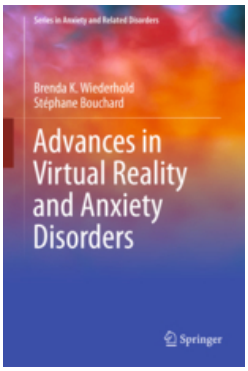

Advances in Virtual Reality and Anxiety Disorders

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13 – Conclusions: The present and the future of Virtual Reality in the treatment of Anxiety Disorders

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1. How to treat anxiety disorders

In the book we described anxiety as a human emotion that requires a complex cognitive system to be experienced (Damasio et al., 2000). When anxiety is directed to a specific event, increases in intensity and its activation is episodic, then we refer to this emotion calling it fear. Fear is easily recognizable even in animals, and has a strong evolutionary basis, since it triggers escape behaviours in case of danger, and allows for survival. Anxiety and fear, however, share the same emotional features to the extent that they can be accounted for as two sides of the same coin; moreover, depending on the range of their intensity, they may be considered normal emotional reactions to the context, or the core

symptom of many psychiatric diseases. The former, thus, are adaptive emotions that belong to the experience of each human being; the latter are maladaptive since they prevent people from conducting a normal life.

We will refer to the second situation as *anxiety disorders*, and they include the different disturbances addressed in the book: specific phobias (fear of flying, fear of spiders, fear of heights etc), panic disorders with or without agoraphobia, social phobia, post traumatic stress disorder, generalized anxiety disorder and obsessive-compulsive disorder. These disorders are very common among worldwide populations (Michael, Zetsche, & Margraf, 2007; Pull, 2008) and strongly impact on personal and occupational life: usual activities such as taking a plane, travelling with the subway, meeting friends and colleagues, or staying in crowded places become very stressful to the extent that, if symptoms are not treated, may lead people to avoid the feared situation. Avoidance behaviours, as time progresses, tend to worsen and then they start a vicious circle: in terms of conditioning paradigms, avoidance behaviours serve as negative reinforcements, since they stop the occurrence of an aversive symptom (anxiety); but, on the other hand, at the same time they contribute to maintaining the link between conditioned stimulus and unconditioned stimulus, and then preventing the extinction phenomenon.

Many different kinds of treatment for anxiety disorders are now available: behavioural treatments, cognitive psychotherapy, medication and biofeedback are among the most common used. Different research studies investigating the effectiveness of the different treatments have demonstrated that exposure-based therapies are more suitable and effective than others (Asukai, Saito, Tsuruta, Kishimoto, & Nishikawa, 2010; Barlow, Ellard, Hainsworth, Jones, & Fisher, 2005; Craske & Barlow, 2007; Deacon & Abramowitz, 2004; Emmelkamp, 2003; Franklin & Foa, 2007; Landon & Barlow, 2004; Olatunji, Cisler, & Deacon, 2010; Rothbaum & Schwartz, 2002).

Exposure is a process in which the patient is progressively exposed to the feared stimulus or the situation that provokes anxiety. Exposure alone, without relaxation training, is documented to be effective in treating a number of anxiety disorders and phobias, such as panic disorder with agoraphobia (Craske & Barlow, 2007), social phobia (Heimberg et al., 1990), and obsessive-compulsive disorder (Franklin & Foa, 2007). However, one of the most influential exposure techniques is the procedure of systematic desensitization developed by Wolpe (Wolpe, 1958), in which exposure is applied during relaxation, an emotional and physiological state considered incompatible with anxiety and fear (Hazlett-Stevens & Craske, 2008). In these protocols, the patient learns to manage anxiety symptoms by replacing emotional maladaptive activation with relaxation and, having the opportunity to monitor his thoughts and beliefs with the therapist, while experiencing anxiety, and learning to downsize his cognitive attributions. This process, repeated over time, helps people to face their fears and break the vicious circle of avoidance.
Traditionally, exposure may be achieved in two manners: *in vivo*, with direct contact to the stimulus, or by imagery (in the person's imagination). However, despite its effectiveness, both types of exposure presents some limitations: some patient report difficulties when asked to imagine the feared situation, because of poor abilities in creating mental images and in getting inside a specific situation; furthermore, emotions have been shown to modulate visual imagery and perception (Borst & Kosslyn, 2010), and in particular fear seems to impair visualization of detailed scenes, making the mental reconstruction of the stimulus to some extent biased and inaccurate; *in vivo* exposure, in contrast, bypasses this limitation but poses other critical issues. First of all, many patients are rather unwilling to expose themselves to the real situations, since it is conceived as too frightening; second, the real situation is not fully under the control of the therapist; third, it requires a high effort in terms of money and time expenditure, since usually the therapist and the

patient must meet each other outside the therapist's office to work together on the stimulus target.

