GENERALIZED MULTIPLICATIVE MODEL FOR PREDICTING POST-TRAUMATIC STRESS DISORDER AFTER NATURAL DISASTERS: THEORETICAL CONSIDERATIONS

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ABSTRACT

Disasters, whether natural, man-made, or technological, all have the potential to affect psychological health, including the onset of posttraumatic stress disorder (PTSD). Several theories have been presented to explain the development of, and recovery from PTSD. This paper considers the possible role of adult attachment in the development of PTSD symptoms after natural disasters. Attachment style is formed in childhood through infant interactions with their primary caregiver. An adult's attachment style is thought to be founded on the beliefs, expectations and feelings that they learnt as an infant with their caregiver and includes secure, avoidant, anxious/ambivalent and fearful attachments. Various mechanisms of how attachment style relates to PTSD symptoms have been proposed. Research has consistently shown that secure attachment is negatively associated with the subsequent development of PTSD and insecure attachment is associated with higher PTSD symptoms in a variety of adult trauma victims. However, none of these investigated samples have experienced a natural disaster. Also, despite an increasing number of studies considering the relationship between attachment and PTSD symptoms, results are mixed and often difficult to compare, first of all, because linear statistical approaches were used. The aim of the study was to present theoretical background for the development of the generalized multiplicative model (GMultM) for predicting PTSD after natural disasters with attachment styles as predictors.

Keywords: natural disaster, posttraumatic stress disorder, adult attachment, generalized multiplicative model.

1 INTRODUCTION

Disasters (e.g. floods, transportation accidents) are traumatic events that are experienced by many people, and may result in a wide range of mental and physical health consequences. It has already been documented that human-made/technological disasters may have different and more marked consequences than natural disasters [1]. Many effects are common to all types of disaster. One type of trauma results from natural disasters such as earthquakes, tornados or hurricanes, forest fires, floods, volcanic eruptions, landslides, or tsunamis. These types of experiences are particularly insidious because they tend to traumatize large populations of people at once, and disaster survivors have an increased risk of developing posttraumatic stress disorder (PTSD). PTSD is one of the most frequent and debilitating psychological disorders documented in the aftermath of, for instance, extreme life events, serious critical incidents and different forms of disasters. The relationship between a traumatic event and the development of PTSD has been established in a number of studies [2], [3].

Concerning the DSM-IV-TR, [4] three symptom clusters comprise the diagnosis of PTSD: (a) re-experiencing symptoms (e.g. flashbacks, intrusive thoughts and images) (b) emotional numbing and avoidance of reminders of the trauma (e.g. places, people, thoughts), and (c) hyper arousal (e.g. increased startle response, irritability, difficulty concentrating).

However, experiencing a traumatic event is necessary but not sufficient to explain the development of symptoms of PTSD. Not everyone who becomes a victim of a traumatic life event will suffer from PTSD afterwards. Which people are more sensitive or vulnerable to develop PTSD after a traumatic event is an important question because of the debilitating effects of the disorder and also for treatment indication.

2 PREDICTORS OF PTSD

Correlations of PTSD after natural disasters are comparable to correlations documented after human-made/technological disasters. In addition to exposure to an event, a number of risk factors for PTSD have been identified and shown to be important across multiple studies. These include psychological factors such as neuroticism, guilt, difficulty concentrating, coping strategies, obsessive traits, and psychiatric comorbidity [5]. Women are more likely than men to have PTSD after natural disasters, and low social support is associated with a higher likelihood of PTSD. A greater degree of exposure to a disaster is consistently associated with the likelihood of PTSD [5].

Several factors such as individual characteristics (e.g. personality, heritability, genetic factors, attachment quality, social skills and relational support), environmental factors (social networks, contacts with friends, family, neighborhood, work), the number of traumatic life events experienced in one's lifetime, and the seriousness of the incident, determine whether or not an individual eventually develops PTSD after experiencing a traumatic event [6], [7].

Two meta-analyses proposed multiple factors have been associated with increased risk of PTSD such as a psychiatric history, familial psychiatric history, child abuse, trauma severity, lack of social support, additional life stress and dissociation during the event [8], [9].

