Experience Design of Intelligent Systems Tasked with Helping Users Recover from Post Traumatic Stress Disorder

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Introduction

Post Traumatic Stress Disorder (PTSD), while popularly associated with war and combat, is a wider mental health issue and can affect anyone who encounters a traumatic emotional experience. The estimated prevalence of PTSD in the American population is 7.8% over a lifetime (Kessler, Sonnega, Bromet, Hughes, & Nelson, 1995; Stam, 2007). Women are more than twice as likely to suffer from PTSD (10.4%) at some point during their lives than men (5.0%) (Kessler et al., 1995). More than a third of people with PTSD fail to recover even after many years, regardless of whether they sought treatment (Kessler et al., 1995). Vulnerability to the onset and persistence of PTSD is not yet clearly understood. However, it is linked to subjective emotional and cognitive processing of a traumatic event (Kessler et al., 1995).

Research demonstrates trauma-related disorders are under recognized, diagnosed and treated (Mille & Torres, 2011). Trauma is experienced in the area of the brain responsible for survival — where only sensations, emotionally conditioned memories and visual images exist — and is not easily accessed by higher level cognitive functions (Steele & Kubaíñ, 2014). PTSD alters the arousal mechanisms in the brain that control central nervous system reactivity and it increases negative emotions. The strategies people use to cope with the symptoms negatively impact interpersonal relationships and physical health, ultimately decreasing quality of life.

However, it is possible to experience a positive psychological change called posttraumatic growth (PTG) in the aftermath of the trauma (Tedeschi, Calhoun, & Groleau, 2015). PTG occurs when the distressful intrusive memories are exchanged for deliberate rumination on core life beliefs that can accommodate the traumatic experience. Growth results when the individual can gain a metacognitive understanding of the trauma experience, find meaning in it and, ultimately, produce a revised life narrative that includes a reconstructed world view (Triplett, Tedeschi, Cann, Calhoun, & Reeve, 2011).

The widespread adoption of digital technology along with rapid advances in artificial intelligence is creating a unique opportunity to expand and improve the treatment of mental health problems (Fairburn & Patel, 2017; Zhou et al., 2015). This paper will review recent research, principals, theory and concepts in the convergence of user experience and intelligent technologies tasked with helping people who suffer with posttraumatic stress disorder recover from the trauma and potentially experience posttraumatic growth. First, posttraumatic stress disorder and posttraumatic growth will be explained in detail along with existing barriers to treatment and the potential of a digital mental health care transformation. Second, user goals and the cognitive impairment caused by PTSD will be examined as they relate to intelligent systems. Lastly, current research and future potential will be detailed around the assessment and treatment of PTSD.

Post Traumatic Stress Disorder

Psychological trauma results from an individual's subjective experience and includes three components: 1) the experience was unexpected 2) the individual was overwhelmed by it and 3) the individual was powerless to prevent the experience from happening and responded with fear, horror or helplessness (Mille & Torres, 2011; Rieck, Shakespeare-Finch, Morris, & Newbery, 2005). In addition to war and combat, traumatic experiences include natural disasters, humanitarian disasters, sexual trauma, assault, accidents, serious illness and more. Memories of the trauma consolidate and become change resistant within six hours of the traumatic event (James et al., 2015).

Psychological trauma is caused by an external event injuring the mind along with its processes and functions and includes damage to the ego, identity and self-structure (Mille & Torres, 2011). Damage to the self-structure often results in a loss of connection with others due to feelings of anger, guilt, shame, uncertainty and vulnerability making healing difficult (Schultz et al., 2015). The adverse effect on interpersonal relationships is often due to the manifestation of behaviors such as isolation and hostility (Mille & Torres, 2011).

