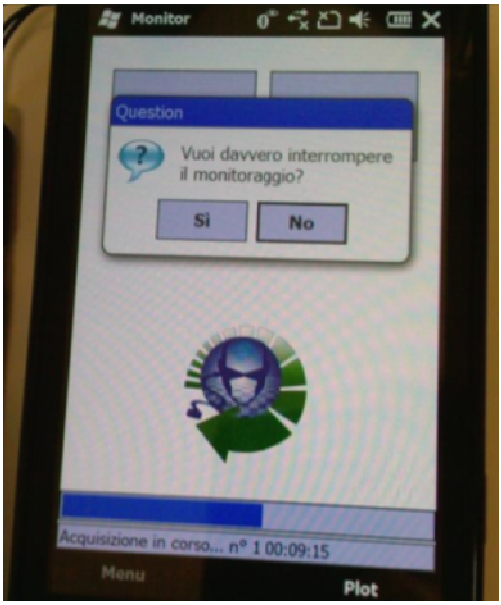

Fig. 6. INTERSTRESS. Mobile Application.

Fig. 7. INTERSTRESS: HRV mobile biofeedback training

The mobile system collects data from a wireless wearable electrocardiogram equipped with a three-axial accelerometer. Then, the mobile application provides a real-time and graphical visualization of user's physiological parameters. For example, by controlling the respiration rate, variations in the HRV indexes control the increase or the decrease of the size of a campfire in a valley or the movement of the waves in a beach.

3. *Personal Biomonitoring System (from the real world to the virtual one):*
It allows pervasive psychophysiological assessment through wearable biosensor in clinical and ecological settings and classifications for the decision support system for the treatment.

The Personal Biomonitoring system is a platform composed of an Electrocardiogram (ECG) module equipped with a three-axis accelerometer and integrated into a wearable chest band that collects, fuses and analyzes psychophysiological data. This wireless Biomonitoring system unobtrusively makes a real-time monitoring of heart rate, heart rate variability, breathing rate, activity data as meaningful physiological parameters related to psychological stress (e.g., [112,113,114,115,116]).

Data extracted by the Personal Biomonitoring System are automatically sent to central database (including physiological parameters collected in clinica settings, such as Electroencelography signals, Skin Conductance signals, Facial electromyography Corrugator and Zygomatic responses, and Respiration signals) for advanced analysis and classifications for the decision support system in order to evaluate psychophysiological status of the patient, monitor his/her progress and adapt the progression of the treatment.

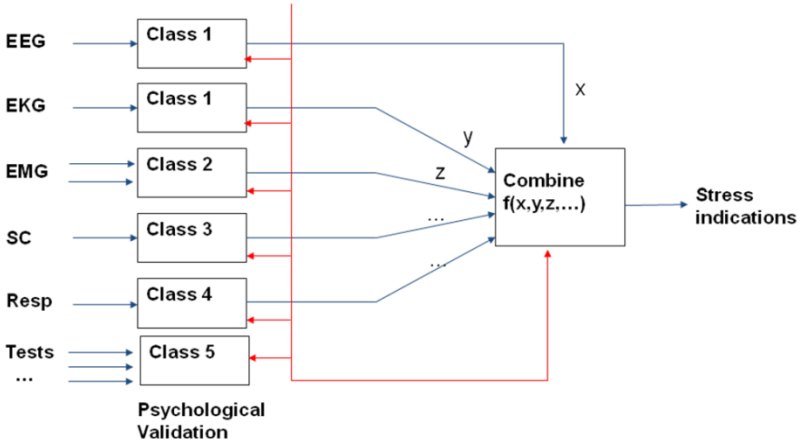

Fig. 8. Signal processing and data fusion for stress detection

4.3 Interreality Paradigm: Challenges and Cost Effectiveness

In a recent review, Riva [117] identified four major issues that may limit the use of the proposed Interrality approach in the assessment and treatment of psychological disorders:

- the lack of standardization in VR hardware and software, and the limited possibility of tailoring virtual environments to the specific requirements of the clinical or experimental setting;
- the low availability of standardized protocols that can be shared by the community of researchers;
- the high costs (up to $200,000) required for designing and testing a clinical VR application;
- expensive technical support or continual maintenance are often required.