For these reasons, the book introduced a novel tool to treat anxiety symptoms that overcomes most of these limitations: virtual reality (VR).

2. Virtual Reality Exposure Treatments: a new way of dealing with anxiety disorders

As we have seen many times during the book, a VR system is a combination of technological devices that allows users in creating, exploring and interacting with 3D environments. This capability is made possible by the use of input tools (trackers, gloves, mice) that send to the computer the position and the movement of the user in real time, graphic rendering that changes the environment coherently with the information acquired, and output devices (visual, aural and haptic) that return to the user feedback of the interaction. The integration of these devices gives the user the opportunity to be immersed in the environment and to experience the sense of *presence* in a computer-generated world. As discussed in the Second Chapter, presence is defined as "*sense of being there*" (Steuer, 1992) or as "*the feeling of being in a world that exists outside the self*" (Riva, Waterworth, Waterworth, & Mantovani, 2011; Waterworth, Waterworth, Mantovani, & Riva, 2010).

Thanks to these features, VR has been considered a useful tool to carry out exposure-based programs that better fit the needs of the patients (Botella et al., 2007). In effect, Virtual Reality Exposure Treatments (VRET) present several advantages when compared to traditional treatments carried out by both *in vivo* and imagination techniques (Wiederhold & WIederhold, 2008). Many of the problems encountered with *in vivo* exposure are easily bypassed by the use of VRET: first of all, it is completely controllable by the therapist, who can grade the intensity of the stimulus following the personal needs of each patient and eventually stop the session in case of excessive emotional activation

(which is, indeed, extremely rare). In this way, the patient feels less uncomfortable about the treatment and his/her motivation increases. Furthermore, a portion of a more complex event can be selected and repeated, in order to practise exactly the critical stimulus instead of wasting time with all other concomitant aspects (Wiederhold et al., 2002). Compared to imagination, VRET offers the possibility to visualize a realistic environment and to interact with it, making the experience more immersive and thus increasing the personal involvement. This will result in a more effective treatment, in terms of number of sessions needed to obtain improvements, and therefore of costs incurred.

There are also some caveats in the use of VRET, that have to be taken into account. First af all, some VR users report symptoms of sickness that target different areas (visual, vestibular, central nervous system, musculoskeletal). The risk of this “cybersickness” could be decreased by a gradual introduction to virtual environments, but in people prone to this kind of symptoms it may be difficult to overcome symptoms. Furthermore there are some medical conditions that represent significant contraindications for the use or VR, such as migraine headache and seizure disorder. Finally, it attention should be paid when using VR with patients affected by psychosis or personality disorders, since they may be predisposed to becoming confused by real versus virtual worlds.

The main problem with the use of VRET is related to practical issues: up to date, virtual reality technology is not yet widespread amongst private clinicians, and therefore a small amount of patients worldwide have had the opportunity to undergo this kind of treatment. Even taking into account this consideration, in recent years there is an increasing interest in evaluating the capabilities of this tool, and many researchers have investigated the effects of VRET on reduction of symptoms of anxiety disorders and specific phobias. A number of qualitative reviews of VRET research studies have pointed out that VRET has good potential in the treatment of specific phobias (Botella et al., 2004; Glantz & Rizzo, 2003; Hodges, Anderson, Burdea, Hoffmann, & Rothbaum, 2001; M Krijn, Emmelkamp,

Olafsson, & Biemond, 2004; Pull, 2005; Wiederhold & Wiederhold, 2003), since it produces better outcomes than imaginal exposure, and it is as effective as in vivo exposure, but being pragmatically a much more attractive alternative.