PTSD is diagnosed by symptom clusters of re-experiencing the trauma in the form of intrusive memories, avoidance behaviors around trauma-related stimuli, negative thoughts and moods and hyperarousal (Kuester, Niemeyer, & Knaevelsrud, 2016; Stam, 2007; Wild et al., 2016). Symptoms present for one month are considered acute, and chronic when present for three or more months (Stam, 2007). People with PTSD report poorer physical health as traumatic memories are stored in the body and the extent of physical symptoms is strongly correlated with the intensity of hyperarousal and avoidance symptoms (Stam, 2007; Ray, 2009).

External stimuli that cause PTSD sufferers to re-experience symptoms are called triggers. Triggers are strongly imprinted forms of fear conditioning and victims tend to have an attentional bias that favors trauma-related stimuli (Stam, 2007). Hypervigilance results as the part of the brain responsible for survival continues to search for danger and react long after the actual threat has passed (Van Der Kolk, 2014).

Posttraumatic Growth Potential

If an individual struggling with PTSD is able to engage with his/her experience of trauma on a deep and meaningful level posttraumatic growth is possible. Posttraumatic growth is identified when life is enhanced on some level as a result of resilience and coping with the aftermath of trauma — not the traumatic event itself. Positive changes include the paradox of feeling more vulnerable, yet stronger, improved relationships, new possibilities for one's life, a greater appreciation of life and/or spiritual development (Tedeschi et al., 2015). As a result of experiencing trauma, people can become more comfortable with intimacy and develop greater empathy for other people who experience life difficulties. In essence, the resilience required to survive trauma often results in experiencing life on a deeper level of awareness (Tedeschi et al., 2015). However, it should be noted that living life on a deeper, more meaningful level does not translate into happiness and that maintenance of the growth often includes continued distress around the reminders of what has been lost (Tedeschi et al., 2015).

With increased access to treatment via intelligent systems designed to support PTG more people may be able to experience a positive side effect from negative trauma.

Barriers to Treatment

After a traumatic event occurs and before help seeking can occur, an individual must often navigate a complex process that includes 1) realizing there is a problem 2) symptoms reach such an intensity that a desire for treatment emerges and 3) action must be taken towards treatment initiation (Schreiber et al., 2010). This process can be influenced by variables such as negative attitudes about mental health services and lack of knowledge around the consequences of trauma (Schreiber et al., 2010).

Negative attitudes around mental health treatment include stigma and shame that contribute to the under reporting of traumatic events and to the seeking of treatment.

Additionally, a lack of awareness around PTSD's ubiquity, detrimental effects, resources available and benefits of treatment has a negative impact on the initiation of treatment (Rizzo et al., 2015). Further, scarcity of treatment options and the high cost of treatment can also be barriers to healing (Fairburn & Patel, 2017). Intelligent systems have the potential to counter all of these barriers by offering treatment privately to anyone with computer or smart phone access and at a much-reduced cost.

A Digital Transformation of Mental Health Care and Potential Benefits

Current and emerging advances in artificial intelligence (AI) along with the insatiable global demand of digital technology are making it possible to enhance the quality, accessibility and efficiency of mental health care (Luxton, 2016). Sensing technologies, machine learning and pattern recognition are profoundly changing the way detection, assessment and response to mental health issues, including PTSD, can be addressed. Natural language processing and virtual reality have made it possible to create empathetic, interactive, intelligent virtual human agents capable of providing treatment and virtual environments conducive to exposure therapy on stimuli (Luxton, 2016; Fairburn & Patel, 2017).

The benefits of this technology have the potential to collectively improve global mental health. As an example, X2AI, a Silicon Valley startup, has developed Karim, an artificially intelligent chatbot designed to provide emotional support in Arabic to Syrian refugees ("Karim the AI delivers psychological support to Syrian refugees | Technology | The Guardian," n.d.). X2AI has partnered with the Field Innovation Team to deliver the tech-enabled mental health disaster relief. Partnerships such as these show promise for helping great numbers of humanitarian and natural disaster trauma survivors.