Schnurr and Vielhauer [10] described negative affectivity/neuroticism as a likely risk factor for PTSD because the personality dimension reflects sensitivity to negative stimuli. Shapinsky, Rapport, Henderson, and Axelrod [11] found a strong positive correlation between negative affectivity and PTSD measures, and a substantial variance in PTSD was accounted for by trait characteristics such as negative affectivity.

Other studies indicated psychological factors that have been linked to resilient response to potentially traumatic events include personality, optimism, extraversion, openness to experience, conscientiousness, low neuroticism, altruism, affect regulation, ego defenses, controlled coping, learned helpfulness, effective behaviors despite fear, positive emotions, e.g. gratitude, love [12]. Social and contextual factors including bonding, teamwork, pre-existing relationships, social institutions, and organizational patterns and roles may also have a protective or buffering effect [13].

Although there are a number of psychological characteristics that have been associated with post-disaster PTSD, there is no one psychological profile, with the possible exception of poor coping [14], that emerges as particularly predisposing to post-disaster PTSD after psychiatric comorbidity has been accounted for.

Several theories have been presented to explain the development of and recovery from PTSD. Cognitive-oriented theories are most commonly referenced in the clinical literature and are the most fully developed and studied [15]. Lazarus and Folkman [16] proposed that cognitive factors such as coping styles and cognitive schemas or attributions mediate response to traumatic experiences in the direction that problem-centered coping generally is more effective in dealing with traumatic stress that emotional coping. A recent literature review gave evidence to the Lazarus and Folkman theory [12].

 Janoff-Bulman [17] has been a major theoretical contributor to the area of PTSD. She concentrated on the nature of trauma victims' pre-existing assumptions about the world and themselves such as the assumptions of benevolence of the world or other people, self-worth and meaningfulness. Similar terms and concepts have been central in cognitive theories for a long time, e.g. "assumptive world" by Parkes [18], "working models" by Bowlby [19], "self-theory/world-theory" by Epstein [20] and Beck's "Cognitive Triad" with negative thoughts about the self, the world, and the future [21]. Many studies have found that people with posttraumatic stress symptoms have more negative world assumptions than people without such reactions [22], [23].

There is accumulating evidence that phenomena such as social support, social cognition, and attachment organization contribute to emotion regulation under conditions of traumatic stress and, more particularly, contribute to risk for or protection against PTSD. Increasingly, researchers and clinicians emphasize the emotional components of PTSD. Specifically, an individual's inability to adequately modulate intensely emotional memories is increasingly seen as leading to symptoms of re-experiencing, hypervigilance, and ultimately avoidance and numbing [24] and the resolution of fear and various other associated emotions is critical to recovery from the disorder.

The relationship between adult attachment styles and PTSD symptoms has been examined in many populations, including prisoners of war, veterans, security workers, those experiencing child abuse, incest, terrorist attacks, childbirth, and domestic violence [25]. PTSD can be defined as an affect regulation disorder resulting from the inability to cope adequately with a stressful or critical event [26]. The inability to regulate emotions during and immediately after a traumatic event is therefore a potential mechanism through which attachment style may influence the development of PTSD symptoms [27].

Attachment style is formed in childhood through infant interactions with their primary caregiver. These interactions determine a child's immediate emotional responses to stress and emotion-regulation in later life [28]. Bowlby's attachment theory proposed that attachment styles, which are developed in childhood act as prototypes for the way in which the child will function in later relationships. Reliable, consistent, reassuring responses to child's needs from the caregiver will lead to a 'secure' pattern of attachment behavior in the infant. Unreliable, inconsistent or neglectful responses from the attachment figure will lead to 'insecurely' attached infants, exhibiting anxious and/or avoidant behavioral styles [29]. Through these interactions, an infant develops an 'internal working model' of relationships (akin to a schema), which enables him/her to regulate, interpret and predict relationship behavior throughout life [30]. An adult's attachment style is therefore thought to be founded on the beliefs, expectations and feelings that they learnt as an infant with their caregiver.

