

Mechanisms of the Formation and Involuntary Repetition of Trauma-Related Flashback: A Review of Major Theories of PTSD

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Abstract: Trauma-related flashback is one of the typical symptoms of patients suffered from posttraumatic stress disorder (PTSD), which intrudes into the body and mind of patients uncontrollably and repeatedly. Psychodynamic theories of mechanisms of the formation and involuntary repetition of trauma-related flashback establish a foundation for most cognitive theories of PTSD. Cognitive behavioral theories of PTSD, from the initial use of behavioristic principles (e.g., conditioning, alternative learning, generalization, etc.) to explain fear conditioning to the emphasis on the roles of cognitive and behavioral factors (e.g., cognitive model or schema, completion tendency, associative network, data-driven processing, analogue representation, etc.) in the representation and retrieval of traumatic information, present a trend of multirepresentational theorizing. Inherited from the theories proposed by Pierre Janet in the early years of the 20th century and based on the integration of existing cognitive behavioral theories of PTSD, theories of the multiple memory system bring new viewpoints on the representation and retrieval of traumatic information in memory. In the last twenty years, several recent theories have received some empirical evidences both in theoretical and applicational. The clinical and nonclinical implications of the psychological explanations of trauma-related flashback, the ideas of further explorations in the theories of PTSD and the directions of future researches of the prevention and treatment of PTSD are presented.

Keywords: Trauma; flashback; psychodynamic; cognitive behavioral; multiple memory system

1 Introduction

The impact of the traumatic event on individuals lasts for a long time. Rather, it seems to have a “magic power” to trap people in the traumatic memory, and the re-experiencing of trauma constantly haunts individuals’ desire for inner peace. For patients suffered from posttraumatic stress disorder (PTSD), they often re-experience trauma-related symptoms uncontrollably, including flashbacks in awakening and nightmares in sleep, which are intrusive or involuntary. Pierre Janet, a French psychiatrist, is the first in describing the repeated intrusion of traumatic experience as “attached to the trauma” in 1911 (c.f., [1]). Sigmund Freud called it “compulsive repetition” [2], which makes the patient fixed in the trauma. In other similar terms, Bessel A. van der Kolk and Onno van der Hart called it “engraving of trauma” [3], and Judith Herman described it as “frozen and wordless memories” [4].

Different from an individual’s intentional memory of trauma, flashbacks are mainly traumatic episodes or fragments [5,6] and are vivid in sensation and perception (vision, audition, olfaction, gestation, tactility, etc.). Therefore, flashback is also known as intrusive imagery [7–9], visual imagery for the most



part [6,10]. Flashback is usually triggered by some internal and external situational cues. When it happens, patients traverse back to the initial traumatic situation, like “time travel”, and re-experience the traumatic event without any information of time and background [6,7,9,10]. It seems that the memory is stuck or frozen in the past time and space. In addition, flashback is often accompanied by intense and painful emotions such as fear, sadness, anger, helplessness [6,7]. Most flashbacks have the peak moments of painful emotions, and these moments are also known as “hotspot” [11,12].

From the perspective of cognitive psychology, flashback, as an abnormal memory phenomenon [9], is an abnormal involuntary autobiographical memory (IAM) related to the traumatic event [13]. The characteristics of intrusive flashback, in contrast with IAM and intrusive memory, can be described as following: it happens in PTSD patients only; its retrieval is spontaneous; its repetitions are from high to very high; the valence of its accompanied emotions is negative only; its levels of distress to patients are from high to very high; its vividness of imageries is very high; attempts of patients to avoid it are high; its disruptions to ongoing activities of patients are from significant to extreme; it makes patients re-experience the traumatic event now [13].

Clinical psychologists have reached a broad consensus on where trauma-related flashback is from. The traumatic event has strong impacts on cognition and emotion of individuals. Different theories of flashback mainly focus on mechanisms of its formation and involuntary repetition, which are also answers to the following two questions: (1) How does flashback form? (2) Why does flashback repeatedly intrude? In order to answer these two questions, this article introduces some influential theories of trauma-related flashback, from the psychodynamic orientation, the cognitive behavioral orientation to the multiple memory system, so as to improve the understandings of flashback and their corresponding clinical and nonclinical implications, and also get more inspirations for the researches of the prevention and treatment of PTSD.