Traditional methods for monitoring mental health tend to be expensive and intrusive while emerging digital treatments have the potential to discretely reach a massive number of people while bypassing the significant barriers of stigma, shame and cost (Zhou et al., 2015; Fairburn & Patel, 2017). Research has shown that connection to others is highly beneficial during times of stress and trauma (Schultz et al., 2015) (Rieck et al., 2005). The potential for digital solutions — such as the combination of a smart phone and a virtual therapist — to provide 24/7 support far exceeds the human limitations of most family, friends and therapists (Luxton, June, Sano, & Bickmore, 2015). Further benefits of AI-powered treatments include perfect memory/recall, ability to adapt to the user, ability to target a specific condition and consistent quality.

With the rapid pace of development it is critical for experience designers to understand the basic principals of PTSD as it relates to user goals, cognitive limitations, assessment and treatment when designing the systems tasked with helping users recover and grow from traumatic experience.

User Goals

The ultimate user goal is to feel better which includes feeling fully alive in the present and able to move on with his/her life (Van Der Kolk, 2014). Feeling better can be accomplished by reducing intrusive trauma memories and the reactivity to triggering stimuli. If both of those can be accomplished then the user's system has the opportunity to calm down, reducing hyperarousal. Improved thoughts and mood are likely to follow once the system isn't flooded with cortisol and responding as if under constant threat. As illustrated in Maslow's Hierarchy of Needs five-tier model, safety is the second tier from the bottom and a physiological need. When an individual's physiological needs are not met, that need becomes a near exclusive organizer of behavior and, safety seeking in PTSD, dominates goals and motivations (Maslow, 1943).

As noted above, trauma memories begin to consolidate within hours of the traumatic incident so by the time a user seeks out information they will most likely be experiencing fear, hurt, anger, shame and powerlessness and, when triggered or hijacked by those emotions, impaired cognitive ability. Initially, users might seek out information in order to make sense of their experience and only later look for tools and treatment, both of which need to be easily found and understood (Schreiber et al., 2010).

While ethical and privacy issues are beyond the scope of this paper, they are critically important to individuals suffering with PTSD (Rizzo et al., 2015). A lack of perceived safety, as mentioned above, is the major issue in PTSD and any device, app, system, agent or human must operate under the highest levels of consent, transparency and accountability in an effort to avoid causing further damage or trauma and to maintain the trust required to facilitate healing (Poulin, Thompson, & Bryan, 2016).

A secondary user goal would be to experience personal growth and positive transformation as a byproduct of the resilience required to survive trauma. The ability to recognize oneself as a survivor and no longer identify as a victim empowers the individual to create a new worldview — one where living may be more intentional and appreciated (Rieck et al., 2005).

Cognitive Impairment and Implications for Intelligent User Interfaces

In normal stress response, arousal is triggered and chemicals are released which prepare the body for a sudden burst of activity or allows the body to adapt to or concentrate on managing the stress (Antunes-Alves & Comeau, 2014). After the stressor has terminated, the brain stops the stress response (Antunes-Alves & Comeau, 2014). However, with PTSD the normal stress response malfunctions and results in a variety of neurological and endocrine disruptions (Antunes-Alves & Comeau, 2014). In individuals with PTSD, the prefrontal cortex — which is responsible for decision making, attention, impulsivity and emotionality — shows decreased activity and is less able to inhibit the amygdala and extinguish fear responses (Antunes-Alves & Comeau, 2014). The amygdala — which is charged with alerting the body to danger and storing information about things that are emotionally significant — of PTSD sufferers is hyper-reactive to stimuli and literally forms new pathways which reinforce, and are reinforced by, stimulus that causes the individual to re-experience the traumatic event (Antunes-Alves & Comeau, 2014; Mathews, Mackintosh, & Fulcher, 1997).