Hazan and Shaver [31], Bartholomew [32], Brennan et al. [33] and some others developed and examined various models of adult attachment styles. Hazan and Shaver [31] developed three categories of attachment (secure, avoidant and ambivalent) that are reflective of those observed in infancy. The model of the self and the model of the other as conceptualized by Bowlby can be combined to describe prototypic forms of adult attachment [32]. If a person's abstract image of the self is dichotomized as positive or negative (the self as worthy of love and support or not) and if the person's abstracted image of the other is also dichotomized as positive or negative (other people are seen as trustworthy and available vs. unreliable and rejecting), then four combinations can be conceptualized labeled as *secure, preoccupied, fearful/avoidant and dismissive/avoidant.*

Securely attached individuals deal with distress by acting constructively and turning to others for emotional and instrumental support [34]. Insecure attached individuals of the

preoccupied and the fearful avoidant types are reacting to stressful events by mentally ruminating on negative thoughts, affects and memories. Ultimately, individuals with *attachment anxiety* have a negative image of themselves and positive of others and appear to be hypersensitive to the problems they experience. When confronted with stressful events they seem to overreact to their negative feelings in order to elicit support from others [35]. Individuals with a fearful-avoidant attachment style have a negative image of themselves and others. When dealing with stressful events, they tend to distance themselves from others [30]. Individuals with a dismissive attachment style have a positive self-image but distrust others; their contact with others is characterized by dominance and an absence of emotional warmth [36]. The affect regulation strategy associated with this style generally involves deactivation. People with a dismissive style are likely to restrict the acknowledgement of distress, dismiss its importance and erect barriers against their own stressful affects and thoughts. Consequently, they appear to be less sensitive to stress [37].

Further studies [33] suggested that there are two fundamental dimensions with respect to adult attachment patterns labelled attachment-related anxiety and attachment-related avoidance. This model uses two dimensions (attachment anxiety and attachment avoidance) to determine whether people are high or low anxiety, and/or high or low avoidance. It can be used to produce four categories of adult attachment: secure (low anxiety, low avoidance), dismissing-avoidant (low anxiety, high avoidance), preoccupied (high anxiety, low avoidance), fearful-avoidant (high anxiety, high avoidance) [33].

Similarly, a secure attachment style should result in greater ability to regulate emotions during a traumatic event and be associated with lower levels of PTSD symptoms. There is some evidence to support this hypothesis, showing that emotion regulation strategies mediate the association between secure attachment and lower levels of PTSD symptoms [38]. Research has consistently shown that secure attachment is negatively associated with the subsequent development of posttraumatic stress disorder (PTSD) in a variety of adult trauma victims [39].

While secure attachment style seems to serve as a protective factor, fearful and preoccupied attachment styles represent risk factors in the development of traumatization following a traumatic experience. Those with a fearful attachment style and preoccupied attachment style were those most likely to develop PTSD as a response to a critical incident [40].

There is debate within the literature about the role of avoidance in the onset and perseverance of PTSD symptoms [41]. Research has highlighted that the negative association between PTSD severity and secure and dismissing attachment may be attributable to the fact that both attachment styles are characterized by a positive view of the self and thus provide a protective factor when dealing with adversity [42]. One deviation regarding the negative association with dismissing attachment and PTSD lies with O'Connor and Elklit [43], who recently reported a high positive association between dismissing attachment and an individual's number of lifetime and current PTSD symptoms. Kobak and Sceery [27] propose that each attachment style relates to distinct patterns of negative affect regulation, with avoidant individuals tending to cut-off from anger and distress, restricting acknowledgement of distress, negatively perceiving social support and expressing hostility within social relationships. This finding provides indirect support for the hypothesis that avoidance of threat-related cues, thoughts and feelings, combined with avoidance of attachment related worries, may be beneficial within the context of recovery from a traumatic event [41].

However, none of the given investigated samples have experienced a natural disaster. To the best of the authors' knowledge, no research on the relationship between attachment

style and PTSD after natural disasters in a general population sample has been published. We argue that pre-event vulnerabilities based on attachment styles may play an important role in post-traumatic stress reactions among disaster survivors. And thus, this paper considers the possible role of adult attachment in the development of PTSD symptoms after natural disasters.