2 Psychodynamic Theories

In Freud’s theory, the unconsciousness and the self-defense mechanism are two key concepts. According to Freud, the traumatic event that caused an extraordinary impact on an individual leads to his/her inability to deal with the traumatic event in a normal way. The information about the traumatic event and the emotional experiences of individuals then enter into the unconsciousness through the self-defense mechanisms (e.g., repression, denial, isolation, dissociation, etc.). Essentially, the original materials of the re-experiencing symptoms (i.e., flashbacks and nightmares of the traumatic event) are the traumatic information and emotional experiences which are not processed normally in the consciousness. This view established a foundation for other theorists to explain mechanisms of the formation of flashback.

Freud’s theory mainly attempts to explain the repeated nightmares of patients with traumatic neurosis. He believed that, unlike the ordinary dream, the function of such special dream is not to relieve anxiety by satisfying some unconscious desires but to enable patients to master the traumatic event or integrate it into the consciousness [2], that is, to give psychological meanings to the traumatic event. This view, emphasizing individuals’ understanding and mastery of the traumatic event, is approved by many theorists. For example, Janet believed that patients have an innate need to “assimilate” and “digest” the traumatic experiences (particularly the “vehement emotion”); and the subjective interpretation of the traumatic event is one of the key factors to determine whether it can be successfully integrated into the existing memory system (c.f., [1]). Russell emphasized the mastery of “affective experience” of trauma rather than cognitive experience [14]. In his viewpoints, the re-experiencing symptoms reproduce the overwhelming feelings in the initial traumatic situation and provide an opportunity for patients to master them again, which can be described as an “attempt to heal”; the main and unresolved feelings of patients may be terror and anger, or simply undifferentiated “adrenaline rush” in facing danger. So, despite of the different viewpoints amongst theorists, whether it is to understand or master cognitive experience of trauma, affective experience, or both, one of the functions of flashback is to promote patients to integrate the information of the traumatic event into the existing memory system, so as to restore the balance of the inner world after trauma. This is not

only the patient's delayed cognitive reprocessing of the traumatic event, but also reflects his/her unconscious desire to repair trauma and self-heal. In Freud's terms, it means "life instinct".

However, Freud himself was not satisfied with such explanation, because it fails to reflect the "evil" nature of the re-experiencing symptoms, which means that the repeated intrusion of flashback and nightmare doesn't come from the patient's own desire, obey all the intentions of the consciousness and resolutely refuse to change but harass his/her mind constantly. Later, Freud proposed the concept of "death instinct" which was inspired by the concept of "compulsive repetition" [2]. According to this concept, the repeated intrusion of traumatic experience is regarded as the "literal regression" of the traumatic event in the unconsciousness [2], which reflects the unconscious desire of self-injury and self-destruction. This unique view was challenged by many theorists. Most of them explained the repeated intrusion of traumatic experience by using functional impairment. For example, Janet found that patients are unable to integrate traumatic information in their memory, and they seem to lose their "ability to assimilate new experiences" (c.f., [3]). Russell argued that the repeated intrusion of flashback and nightmare reflect the dysfunction of the patient's feeling system [14]. In addition, even Freud himself proposed that patients with traumatic neurosis lose the ability to avoid traumatic experience, and thus are suffering from it repeatedly [2]. It can be said that the survivors of traumatic events are not lucky ones, but the unfortunate ones who continue to be haunted by the trauma.

3 Cognitive Behavioral Theories

According to cognitive behavioral theories, trauma-related flashback is viewed as an abnormal memory phenomenon of trauma. In cognitive behavioral theories of PTSD, the principles and/or concepts, such as conditioning, existing cognitive model or assumption or schema, completion tendency, associative network, data-driven processing, analogue representation, etc., are used to explain mechanisms of the formation and involuntary repetition of trauma-related flashback.

3.1 Learning Theories of PTSD

The patient's fear conditioning of the traumatic event (i.e., fear memory) leads to flashback, and the reactivation of fear memory by associated stimuli (including stimuli in the initial traumatic situation and other similar stimuli after the traumatic event) leads to the repetition of flashback.

3.1.1 The Two-Factor Learning Theory

Mowrer proposed this theory to explain anxiety disorders [15], using the principles of conditioning. According to this theory, there are two phases: (1) The patient obtains fear conditioning (S-R) through classical conditioning in the initial traumatic situation, which resulting in the establishment of an association (S-S) between neutral stimuli and unconditioned stimuli (i.e., USC, stimuli that naturally cause fear responses) in the initial traumatic situation through alternative learning. So, neutral stimuli become conditioned stimuli (CS) that can arouse fear directly. After trauma, due to the roles of generalization and secondary alternative learning, other stimuli similar to initial neutral stimuli become CS. (2) The repetition of flashback (i.e., spontaneous exposure), under normal circumstances, will naturally extinguish the established associations between fear conditioning and CS, but the extinction of these associations often fails because of the patient's avoidance behaviors to CS (e.g., distraction, blocking of memories, etc.), while avoidance behaviors, through operational conditioning, will be negatively reinforced by the reduction in fear, leading to the maintenance of fear conditioning. Mowrer's theory abides by the tradition of behavioristic psychology and has an important influence on behavioral therapy for PTSD (e.g., exposure therapy, systemic desensitization therapy). For example, imaginal exposure is used to reduce PTSD symptoms such as nightmares [16,17].