The resulting cognitive impairment in executive function, receptive language, attention to detail and memory capacity is due to the fact that the rational brain lacks control over the emotional brain (Van Der Kolk, 2014; Liu et al., 2008). During a triggering event, the user is hijacked by their fears and emotions. Designing systems for users with cognitive impairment due to PTSD is an area in need of more research. However, related research has shown that effective user interfaces for cognitive impairment support multiple — text, audio, visual and haptic — modalities (Liu et al., 2008). This multisensory approach has the ability to reduce cognitive load as each sensory system is believed to have its own working memory operating in parallel with the others (Reese, Pawluk, & Taylor, 2016). Ideally as PTSD patients improve or become less reactive, intelligent temporal modeling (decision-making over time) would have the ability to scaffold functionality and adapt to improved cognition (Bennett & Doub, 2015).

Assessment Potential

Before treatment and healing can begin, an accurate screening, assessment and diagnosis of PTSD must be made. Many people who've experienced a trauma may not be actively engaged in mental health care or aware of the threat of developing PTSD. For this reason, the developments in intelligent surveillance technologies, big data and predictive analytics have the potential to change the public health paradigm on a global scale (Poulin et al., 2016). The ability to detect and identify developing mental health issues at the onset and measure severity is a formidable which goal a number of researchers are undertaking.

Chris Poulin and colleagues' Durkheim Project, designed to predict and enable intervention for suicide risk in the military and veteran population, may set the stage for a similar approach for prediction and intervention of other mental health issues such as PTSD (Poulin et al., 2016). In the Durkheim Project, medical records data is aggregated with text and image data from social media and mobile applications. Single keywords and multi-word phrases are analyzed by a supervised, machine-learning algorithm that identifies individuals at risk for suicide. Depending on the level of the risk alert, a monitoring clinician or a pre-identified buddy may be notified or supportive messages can be sent directly from the system to the at-risk individual (Poulin et al., 2016). Suicide risk is a possibility for many mental health illnesses including PTSD. Therefore, seamless intervention in life-threatening situations is a mandatory requirement for any intelligent solution.

Research shows that interventions soon after trauma are lacking and that intervention performed sooner than later can minimize the damage trauma inflicts on the individual (Yuan, Koss, & Stone, 2006; James et al., 2015). By using big data surveillance and analytics it may be possible to intervene and dissipate PTSD symptoms before they have a detrimental effect on quality of life. Research will be needed to determine what type of surveillance might be required to predict the risk of PTSD since it can be caused by many traumatic events. Research will also be needed on how to intervene with individuals who may or may not be open to intervention.

Saeed Abdullah and colleagues conducted research around bipolar disorder and passive sensing of social rhythms to predict the risk of relapse (Abdullah et al., 2016). The data stream collection came from smart phones and included communication patterns such as phone call duration, speech analysis, sleep, physical activity, device usage, location and movement data. Machine learning was then applied to the data to model and predict markers and patterns in behavior (Abdullah et al., 2016). Data such as this, if available from before and after the trauma incident, could provide valuable information around the severity of avoidance behaviors of individuals with PTSD. This data could be used to create custom and effective treatment plans.

While many wearable devices are being developed to measure biosignals, Dawei Zhou and colleagues completed a study attempting to determine mental health states using unobtrusive multimodal sensing technologies, machine learning and social media (Zhou et al., 2015). In an effort to produce real-time assessments of user's emotions and mental health, researchers collected data with the built-in video cameras of mobile devices on head movement, heart rate (face color changes due to blood flow), eye blink, pupil variation and facial expression (Zhou et al., 2015). Additionally, user interaction was collected in the form of keystrokes and mouse operations. Social media content (positive and negative) was used to affect the user's mental state and was analyzed with a natural language processing tool that detected sentiment (Zhou et al., 2015). The data was extracted, weighted and classified and was able to produce an emotion inference of positive, negative or neutral. This technology could be helpful for individuals with PTSD to measure the effects of triggering content on their emotional well-being and track progress during treatment. The challenge for this particular approach is to extract meaning from the diverse and noisy data collected in a variety of changing conditions. As larger data sets grow, more interesting patterns may develop and lead to a deeper understanding of the connection between mental health and subtle, observable physical manifestations.