Recently, even more powerful statistical analyses, such as quantitative meta-analyses, have been conducted on studies reporting VRET treatments. Parson and Rizzo (Parsons & Rizzo, 2008) have collected data from 21 articles who have evaluated anxiety and/or phobia before and after VRET. The results revealed that VRET has a statistically large effect on all affective domains, and thus it is a relevant approach to reduce anxiety-related symptoms. Similarly, Powers and Emmelkamp (Powers & Emmelkamp, 2008) provide effect size estimates for virtual reality treatment in comparison to in vivo exposure and other control conditions. They found a predictable larger effect of VRET compared to the control conditions; but more interestingly, VRET outperformed in vivo exposure.

An other line of research investigated the cognitive mechanisms underlying VRET and their weight in reducing symptoms (Côté & Bouchard, 2005). The effectiveness of traditional cognitive-behavioural treatments is usually justified following three major explanations: the information processing model, the perceived self-efficacy model (PSE) and the cognitive/ dysfunctional beliefs model. Even if all the three mechanisms are involved in VRET, the perceived self-efficacy and the change in dysfunctional beliefs are the best predictors of good outcome, and then are strictly required also when the stimuli are virtual in nature (Cotè & Bouchard, 2009).

Table 1 summarizes the most recent studies (last five years) that examined the effects of VRET for reducing anxiety disorders and phobias (Beck, Palyo, Winer, Schwagler, & Ang, 2007; Botella et al., 2010; Botella, et al., 2007; Cornwell, Heller, Biggs, Pine, & Grillon, 2011; Difede et al., 2007; Freedman et al., 2010; Gamito et al., 2010; Gerardi, Rothbaum, Ressler, Heekin, & Rizzo, 2008; M. Krijn et al., 2007; M Krijn, Emmelkamp, Olafsson,

Schuemie, & van der Mast, 2007; Malbos, Mestre, Note, & Gellato, 2008; McLay, McBrien, Wiederhold, & Wiederhold, 2010; McLay et al., 2011; Perez-Ara et al., 2010; Price & Anderson, 2012; Price, Mehta, Tone, & Anderson, 2011; Ready, Gerardi, Backscheider, Mascaro, & Rothbaum, 2010; Reger & Gahm, 2008; Rizzo et al., 2009; Robillard, Bouchard, Dumoulin, Guitard, & Klinger, 2010; St-Jacques, Bouchard, & Belanger, 2010; Tortella-Feliu et al., 2011; Wallach, Safir, & Bar-Zvi, 2009, 2011; Wood et al., 2009)

Author and year of publication	Type of disorder	Samples	Experimental design	Condition(s)	Follow-up	Short term outcome
Krijn, 2007	Acrophobia	26	Randomized crossover	- VRET - VRET + self statements	At 6-month follow-up, most gains during treatment were not fully retained	VRET effectiveness not influenced by the addition of self-statements
Botella, 2007	Arachnophobia	12	Open clinical trial	- VRET	The therapeutic gains were maintained at a 3-month	Improvement in all clinical measures at Post-treatment
St-Jacques, 2010	arachnophobia	31 (children)	Between subjects design	- IVE - IVE + VRET	-	The use of virtual reality did not increase motivation toward psychotherapy
Pérez-Ara, 2010	Panic disorder and agoraphobia	29	Between subjects design	- VR interoceptive Exposure Simultaneous Condition - Interoceptive Exposure Traditional Condition	Results maintained or even improved at 3-month	Both treatment conditions significantly reduced the main clinical variables at post-treatment
Malbos, 2008	Claustrophobia	6	Open clinical trial	- VRET	Gains maintained at 3-month	Significant reduction in fear towards the enclosed space and quality of life improvement
Krijn, 2007	Fear of flying	86	Between subjects design	- VRET - Bibliotherapy (BIB) - CBT	-	Treatment with VRET or CBT was more effective than BIB. No statistically significant difference between VRET and CB
Tortella-Feliu, 2011	Fear of flying	60	Randomized between subject design	-VRET -CAE-T -CAE-S	Gains maintined at 1-Yr follow-up	Results indicate that the three interventions were effective in reducing fear of flying; furthermore, there were no significant differences between them in any of the outcome measure.
Beck, 2007	PTSD	6	Open clinical trial	- VRET	-	Significant reductions in post-trauma symptoms involving re-experiencing, avoidance, and emotional numbing
Botella, 2010	PTSD	10	Randomized between subject design	- CB - CB + VRET		CBT + VRET was as effective as CBT
Difede, 2007	PTSD	21	Randomized between subject design	- VRET - WL		VRET group showed a significant decline in PTSD scores