3.1.2 The Anxious Apprehension Model

This model was proposed by Jones et al. to explain PTSD and the panic disorder [18], equating flashback to panic attack basically. This model focuses on the pathogenicity of PTSD, including the

biological vulnerabilities, the traumatic event itself and intense emotional experiences of patients during trauma. This model emphasizes cognitive factors after trauma that produce a feedback cycle of anxiety. According to this model, patients have an attention bias towards the false “emotional alarms” information and associated stimuli, and thus keep a high degree of alert even in the absence of danger. The anxious apprehension of patients focuses on the cognitive and physiological cues or responses in the initial traumatic situation. The purpose of such apprehension is to avoid the pains caused by the alarms. The alarms learned by patients lead to high arousal symptoms and form a feedback cycle through the association between symptoms and the cues in the initial traumatic situation. This negative feedback cycle, thus, causes continuous re-experiencing symptoms. In order to avoid triggering the alarms, patients tend to avoid emotional interoceptive information (e.g., through emotional numbness), as well as the related external environmental and traumatic stimuli. However, this avoidance causes the negative reinforcement. This model, emphasizing the repetition of flashback and the role of negative posttraumatic attention bias, is important to cognitive behavioral therapy (CBT) for PTSD (e.g., exposure therapy, attention bias modification).

3.1.3 The Warning Signal Hypothesis

By this hypothesis, Ehlers and her colleagues provided, from a perspective of the function of symptoms, a broader explanation for the repetition of flashback [19]. They believed that the contents of flashbacks are not random fragments, nor the stimuli at the most serious moment of the traumatic event, but the stimuli at a short time before the traumatic event happened or before it became more serious. For example, the contents of flashbacks of a car accident survivor are the bright headlights, which are the stimuli he/she saw immediately before the accident happened. They suggested that flashback is an early warning signal that can help patients predict (sometimes pre-consciously) the future possibilities of danger and avoid another harm or sufferings. According to their hypothesis, most of the contents of flashbacks (i.e., the significant stimuli) are neutral and serve as signals in marking the sequence or place of the initial traumatic event. The associations between these signals and the traumatic event are only temporary and accidental, but not essential and inevitable. Therefore, flashback itself doesn't cause intense emotional and physiological responses. What cause these responses are patients' expectations of the sequence following these stimuli. The cues that can trigger flashback only need to have perceptual similarity with the warning signal stimuli, but need no any semantic associations. Thirteen years after this hypothesis was proposed, Ehlers reasserted the above views and proposed that it is key to train patients to discriminate between the stimuli that were present during the trauma (“then”) and the innocuous triggers of re-experiencing symptoms (“now”) [20]. This theory increases understandings of stimuli that trigger flashbacks and is beneficial to some therapeutic plans which applied CBT.

3.2 Social Cognition Theories of PTSD

Flashback results from the extraordinary damages from the traumatic event to the existing internal cognitive models or assumptions of patients and the simultaneous operations of psychological mechanisms. The innate instinct for integrating new information, functioning in reconciling the incompatibility between the traumatic information and the existing cognitive models, leads to the repetition of flashback.

3.2.1 Stress Response Theory

As a basic and most influential theory in social cognitive theories of PTSD, Horowitz's theory of flashback has roots in the psychodynamic theories [21]. According to this theory, there is a set of cognitive models about the world pre-stored in an individual's mind (e.g., “Death and disease will not easily fall on my head.” “I am competent to achieve my life goals.”). When facing the traumatic event, during which the traumatic information is often incompatible with his/her existing cognitive models, an individual cannot assimilate or integrate the information successfully, resulting in an initial response “outcry” and an information overload. At this time, all kinds of his/her psychological defense mechanisms