To address these challenges, Riva and his team developed NeuroVR (http://www.neurovr.org) in 2007 – a free virtual reality platform based on open-source elements, and the updated version in 2010: NeuroVR 2 [118]. The software allows non-expert users to adapt the content of several pre-designed virtual environments to the specific needs of the clinical or experimental setting. The key features that make NeuroVR suitable as assessment and treatment tool for Interreality paradigm are the possibility to customize the virtual environments according to the characteristics of the patient, the enriched and engaging experiences provided to the patient, and the possibility to wirelessly connect virtual environment to wearable biosensors [118].

On the other side, mobile phones have became more and more popular in everyday life since they have quickly evolved from only voice and text-based devices enabling minimal user-device interaction, to low-cost Personal Digital Assistant, with digital camera, GPS and navigator, MP3 and video player, interactive agenda, advanced 3D graphics, Instant Messaging and Internet Browser equipped with 3G/UMTS and 4G [119].

As suggested by Preziosa [106], the critical advantages that mobile phones may introduce in Interrality paradigm are the following:

- the wide diffusion of mobile platforms reduces the problems of digital divide and offers the possibility of research and treatment access;
- mobile phones guarantee the availability of the contents any time and everywhere: in this sense their portability would be an eligible feature for assessments done in the patient's context;
- the interactive feedback increasing participants' compliance to the treatment and their self-efficacy;
- the high connection speeds offer new opportunities for a quick transfer and management of data for the clinical practice.

As recently suggested by Simpson [120], the evaluation of costs encountered or saved by introducing the use of ICTs must balance technological, training and support costs with factors such as reduced treatment costs, a longer lifetime

horizon, improved family and work commitments, costs incurred through time and expense of travel. In this perspective, recent studies suggest that the use of Interreality technologies (virtual reality and mobile phones) may lead to cost savings and improved outcome for both patients and health services [121,122].

5 Conclusion

The incredible value of Interreality Paradigm lies in bridging the gap between virtual and real world by integrating different technologies to develop assessment and treatment protocols actually missing in the traditional research and clinical fields of psychological disorders. Interreality paradigm is based on a closed-loop concept that involves the use of several integrated positive technologies for assessing, adjusting and/or modulating the emotional regulation of the patient, his/her coping skills and appraisal of the environment based upon a comparison of that patient's behavioral and physiological responses with a training or performance criterion. From a technological viewpoint, Interreality is based on the following elements: a) 3D individual and/or shared Virtual Reality worlds; b) Personal Digital Assistants and/or mobile phones (from the virtual world to the real one); c) Personal Biomonitoring system (from the real world to the virtual one). On one side, the patient is continuously assessed in virtual and real worlds by tracking the behavioral and emotional status in the contexts of challenging tasks thanks to pervasive biosensors (*customization of the therapy according to the characteristics of the patient*). On the other hand, feedback is continuously provided to improve both the appraisal and the coping skills of the patient through a conditioned association between effective performance state and task execution behaviors (*improvement of self-efficacy*).

In conclusion, we argue that the potential advantages offered to Positive Technology by the inclusion of pervasive sensors and computing are:

- *a real-time feedback between real and virtual worlds:* Interreality Paradigm uses biosensors, activity sensors and mobile devices (PDAs, mobile phones, etc.) both to track in real-time the behavior and the health status of the user and to provide targeted suggestions and guidelines;
- *an extended sense of community:* Interreality Paradigm uses hybrid social interactions and dynamics of group sessions to provide each users with targeted – but also anonymous, if required – social support in both physical and virtual world;
- *an extended sense of presence:* Interreality Paradigm uses advanced simulaions (virtual experiences) to transforms health guidelines and provision in experience. In Interreality Paradigm, the patient do not receive abstract information, but live meaningful and engaging experiences.

Obviously, any new paradigm requires a lot of effort and time to be assessed and properly used. Without a real clinical trial, the Interreality paradigm will remain an interesting, but untested concept. However, a recently funded European project,

"INTERSTRESS – Interreality in the management and treatment of stress-related disorders - will offer the right context to test and tune these ideas.

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