						compared with the WL group
Freedman, 2010	PTSD	1	Case study	- EI +VRET	Gains maintained at 6-month	Large post - treatment reductions in PTSD symptoms
Gamito, 2010	PTSD	10	Randomized between subject design	- VRET - EI - WL		Decrease on PTSD as well as on psychopathological symptoms in the VRET group when compared to EI and WL groups
Gerardi, 2008	PTSD	1	Case Study	- VRET		Improvement in PTSD symptoms
Mc Lay, 2010	PTSD	10	Open clinical trial	- VRET - IVE + EI		VR-based and traditional therapy were found to be safe and effective in the combat theater
Mc Lay, 2011	PTSD	10	Randomized between subject design	- VRET - TAU		Seven of 10 participants improved by 30 percent or greater while in VRET, whereas only 1 of the 9 returning participants in TAU showed similar improvement.
Ready, 2010	PTSD	9	Randomized between subject design	- VRET - Present-centered therapy		No significant differences emerged between treatments
Reger, 2008	PTSD	1	Case study	- VRET		Self-reported PTSD symptoms and psychological distress were reduced at post-treatment relative to pre-treatment reports
Rizzo, 2009	PTSD	20	Open clinical trial	- mixed clinical protocol including VRET, IVE, EI		16 patients no longer meet diagnostic criteria for PTSD at post treatment
Wood, 2009	PTSD	12	Open clinical trial	- VRET		The VRET participants' clinical levels of PTSD and Depression significantly reduced
Wallach, 2009	Fear of public speaking	88	Randomized between subject design	- VRET - CBT - WL		VRET and CBT were significantly more effective than WL in anxiety reduction, but twice as many participants dropped out from CBT than from VRET
Wallach, 2011	Fear of public speaking	78	Randomized between subject design	- VRET - CBT - WL		VRET and CT proved to be equally effective to CBT in reducing Public Speaking Anxiety relative to a control group, with minimal differential effects between them. therefore, employing either one may be

					satisfactory and sufficient.
Robillard, 2010	Social Anxiety	45	Randomized between subject design	- VRET+ IVE - IVE - WL	Significant reduction of anxiety on all questionnaires as well as statistically significant interactions between both treatment groups and the waiting list.
Cornwell, 2011	Social Anxiety	32	Open clinical trial	- VRET	The VR environment is sufficiently realistic to provoke fear and anxiety in individuals highly vulnerable to socially threatening situations.
Price, 2011	Social Anxiety	41	Randomized between subject design	- VRET - WL	Results suggest that total presence and realness subscale scores were related to in-session peak fear ratings. However, only scores on the involvement subscale significantly predicted treatment response.
Price, 2012	Social Anxiety	67	Randomized between subject design	- VRET - CT - CBT (EGT) - WL	There were was no evidence for a difference in this effect across VRE and CBT. This is the first empirical study to show that early outcome expectancy is related to treatment response for a virtual reality-based treatment for social anxiety.

CAE-S = self-administered computer-aided exposure
CAE-T= computer-aided exposure with a therapist's assistance throughout exposure sessions
CBT = Cognitive Behavioral Therapy
CT= Cognitive Therapy
EI = Imaginal Exposure
IVE = In vivo Exposure
TAU = Treatment as usual
VRET = Virtual Reality Exposure Therapy
WL = Waiting List

3. From Virtual Reality to InterReality

As shown by the most recent meta-analysis (Opris et al., 2012), that included most of the studies reported in Table 1, on one side VRET does far better than the waitlist control and has good stability of results over time, similar to that of the classical evidence-based treatments. On the other side, the post-treatment results show similar efficacy between the

behavioral and the cognitive behavioral interventions incorporating a virtual reality exposure component and the classical evidence-based interventions, with no virtual reality exposure component.

In other words, even if VRET demonstrated good capabilities in the treatment of anxiety disorders, there is still room for improvement. But how may we improve VRET?