begin to operate and he/she is in a state of “numbness-denial” (e.g., feel numb, deny the traumatic event, avoid reminders of it) while the information overload of the traumatic event (e.g., images, thoughts, moods, etc.) is suppressed into the unconsciousness and stored in a special “active memory”. The nature of flashback can be seen as an information overload that patients fail to process normally. In addition, Horowitz proposed the concept of “completion tendency” to explain the repetition of flashback. He believed that completion tendency is the driving force of cognitive processing, an innate instinct for processing information, and also a psychological need to integrate new information into the existing cognitive models. He proposed that, after trauma, completion tendency enables the contents in “active memory” repeat instinctively and tries to integrate the information of trauma into the existing cognitive models. But this results in breaking down of psychological defense mechanisms of patients and the information of trauma, in the forms of flashback, reentering into the consciousness. The repeated cycle between two opposing parts in operation, completion tendency and psychological defense mechanisms, cause the repetition of flashback. Therefore, in the gradual process of integrating the traumatic information into the existing cognitive models, patients constantly swing between two states, flashback and “numbness-denial”, until they develop a new cognitive model that could understand the traumatic event comprehensively.

3.2.2 Theory of Shattered Assumptions

This theory, proposed by Janoff-Bulman [22], is basically consistent with that of Horowitz [21]. In her theory, Janoff-Bulman focused on why the existing cognitive assumptions or beliefs of individuals about the world are incompatible with the traumatic information. She emphasized three common cognitive assumptions or basic beliefs, which significantly affect how individuals respond to the traumatic event, including: (1) The world is kind and other people are in general well-disposed towards us; (2) The world is meaningful and there are reliable rules and principles that enable us to predict which behaviors will produce which results; (3) We ourselves are personally good, moral, and well-meaning. The traumatic event breaks or shatters the naive and beautiful assumptions or fantasies of individuals about the world and themselves. Janoff-Bulman also proposed that individuals can naturally create new assumptions about the world through the repeated cycle, like Horowitz described [21], between the traumatic re-experiences and avoidance behaviors, and also through the deliberate reflections of the traumatic event. This is exactly why Janoff-Bulman is more optimistic than Horowitz.

3.2.3 Emotional Processing Theory

Based on the researches in victims of violence and rape, Foa and her colleagues proposed this theory [23,24]. They emphasized cognitive factors before, during and after the traumatic event can mutually strengthen the key negative schemas including incapable self and unsafe world. According to this theory, before the traumatic event happened, the more rigid the existing cognitive assumptions or beliefs are, the greater the impact of the event (i.e., the higher severity of the event perceived by an individual) and the higher possibility of suffering from PTSD are. These cognitive assumptions or beliefs may be either positive (e.g., capable self and safe world), which are contradictory to the traumatic event, or negative (e.g., incapable self and unsafe world), which can be reconfirmed or consolidated by the traumatic event. This theory is an important supplement to the theory of shattered assumptions [22]. Additionally, this theory also emphasizes the pathogenicity of individuals’ negative cognitive appraisals (about themselves, all the events during the initial traumatic situation, the posttraumatic symptoms, the disturbances to daily activities, others’ reactions and behaviors, etc.), because these appraisals can aggravate perception of incapable self.

3.2.4 Summary

These three theories above focus on how traumatic information conflicts with and goes beyond the existing cognitive models or assumptions of individuals, as well as on their posttraumatic long-term regulations. Therefore, these theories not only provide an important theoretical reference for the

prevention education for PTSD but also mention therapists, in the treatment of PTSD, should pay more attention to the posttraumatic cognitive modification which can help patients update their cognitive models about themselves and the world. However, these theories fail to explain clearly how the traumatic event impacts individuals in a short period of time (e.g., how the existing assumptions or beliefs shatter), and how the traumatic event is represented in memory (e.g., how the information overload of trauma is represented in “active memory”).

3.3 Information Processing Theories of PTSD

The traumatic event and its associated stimuli and responses are encoded, stored, and reactivated in a special way. If the traumatic information is not processed properly, things will go wrong.

3.3.1 Theory of Fear Network

Lang reformulated fear conditioning within a more comprehensive cognitive framework [25]. His reformulation is a very important theoretical source of information processing theories of PTSD. In this theory, Lang constructed an associative network in the memory system. He proposed that a fear memory is composed of associations among different nodes, namely, fear network. These nodes represent three kinds of propositional information: (1) Stimulus information about the traumatic event (e.g., sights, sounds, etc.); (2) Response information or emotional and physiological responses of individuals to the traumatic event; (3) Meaning information, primarily cognitive appraisals of individuals about the degree of threat. In this fear network, cognition and emotion are integrated into a whole response program whose function is to enable individuals to quickly escape from or avoid danger. PTSD patients have unusually coherent and stable fear memories which are very easy to be reactivated by the stimulating elements that are ambiguous but contain some similar contents with fear memories. When fear network is reactivated, patients experience the same physiological responses almost like in the initial situation and tend to make the same appraisal (i.e., the degree of the current risk is the same as the initial traumatic event). Therefore, flashback is a part of fear memory and contains information of stimulus and response. According to this theory, the formation of flashback can be understood as the formation of fear network, and all three kinds of information and similar information in fear network can reactivate fear memories (i.e., trigger flashbacks). The repetition of flashback is attributed to a large number of stimulating elements in the environment.