While much more research is needed, sensing technologies, machine learning and pattern recognition are being developed that can improve the screening, assessment and diagnosis of PTSD and its severity. The benefit of users receiving earlier interventions that are tailored to their specific trauma has the potential to reduce the detrimental effects of PTSD and its symptoms and improve collective mental health.

Treatment Potential

Using intelligent technologies to treat PTSD is expanding opportunities to provide point-of-care and advice to users with negative bias against mental health treatment or who prefer anonymity, users without access to local treatment and users who cannot afford traditional care. Cognitive therapy — which includes updating trauma memories, reclaiming one's life, discrimination training around triggers and reducing unhelpful strategies such as hyperarousal — has proved very effective for PTSD (Wild et al., 2016). Research into new tools including virtual humans and virtual reality to deliver cognitive therapy with reduced or non-existent face-to-face contact is showing exciting promise for treating PTSD.

Jennifer Wild and colleagues conducted a pilot study on internet-delivered cognitive therapy for PTSD (Wild et al., 2016). While the study was small, patients responded quickly to treatment and 80% no longer tested positive for PTSD at the end of the approximately 10 week process (Wild et al., 2016). The personalized program — outlined by this video — begins with education, case samples, testimonials, videos modeling treatment and goal setting. Patients process their trauma memory by recording it either in writing or by talking about it with voice recognition software or by making audio recordings. Later, as new perspectives are gained, the memories can be updated. Patients also work through modules on topics like guilt, shame, anger, depression and panic attacks.

Additionally, the program includes exercises to work with stimulus discrimination, experiments to test fears and activities to reclaim one's life. A key aspect of the program is the monitoring of symptoms and the ability for patients to see their progress in charts. Therapists provide primarily asynchronous support and suggestions via texts, email, videos and brief calls. Patients reported feeling well supported even though the face-to-face time with the therapist was only 20% of traditional cognitive therapy (Wild et al., 2016). The researchers attribute the ability to create a trusting relationship with such little face time to good site functionality, illustrative videos and consistent therapist contact.

In theory, therapists using this model could help five patients to the one they treat with traditional cognitive therapy (Wild et al., 2016). By applying artificial intelligence, machine learning and a virtual therapist to such a program, the number of patients able to receive care could grow exponentially. This implementation could bypass many of the barriers around mental health treatment that prevent people from seeking treatment (Yuan et al., 2006). The promise of intelligent systems to allow trauma victims to anonymously access targeted mental health treatment and at a reduced cost could alleviate a great deal of suffering (Rizzo et al., 2015).

An aspect of PTSD for many individuals is that family and friends do not understand it or know how to help. This deepens feelings of loneliness and isolation (Ray, 2009). The development of empathetic, conversational virtual companions, agents or therapists could allow individuals to get treatment privately on their own terms and provide a validating source of empathy and information (Seïler & Craig, 2016). Virtual human studies have shown increased levels of disclosure (Rizzo et al., 2015). Research on the perceptions of empathetic virtual agents has shown that people are willing to suspend disbelief and accept the agent as a companion as long as the functionality and the utility provide a good user experience and believability and reliability are optimized (Seïler & Craig, 2016). User testing on virtual agents revealed users prefer to have a choice of character archetypes including gender, age, dialog style and style of dress (Rizzo et al., 2015).

Prototypes of virtual humans capable of rich conversations that can recognize nonverbal cues and reason exist today and are on the verge of escaping the laboratory. The SimCoach project is an example of this technology and was developed to promote anonymous access to healthcare information and advice to military service members and veterans (Rizzo et al., 2015). SimCoach characters were designed to make users feel comfortable and confident around the idea of initiating treatment by providing support and encouragement in an environment deeply engrained with negative stigma. Recent research suggests that virtual humans lower barriers to disclosing information because the fear of being judged by another person is lessened (Rizzo et al., 2015).