As underlined by Riva and colleagues (Riva, 2009a; Riva, Raspelli, Algeri, et al., 2010; Riva, Raspelli, Pallavicini, et al., 2010), in VRET the virtual experience is a distinct realm, separate from the emotions and behaviours experienced by the patient in the real world: the behaviour of the patient in VR has no direct effects on the real life experience; the emotions and problems experienced by the patient in the real world are not directly addressed in the VR exposure.

To overcome this limitation the "*InterReality*" (IR) paradigm extends the clinical setting to a hybrid environment, bridging physical and virtual world (Riva, 2009a). By bridging virtual experiences – fully controlled by the therapist, used to learn coping skills and emotional regulation - with real experiences – that allow both the identification of any critical stressors and the assessment of what has been learned – using advanced technologies allows "*InterReality*" to offer a comprehensive clinical experience. The idea of a stricter link between real and virtual worlds is not new: the use of "augmented reality" or "mixed reality" technology blends virtual objects seamlessly into views of the real world. Nevertheless, all the previous attempts of connecting virtual and real worlds tried to remove the boundaries between. The main outcome is a blurred experience that is neither virtual nor real. Apparently, working in a blurred world, in which boundaries are not always clear, is more a problem than an advantage: the lack of boundaries calls for new concepts of self, identity and community that have to be learned, managed and shared. More, it does not allow us to exploit the specific advantages that virtual and real world afford us. For instance, virtual worlds are designed to augment humans and provide them with the capability to

manipulate information in ways that are not normally possible in the real world. But in blurred worlds, the level of augmentation is constrained by the features of the task/context in which the user is involved.

The main goal of IR is the connection between virtual and real worlds without removing the boundaries that defines them.

The interconnections between virtual and real world is bidirectional:

- *behaviour in the real world influences the virtual environment*. For example: if emotional regulation is poor during the day, then some exercises in the virtual environment are unlocked in order to train this ability;
- *behaviour in the virtual world influences the real life*. For example: if I participate in a virtual support group I can interact with other participants during the day via SMS.

The link between virtual and real world is made possible by the following technologies:

- *3D individual and/or shared virtual worlds (3DWs)*: they are immersive (in the therapist's office) or non-immersive (at home) environments inhabited by motional avatars, representing other users. The immersivity is produced by providing immersive output devices (head-mounted display, force feedback robotic arms, etc.) and a system of head/body tracking to guarantee the exact correspondence and co-ordination of users' movements with the feedback of the environment. The user can interact with others, socialize and participate in individual and group activities.
- *Personal biomonitoring system (from the real to the virtual world):* it's made up of bio and activity sensors that monitor the emotional status of the patient and coherently modify the virtual environment. This link may be achieved in real time or not.

- *Personal digital assistance (PDA) and/or mobile phones (from the virtual to the real world):* these devices offer the opportunity to always be connected with the virtual world where the user can receive warnings and feedback, perform homework assignments, and meet other users in the context of social networks.

Compared to traditional cognitive behavioural therapy, IR presents some interesting specific characteristics of the patient; moreover, in the context of IR, the patient is engaged in activities and processes that focus on relational changes and self-efficacy as well; finally, IR, merging virtual and real worlds, gives the opportunity to address during the training the emotions and fears experienced in real life. Tables 2 and 3 summarize the clinical areas in which IR can improve the standard treatment for both patient and therapist respectively.

Furthermore, from a clinical standpoint, IR offers some innovations to current VR protocols as well: objective and quantitative assessment of symptoms using biosensors; provision of warnings and motivating feedback to improve compliance and long-term outcome. The limitations of this approach parallel the ones of VR. The most evident limitation is related to the availability of the equipment: all the technological needs increases dramatically the costs of the intervention and makes the protocol less likely to be applicable by private clinicians; the contribution of the patient in the management of the sessions outside the therapist's office require a good level of familiarity with technology, and could prevent some patients from being included in the protocol.

To date, in literature there is a lack of clinical trials assessing the usability and the effectiveness of the IR paradigm. Some pioneering applications of the technologies involved in IR protocols have been undertaken in the field of mental health, but never assembled together in the way aforementioned.