3.3.2 Cognitive-Action Theory

Based on researches in veterans of the Vietnam War and Lang’s reformulation of fear conditioning [25], Chemtob and his colleagues proposed this theory to analyze the structure of fear network more specifically [26]. They regard fear network as a parallel hierarchical system. In addition, this theory put forward an evolutionary view on the re-experiencing and high arousal symptoms of PTSD. They suggested that fear network of PTSD patients is continuously activated, which makes patients in the functional state of “survival mode” for a long time but this mode is only adaptive in the traumatic situation. About re-experiencing symptoms, the warning signal hypothesis [19] is similar to this suggestion.

3.3.3 New Viewpoints about Fear Network

Foa and her colleagues, combined theories of Lang [25], Horowitz [21], and Janoff-Bulman [22], emphasized the role of subjective perception of individuals in the formation and reactivation of fear network [27]. Their new viewpoints about fear network are influential. They believed that the traumatic event has a “memorial significance” to an individual but violated his/her existing basic concepts of safety, so the representation of the traumatic event in his/her memory is different from the ordinary life event. The nodes in fear network represent three kinds of information: (1) Stimulus information of the traumatic event; (2) Cognitive, behavioral and physiological response information of individuals during the traumatic event; (3) Information of connection between stimulus and response. In addition, the severity of the traumatic event determine the degree of disturbance to normal cognitive processing (e.g., attention,

encoding, storing, etc.). The more serious the traumatic event is, the more fragmented fear network becomes. Because PTSD patients' basic hypothesis about safety is subverted by the traumatic event, a large number of environmental cues then can reactivate fear network, resulting in a very low activation threshold of fear network. Furthermore, they believed that individuals have an innate cognitive processing need for integrating the information of the traumatic event into a broader memory system. Before fear network is integrated into the existing memory system, the connections between the nodes in fear network must be weakened. The way to weaken these connections is to reactivate fear network (e.g., through imagination exposure), and the way to modify them is to combine the information incompatible with fear network (e.g., the habitual experience of fear). According to the viewpoints of Foa and her colleagues, it can be seen that the difficulty of information integration is due to the characteristics of the traumatic event memory itself (i.e., the special representation in the memory system). But according to social cognition theories of PTSD [21–24], the difficulty is due to the conflicts between the integration processing and the existing beliefs and assumptions of individuals.

3.3.4 Cognitive Processing Theory

Like the viewpoints of Foa and her colleagues [27], this theory proposed by Creamer and his colleagues also holds that only after fear network is reactivated can it have an opportunity to be settled [28]. In this theory, they proposed a concept of “network resolution processing”, also can be seen as an innate cognitive processing need, through which fear network is settled or integrated into the memory system. Furthermore, this theory, based on some longitudinal research results, also suggested that the more early flashbacks in PTSD patients, the better network resolution processing and prognosis; on the contrary, the less early flashbacks, the worse prognosis.

3.3.5 Summary

Compared with social cognition theories of PTSD, information processing theories of PTSD describe the process of cognitive processing of traumatic information (including during and after trauma) more clearly, and build a theoretical foundation for CBT treatment of PTSD. However, these theories pay little attention to distinguish flashback from the ordinary traumatic memory (i.e., intentional memory of the traumatic event), thus it is difficult to explain why fear memory of patients can cause rapid responses (e.g., flashbacks and physiological symptoms) but the memory itself is chaotic and includes so many blanks [29].

3.4 Self-Memory System Model

This model [30], proposed by Conway et al., is originally used to describe the hierarchical structure of the autobiographical memory (AM), and later to explain the representation and retrieval of traumatic information related to flashbacks in the AM system.