Regardless of whether the clinician is an AI-powered virtual human or a real human, best practices must be used to promote healing and the possibility of posttraumatic growth. The protocol must include listening carefully to the language used by the patient and supporting the same terminology, validating the existential framework created and respecting biases. To encourage posttraumatic growth, the clinician must listen for and label the patient's own stories of emerging posttraumatic growth. Yet, this can never be at the expense of empathy for the suffering experienced (Tedeschi et al., 2015). Exciting and useful potential exists for virtual humans to help suffering humans as advances in computing power, graphics and animation converge with those of artificial intelligence, speech recognition and natural language processing (Rizzo et al., 2015).

Additional research is being conducted that deals exclusively with mitigating the intrusive and painful memories that are hallmarks of PTSD. Research by Ella James and colleagues showed a promising reduction of intrusive trauma memories when participants were tasked with a visuospatial task during recall of the trauma memory (James et al., 2015). The study demonstrated that established memories can be weakened when they are recalled and the limited-capacity working memory is also attending to a game of Tetris (James et al., 2015). This study reduced intrusion frequency without disrupting recall and recognition and that could prove helpful for those suffering from PTSD (James et al., 2015). However, more research is required as the model used for trauma did not truly meet the criteria for a traumatic event and the reconsolidation experiment was performed 24 hours after exposure. To help PTSD sufferers, the reconsolidation would need to be effective for a true traumatic event that may have happened many months or even years prior.

Potentially, intelligent systems could be used to determine the best task and protocol to be pared with each type of specific trauma memory (i.e., combat trauma vs. sexual).

Much of the hyperarousal associated with PTSD is about lack of control around feeling safe. An asset to any system would be to give a level of control back to the user. During treatment, artificial intelligence, machine learning and predictive analytics can be used to help PTSD sufferers take control of the digital stimulus that triggers their re-experiencing trauma. Users should be empowered to scaffold — filter completely, receive warnings prior or flood themselves with — triggers while online, watching TV or listening to radio. For example, a user traumatized by sexual abuse could be spared any news or entertainment that involved sexual violence. The ability to enable stimulus discrimination, at least in devices connected to the filtering mechanism, gives some power back to the individual while they work toward reducing reactivity (Wild et al., 2016).

As set forth above, when confronted by a PTSD trigger the cognitive function of an individual is impaired as available resources are being utilized or suppressed to effectively manage the perceived threat. As such, it may be necessary to employ multisensory presentation — visual, auditory, tactile — in an effort to reduce the cognitive load on any one channel to maximize opportunities to be perceived/understood (Reese et al., 2016). This important point should be kept in mind when designing virtual reality or augmented reality systems for exposure therapy which aims to reduce reactivity to stimuli by safely exposing the patient to the stimulus (Luxton, June, et al., 2015).

Conclusion

Rapid advances in intelligent technology show great promise for a successful multi-modal, multi-prong approach to diagnosing and treating mental illnesses such as PTSD on a global scale. However, the technological developments and applications are emerging so quickly they risk challenging or even violating existing medical ethics requirements and laws (Neuman, 2016; Luxton, Anderson, & Anderson, 2015). Additionally, legal liability for problems such as misdiagnosis, worsening of symptoms, adverse reactions, self-harm and medical emergencies will need to be addressed (Luxton, Anderson, et al., 2015). While these issues are beyond the scope of this paper, it is critical that designers, manufacturers and end users are aware of these ethical issues and take proactive approaches to designing systems that optimize patient privacy, safety, autonomy, trust and accountability (Luxton, Anderson, et al., 2015). Finally, it is imperative that validated, peer-reviewed medical research be conducted to evaluate the intelligent treatments and technology and establish updated best practices for this brave new world of mental healthcare in a continued effort to do no harm (Fairburn & Patel, 2017) (Poulin et al., 2016).

Resources

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