Recently, the capabilities of mobile phones as a tool for responding to a variety of clinical needs have been investigated (Preziosa, Grassi, Gaggioli, & Riva, 2009). The interest

demonstrated towards this device is motivated by its wide diffusion: the level of mobile phone penetration has rapidly increased in the last decades, to the extent that a large portion of the population in Europe and the United States owns at least one mobile phone. Furthermore, the advanced technology now available allows mobile phones to combine the use of traditional phones, such as calling someone, to the broader communication capabilities, supporting 3D graphics, pictures, musical sounds and software programs. Authors presented two studies based on the use of the mobile phones for anxiety management. In the first experiment, a Stress Inoculation Training to reduce exam stress has been applied: the results demonstrated that the combination of video and audio narratives administered via UMTS induced more relaxation compared to the other experimental conditions (either only video or only narratives administered with alternative means, such as CD and Mp3 readers). In the second study, relaxation abilities were successfully trained in a sample of stressed patients by mobile narratives experienced on mobile phones. The outcome of this research, taken together with other experimental studies on mobile phones suggest that this technology is promising in the treatment of anxiety disorders, since it offers the opportunity to close the gap between in-office and at-home sessions.

4. Conclusions

In the past decade medical applications of virtual reality (VR) technology have rapidly developed, and the technology has changed from a research curiosity to a commercially and clinically important area of medical informatics technology (Riva, 2009b; Riva, Algeri, et al., 2010). This book clearly underlines this transformation.

However, there is a growing recognition that VR can play an important role in clinical psychology, too.

One of the main advantages of a virtual environment for clinical psychologists is that it can be used in a medical facility, thus avoiding the need to venture into public situations. In fact, in most of the existing applications, VR is used to simulate the real world and to assure the researcher full control of all the parameters implied. VR constitutes a highly flexible tool, which makes it possible to program an enormous variety of procedures of intervention on psychological distress. The possibility of structuring a large amount of controlled stimuli and, simultaneously, of monitoring the possible responses generated by the user of the program offers a considerable increase in the likelihood of therapeutic effectiveness, as compared to traditional procedures.

More, the availability of low-cost hardware and software is opening the VR experience also to individual clinicians. For instance, the NeuroVR platform (http://www.neurovr.org) - a cost-free virtual reality toolkit based on open-source software - allows non-expert users to easily set up a clinical virtual environment (VE) and to visualize it using both immersive and non-immersive technologies (Riva et al., 2009; Riva et al., 2011; Riva et al., 2007)

Finally, the reduction in the distance between virtual and real world allowed by the IR paradigm frames VR in a more contextualized experiential process (Riva, 2009a).

Specifically, the clinical use of IR is based on a closed-loop concept that involves the use of technology for assessing, adjusting and/or modulating the behaviors and emotions of the patient in both real and virtual worlds (Riva, 2009a; Riva, Raspelli, Pallavicini, et al., 2010). On one hand, the patient is continuously assessed in the virtual and real worlds by tracking their behavioral and emotional status in the context of challenging tasks (*customization of the therapy according to the characteristics of the patient*). On the other hand, feedback is continuously provided to improve the skills of the patient through a conditioned association between performance and execution of assigned tasks (*improvement of self efficacy*).

In general, this closed-loop experience is used as a trigger for a broader empowerment process. In psychological literature *empowerment* is considered a multi-faceted construct reflecting the different dimensions of being psychologically enabled, and is conceived of as a positive additive function of the following three dimensions (Menon, 1999):

- *perceived competence*: reflects role-mastery, which besides requiring the skillful accomplishment of one or more assigned tasks, also requires successful coping with non-routine role-related situations;
- *perceived control*: includes beliefs about authority, decision-making latitude, availability of resources, autonomy in the scheduling and performance of work, etc;
- *goal internalization*: this dimension captures the energizing property of a worthy cause or exciting vision provided by the organizational leadership.

On one side, in the real world, the dynamic behavioral profile of the patient and his/her physiological response to events is collected and assessed through different sensors (e.g. GPS) and biosensors (e.g. HR, SCR). Using this data, both patient and therapist can identify the antecedents and the consequences of any crisis. More, it is even possible to forecast a possible anxiety attack and to provide in real time suggestions and feedback to the patient.