According to the model, the AM is a knowledge-based and conceptual organized system, which is continuous and multilayered. The AM system has four levels: (1) The broader conceptual themes (e.g., interpersonal relationship) in the life story; (2) The life stage (e.g., when I was in college); (3) The ordinary event (e.g., meeting friends); (4) The specific knowledge of the event or the specific episodic memory (e.g., the party with my friends on the day of graduation celebration). In the AM system, the level of specific episodic memory including sensory and perceptual details is the lowest or the most specific. It can be intentionally retrieved from top to bottom (i.e., generative retrieval) or triggered from bottom to top by some internal and external situational cues (i.e., direct retrieval). Conway believed that the AM provides, by life history of individuals, the related autobiographical contextual knowledge (e.g., spatiotemporal connection) for the maintenance of the specific episodic memory [31,32].

Therefore, flashback is regarded as some components of the episodic memory of the traumatic event but lack of the conceptual contextual knowledge framework (i.e., sensory and perceptual information). The repetition of flashback is that some components of the episodic memory of the traumatic event are constantly directly retrieved (i.e., intrusion in the consciousness) [33]. Compared with above theories of PTSD, this model distinguishes flashback from the ordinary traumatic memory which is lack of specific

sensory and perceptual details of the traumatic event in the AM system. Because of the importance of modification and promotion in memories (especially unwanted emotional memories), for patients with psychological disorders [34,35], this model is helpful in designing memory training programs for the prevention education and treatment of PTSD. For example, the program of memory specificity training (MEST), a 4-week group training program, can improve the memory specificity of PTSD patients and induce PTSD symptoms [36].

3.5 Cognitive Model of PTSD

This model [37], proposed by Ehlers et al., is an integrated model in explaining PTSD. It mainly integrated theories of learning and information processing and the self-memory system model, emphasizing the impact of cognitive factors of individuals and the special processing of traumatic information.

According to this model, an individual's over negative appraisal of the traumatic event and/or posttraumatic sequelae, his/her self-protective cognitive and behavioral strategies (e.g., avoidance, suppression) and other cognitive factors have important effects on the maintenance of symptoms. Several studies have shown that all of the following cognitive factors of individuals can predict the maintenance of PTSD: negative appraisals of the traumatic event, negative interpretations of the initial symptoms, and posttraumatic negative interpretations of other people's responses [37–39]. Furthermore, efforts of individuals to change the negative cognition and the traumatic memory are usually prevented by some self-protective cognitive and behavioral strategies [37,39], also resulting in the maintenance of symptoms.

As for the special processing of traumatic information, it means that the related AM is disturbed, which includes poor or inadequate elaboration and contextualization, strong associative memory, and strong perceptual priming. First of all, in the process of information processing of the traumatic event, data-driven processing (focusing on sensory impressions) is relatively strong, while conceptual processing (focusing on the meaning of the traumatic situation, the organization and contextualization of information) is relatively weak. Therefore, some sensory and perceptual information of the traumatic event has not been adequately elaborated and not been properly integrated into the general database of autobiographical contextual knowledge. Then they become materials of flashback. Secondly, in the initial traumatic situation, the associations of S-S and S-R are so strong that the related or similar stimuli can trigger flashback and/or emotional responses. The process of retrieving flashback from the associative memory is usually clue-driven and out of the consciousness. Finally, in the initial traumatic situation, the temporarily related stimuli have a strong perceptual priming effect (i.e., the perceptual threshold of these stimuli is reduced), so that it makes patients be much easier to detect the related cues that can directly trigger flashback. Even stimuli with different states or forms from the initial traumatic situation can also trigger flashback because of the ambiguous similarity in perception. Many studies have confirmed the relationship between flashback and data-driven processing [38,40–43], as well as the relationship between flashback and strengthened perceptual priming [44–49].

Therefore, flashback is the sensory and perceptual information in the initial traumatic situation which is data-driven processed but inadequately contextualized or conceptual processed. And flashback is different from the ordinary traumatic memory. The repetition of flashback is basically because of the strong perceptual priming in the initial traumatic situation, which results in flashback, before it is adequately contextualized, constantly being triggered by a lot of possible internal and external situational cues with the ambiguous perceptual similarity to the initial temporarily related stimuli. For the prevention education and treatment of PTSD, this model can bring many valuable ideas and some of which have been confirmed in several intervention studies of the simulated trauma [48,50,51].

3.6 Schematic, Propositional, Analogue, and Associative Representational Systems Model of PTSD (SPAARS)

The SPAARS model [52,53], proposed by Power et al., is an integrated model based on fear network and multirepresentation to explain PTSD and distinguishes flashback from the ordinary traumatic memory. This model is originally used to explain normal emotions, and later applied to the field of psychopathology. According to this model, emotion consists of four independent and interrelated levels or forms of psychological representation, which are: (1) Schematic representation, which is similar to the cognitive models described in cognitive behavioral theories and represents the abstract general knowledge; (2) Propositional representation, which represents the meaning in the verbal forms; (3) Analogue representation, which stores the information in the forms of visual, auditory, olfactory, gustatory, tactile, proprioceptive “images” and encodes the information in the nonverbal form and then adds it to the propositional representation; (4) Associative representation, which is similar to fear network and represents the associations between the above representations.