Another important point is that determining causality in the relationship between adult attachment and PTSD is difficult. Ortigo et al. [44] highlight the relative lack of empirical examination of the mechanisms linking attachment and PTSD. Despite an increasing number of studies considering the relationship between attachment and PTSD symptoms, results are mixed and often difficult to compare, first of all, because linear statistical approaches were used. It seems evident that causality cannot be determined by pooling data that quantifies *associations* between attachment and PTSD symptoms.

The aim of this study was to present theoretical background for the development of the generalized multiplicative model (GMultM) for predicting PTSD after natural disasters.

3 GENERALIZED MULTIPLICATIVE MODEL OF PTSD

All the studies of PTSD mentioned above used statistical analysis procedures such as correlation analysis, stepwise linear regression, analysis of variance, discriminant analysis, or similar statistical techniques based on the general linear model or one of its multivariate generalizations. The problem is that such approaches do not yield information about linkages between causes and effects, especially in case of nonlinearity of interactions within system under study. The limitations of such models as exploratory and predictive tools are well known and describe elsewhere [45].

In our study, we propose the 'method of response functions' (MRF) as a method of the construction of purposeful, credible integrated models from data and prior knowledge or information. The MRF implies credible models in the sense that they are identifiable, and, hopefully, explains system output behavior satisfactorily. We argue that nonlinear regression technique based on the method of response function is one the most appropriate approach for modelling complex social systems and processes. The theory of the method of response function and its applications has been described in several articles and monographs [45].

In using MRF, the overall goal is to identify interacted characteristics affecting perception or behavior, for instance, which may not have been readily evident in the data. This provides the analyst with a global overview of the relationships between variables. Such insight is highly valuable in psychological and sociological research dealing with data derived from questionnaires. The technique may also reveal findings not even considered during the formulation of original hypotheses. This is especially advantageous when relationships between factors are nonlinear or multidimensional, as is often the case in social sciences.

The method of response function (MRF) can be designated as a general methodology for "grey-box", or semi-empirical, modelling which allows the modeler to incorporate into the structure of the nonlinear regression whatever prior knowledge is available. This technique is intended to combine the best of two worlds: knowledge-based modelling, whereby mathematical equations are derived in order to describe a process, based on a physical or chemical analysis, and "black-box" modelling, whereby a parameterized model is designed, whose parameters are estimated solely from measurements made on the process. We describe the design methodology of a grey-box model, and illustrate with three examples.

Let us assume the basic definitions of the MRF. By factors we mean the system's properties that directly affect processes or characteristics under study. We designate the

factors as a vector $x = (x_1, x_2, \ldots, x_n)$. Then, by *partial response function* of the characteristic or the process we mean a function which depends on a single active factor, i.e. the function of a single variable $f_i(x_i)$. In many typical cases, the graph of the partial response function f_i to the variability of the factor x_i is a unimodal or *S*-shape curve. By *generalized response function* we mean a function $F(x_1, \ldots, x_n)$ which accounts for all the factors considered and presented as a combination of partial response functions $f_i(x_i)$. A generalized response function can also be determined as an *N*-dimensional geometric figure, or its data matrix equivalent, which gives the levels of an important system response as a function of combinations of levels of the factors to which that system is exposed.

Thus, it is necessary to note, that designation of the system's characteristics as factors and responses is entirely determined by statement of a problem.

Now we propose to present the generalized response function in the form

$$F(x_1, \ldots, x_n) = \prod_{i=1}^{n} f_i(\alpha^i, x_i), \tag{1}$$

where *n* is the number of the factors under study, α^i is a vector of parameters, the value of which we have to determine in the process of identification. Basically, it has been criticized that the multiplicative form represents the independence of the influencing factors. We'll demonstrate later that this problem can be resolved successfully using some specific technique for the evaluation of parameters of the generalized response function $F(x_1, \ldots, x_n)$. We introduce also the additional restriction in the identification procedure:

$$\max_{x_i} f_i(\alpha^i, x_i) = 1 \tag{2}$$

It is evident that standardization condition (2) gives us a possibility to compare the impact of different factors on the process under study.