On the other side, VR can be considered the preferred environment for the empowerment process, since it is a special, sheltered setting where patients can start to explore and act without feeling threatened (Vincelli, 1999). In this sense the virtual experience is an "empowering environment" that therapy provides for patients.

Besides, it is unnecessary to wait for situations to happen in the real world because any situation can be modelled in a virtual environment, thus greatly increasing self-training possibilities (Riva, Molinari, & Vincelli, 2002). In addition, VR allows the situation to be graded so the patient can start at the easiest level and progress to the most difficult.

Gradually, because of the knowledge and control afforded by interactions in the virtual world, the patient will be able to face the real world.

For these reasons, the future of health technology for the treatment of anxiety disorders will probably include two main features: portability and InterReality. Portability refers to the use of portable devices (tablets and smartphones) to provide VR everywhere. Having the possibility to run a VR system on a mobile device will allow patients to practice the skills learned in the therapist's office by themselves and without limitations.

Currently the mobile phone supports advanced communicative features such as real time video communications, audio, and the exchange of texts and videos. This innovation will increase in the next few years, so a new generation of hardware accelerated mobile devices will soon be joined by a suite of emerging 3D software standards that give developers the ability to create interactive content and other applications that have not been possible before (Preziosa, et al., 2009). More, the creation of two open standards (Ant+ - http://www.thisisant.com/ - and Bluetooth 4) for connecting biosensors to mobile phones is pushing the development of personal sensors for advanced self-tracking.

This trend is also parallel to the development of online VR worlds, such as SecondLife (http://www.secondlife.com) or JustLeapIn (http://www.justleapin.com).

Compared to the traditional VR worlds, the online worlds appear to have much to offer to exposure-based therapy. Since they allow multiplayer's interactions, the therapist and the patient can share the same online virtual space. This means that the therapist can accompany the patient through a particularly threatening experience just by logging onto a specific website and adopting a preferred avatar. The way of interaction as well as the surrounding environment can be easily modified on the basis of therapeutic needs. In the case of social phobia, for example, after practicing with the therapist within a closed environment (i.e. the therapist's virtual office), the patient can be taken to a virtual world populated by other avatars and asked to initiate a conversation and obtain feedback from

them in real-time audio through the use of a microphone. Similarly, patients with agoraphobia can be exposed to a variety of unfamiliar worlds different from those the clinician can provide in an office setting. As reviewed by Gorini and colleagues (Gorini, Gaggioli, Vigna, & Riva, 2008), many environments created specifically for therapeutic purposes are available within the platform of Second Life. Most of them aim at providing help to patients and caregivers dealing with psychiatric and neurological diseases: Brigadoon, for example, is a private island in which people suffering from Asperger's Syndrome may meet each other and have the opportunity to practise their social skills (http://braintalk.blogs.com/brigadoon/2005/01/about_brigadoon.html). With similar goals, Live2Give (http://slurl.com/secondlife/144/210/28) is designed for patients affected by cerebral palsy. A third example of this application is targeted specifically for anxiety symptoms. Starting from a personal experience, Roberto Salvatierra, a medical student with agoraphobia, created a virtual environment to help other people suffering from the same disorder (http://slurl.com/secondlife/neptune/128/110/30). These are just a few examples describing the promising potential of on-line virtual worlds in the field of psychological therapy.

The bridging of mobile devices with online VR worlds is the final goal of the IR paradigm. On one side, the patient will be continuously assessed in the virtual and real worlds by tracking the behavioural and emotional status in the context of challenging tasks (*customization of the therapy according to the characteristics of the patient*). On the other side, 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 behaviours (*improvement of self efficacy*). In sum, from the clinical viewpoint, the IR paradigm may offer the following innovations to current protocols for anxiety disorders:

- *objective and quantitative assessment of symptoms using biosensors and behavioural analysis*: monitoring of the patient behaviour and of his general and psychological status, early detection of symptoms of critical evolutions and timely activation of feedback in a closed-loop approach;
- *decision support for treatment planning:* monitoring of the response of the patient to the treatment, management of the treatment and support to the clinicians in their therapeutic decisions.
- *provision of warnings and motivating feedback to improve compliance and long-term outcome:* the sense of "presence" allowed by this approach affords the opportunity to deliver behavioural, emotional and physiological self-regulation training in an entertaining and motivating fashion.

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