According to the SPAARS model, the trauma-related information and experiences and responses of individuals are encoded in parallel, through schematic, propositional and analogue representations, while associative representation connects above three traumatic representations. Because the traumatic event threatens an individual’s survival and/or causes other loss of values and results in intense appraisal emotions (e.g., fear, helplessness, sadness, etc.) [54,55], the traumatic memory is distributed in all four levels of representation systems. The traumatic information distributed in schematic, propositional and analogue representations cannot be assimilated by the existing memory system of individuals at first, so that it maintains a high level of internal cohesion and composes, by associative representation, a traumacentric fear network with other representation elements. Therefore, the external cues which represent episodes of traumatic experiences of individuals can reactivate the whole traumatic memory, and then flashback occurs. In addition, because of the incompatibility between the traumatic event and the existing cognitive schemas of individuals about the world and themselves and the threat caused by the incompatibility, the cognitive processing resources are allocated to assimilation processing. Assimilation processing makes individuals repeatedly evaluate the incompatible and threatening nature of the related representations of the traumatic event in memory, and then a fear state is activated in a chronic and low level so that they are continuously held in a state of danger (i.e., high arousal symptoms), and the traumatic information intrudes into consciousness in various forms (e.g., flashback, nightmare, etc.). The chronic activation of the fear state and its related representations also leads to cognitive processing bias of the trauma-related information, and then the internal or external cues related to the traumatic event are much easier to be selectively processed and the trauma-related information in memory is reactivated, so that the re-experiencing symptoms are aggravated. As PTSD symptoms continue, the association between the trauma-related information and appraisal emotions is strengthened during re-experiencing, and the internal or external cues related to the traumatic event can lead to the automatic arousal of emotions.

To put it briefly, the SPAARS model distinguishes flashback from other traumatic memories (i.e., information in other levels of representation) in fear network. Flashback can be regarded as the trauma-related information, in the forms of sensation and perception, in the analogue representation but is not assimilated into the memory system, while the ordinary traumatic memory is mainly the information in the propositional representation. Assimilation processing, in order to restore the internal cognitive balance after trauma, causes the chronic activation of the fear state which leads to the repeated intrusion of flashback. This model is also helpful for specific memory training programs.

4 Theories of the Multiple Memory System

Different from the view of cognitive psychology on memory system, many theorists and researchers have advocated the view of multiple memory system since the 20th century. They believed that there are one or more memory systems different from the episodic memory and functioning independently [9]. For example, Pierre Janet, who studied the traumatic memory, is one of the first theorists to propose the idea of multiple memory system. In the early years of the 20th century, Janet believed that there are both

image-based memory system and verbally based narrative memory system (c.f., [9]). The image-based memory system, which has existed since the birth of an individual, includes the sensory and perceptual details of some major situations in life, and its contents can be communicated through images. But the verbally based narrative memory system, depending on language, develops from the early childhood and its contents can be communicated through narrative. Based on the related research evidences, Brewin has confirmed that there is a “long-term perceptual memory system” [9] which rarely obtains intentional attention of individuals. He proposed that the long-term representation is “selective or incomplete reflection of sensory input” [9].

Flashback and the ordinary traumatic memory are distinguished in the multiple memory system clearly, so that many researchers have new explanations of flashback. For example, Janet first proposed that flashback is different from the ordinary traumatic memory, which is composed of sensation, perception, affective state, behavioral reenactment, etc. and remains unchanged for a long time (c.f., [56]). In viewpoints of van der Kolk et al. [57], flashback is different from memories of other important life events, which is initially stored as sensory fragments and lack of a coherent semantic components.

Based on the perspective of multiple memory system and inherited from the theories of Pierre Janet especially, Brewin and his colleagues proposed the dual representation theory of PTSD (DRT) which is an integration of the existing cognitive behavioral theories of PTSD [7,9,58,59]. The DRT has brought some new viewpoints about the representation and retrieval of traumatic information in different memory systems, illustrated the different functions of the dual memory system clearly, and emphasized that the solution to trauma is to achieve integration of traumatic information.