Then the generalized multiplicative model (GMultM) of PTSD is looking as follows:

$$PTSD_{\text{mod}} = PTSD_{norm} \cdot \exp(-F_{st})$$

$$F_{st} = f_1(SEC) \cdot f_2(ANX) \cdot f_3(FEAR) \cdot f_4(AV)$$

$$f_1(SEC) = \alpha_1 \cdot \left(\frac{1}{b_1 + \exp(c - d_1 \cdot SEC)} \right) \tag{3}$$

$$f_j(x_j) = 1.0 - b_j(1.0 - \exp(-c_j \cdot x_j))^{d_j}, \quad j = 2,3,$$

$$f(Av) = \alpha_4 \left(AV^{b_4} \cdot \exp(-c_4 \cdot (\frac{AV}{AV_{\max} - AV})^{\gamma_4}) \right),$$

where $PTSD_{\text{mod}}, PTSD_{norm}$ are the actual values of PTSD resulted from the Impact of Event Scale-Revised (IES-R) [46] and mean score in the given sample, *SEC* are the scores of secure, *ANX* are the scores of anxiety, *FEAR* are the scores of fearful, *AV* are the scores of avoidant attachment styles, F_{st}, f_j are the generalized and partial response functions respectively, $\alpha_j, b_j, c_j, d_j, \gamma_j$ are parameters for evaluation, $j = 1, \ldots, 4$.

Generally speaking this model indicates that the level of PTSD after natural disaster is decreasing with the increasing of pre-event secure attachment style and is increasing with the increasing of pre-event preoccupied and fearful attachment styles. Based on our literature overview we argue that partial response function of dismissing attachment style is unimodal. It means that the level of PTSD after natural disaster is decreasing with the increasing of pre-event avoidant attachment style until optimal point and is increasing after this point.

As function (3) is nonlinear in parameters, the problem of parameter estimation can be solved only by numerical methods. The parameters are determined by minimizing the sum of squared differences between estimated data and survey measurements. The corresponding parameters estimation is provided with the module "lsqnonlin" from the program package MATLAB Optimization Toolbox. We enter the coded values because the "natural" measurements of personality variables under study had different ranges that might cause difficulties for the parameter's estimation procedure. All raw scales are linearly converted to a scale from 0 to 10, with a higher score indicating higher levels of personality variables. We identify the parameters by using several initial approximations, until the process converged to a single point and checked the obtained results using the convergence criteria for nonlinear optimization procedure. Nevertheless, the final solution is selected according to the following guidelines of psychological relevance: (1) the selected parameter values should keep the residual errors between model and data as small as possible but not greater than the value of standard error of measurement; (2) parameter estimates should make psychological sense. For example, a reasonable view of the partial response function graphs should be obtained for the variables under study.

Another guideline is the absence of other solutions in the vicinity of the found solution.

4 FUTURE RESEARCH DIRECTIONS

To be able to provide the identification of parameters of GMultM and its validation we are collecting data on PTSD and attachment styles in the sample in Novorossiysk, city located on the Black Sea shore in Southern Russia where climate change disasters such as storm wind, flooding and earthquake occur now very often.

Demographic variables include age and gender. Subjects are assessed with the following measures: The Impact of Event Scale-Revised (IES-R) [46] and The Relationship Questionnaire (RQ) [36]. Russian-validated translations of all measures are used.

5 CONCLUSIONS

In the present study, we proposed the generalized multiplicative model for predicting PTSD after natural disasters based on data and prior knowledge or information on adult attachment styles. Understanding who is at risk for long-term PTSD after disasters is critical. More importantly, identifying factors associated with these PTSD patterns may minimize the long-term psychological consequences of disasters. The finding that fearfully attached individuals are more likely to report PTSD symptoms than other attachment types may be important. More widely, results highlight the importance of secure attachment, and therefore provide support for all type of interventions aimed at promoting secure attachment styles. The proposed model can be applied as effective assessment tool not only for the basic level of PTSD but also for indication of the most important variables for pre-impact intervention.

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