The DRT has two versions, the original [58,59] and the revised [7,9]. According to the original DRT, traumatic information is represented by two parallel memory systems: the verbally accessible memory system (VAMs) and the situationally accessible memory system (SAMs). Both of them are parts of the normal memory, and one will take precedence over the other at different times. VAMs includes the records of conscious experiences, and its capacity of processing is limited. It supports abstract declarative representation and autobiographical contextual knowledge which can be retrieved either voluntarily or involuntarily. Moreover, individuals can communicate the contents in VAMs with others verbally and can also modify the contents intentionally. SAMs stores the low-level represented information (i.e., specific sensory and perceptual images, physiological responses) which is closely bound with sensations and emotions. Unlike VAMs, SAMs' capacity of processing is not limited but not related to autobiographical contextual knowledge. It can only be triggered by the internal and external situational cues (i.e., involuntary retrieval), and it is the basis of re-experiencing symptoms (flashbacks and nightmares) related to the traumatic event. Moreover, individuals has difficulties in communicating the contents of SAMs with others verbally, and also in controlling them intentionally.

When individuals are involved in the traumatic event, different from the normal process of memory representation and retrieval during which VAMs and SAMs are connected and VAMs usually inhibits the activation of SAMs, VAMs is responsible for solving the negative beliefs and the emotions caused by them, while SAMs is responsible for managing the sensory and perceptual information. However, because of the attention stenosis and the loss of hippocampal function caused by the extreme stress state during the traumatic situation, VAMs' capacity of processing is so limited that some parts of the sensory and perceptual information are stored in SAMs and disconnected with VAMs. This results in trauma-related flashbacks and nightmares without appropriate autobiographical contextual knowledge being different from the ordinary traumatic memory.

After trauma, attention and memory bias of individuals give priority to the cues related to the traumatic event. So, VAMs and SAMs are activated at the same time and enable individuals carry on emotional processing of the traumatic event. During this process, VAMs consciously adjusts the conflicts caused by the traumatic event, by searching meanings, judging causes, attributing responsibilities, etc.; SAMs, by re-experiencing symptoms, provides VAMs the related sensory and perceptual information and physiological response and enables VAMs conduct cognitive readjustment. By consciously recovering the sense of security and control or appropriately adjusting the expectations for the world and themselves,

emotional processing of individuals aims to reduce negative emotions, achieve the integration of traumatic information, and reorganize memory and prevent SAMs from being reactivated. However, some internal cues are often reactivated during emotional processing and thus lead to entrance of the information in SAMs into the consciousness. Flashbacks and nightmares then come after. The posttraumatic emotional processing may be influenced by several factors such as the severity and duration of the traumatic event, the significance of the traumatic event to individuals, the appropriate social support to individuals and so on. There may follow three different results: (1) Completion/integration, which means that traumatic memory is adequately processed or worked through; (2) Chronic emotional processing, which means long-time continuous emotional processing due to inadequate processing of traumatic memory; (3) Premature inhibition of processing, which means that individuals try to avoid recalling the traumatic event and forms a set of automatic avoidance models to monitor the sensory input of associated stimuli but without conscious processing. Although it seems that individuals have recovered from the trauma, the inadequate processed traumatic information is easily reactivated. The last two results show that the traumatic information has not been integrated in the memory system which explains the delayed onset of PTSD. Generally, the integration of traumatic information after trauma is a gradual process, which will not be accomplished overnight. Emotional processing often lasts for a period of time (or even for a long time) after trauma and results in repeated intrusion of flashbacks and nightmares.

The revised DRT is based on the neurobiological model of normal memory and mental imagery [60,61]. Compared with the original DRT, the main work of Brewin and his colleagues in the revised is to rename and describe two memory systems and elaborate the neural mechanisms of the representation and retrieval of intrusive imagery (i.e., flashback) [62], emphasizing the role of specific information processing pathways [63]. According to the revised DRT, two memory systems, contextual memory (C-memory) and sensation-based memory (S-memory), are independent but mutually influential and have different representation pathways: contextual representation (C-rep) in the ventral pathway of visual processing and sensational representation (S-rep) in the dorsal pathway. Different from the ordinary memory, the process of memory representation and retrieval of the traumatic event is abnormal [62], which means that: individuals encode traumatic information pathologically (i.e., formation of flashback), in which S-rep is up-regulated or enhanced, C-rep is down-regulated or weakened, and C-rep and S-rep are disconnected. Thus, the nature of flashback is partially processed sensory and perceptual information of the traumatic event and stored in S-memory (i.e., the long-term perceptual memory system) [9]; the retrieval of traumatic information (i.e., re-experiences flashback) shows that the visual images are driven by S-rep from bottom to top, triggered by the internal and external situational cues and not affected by the weakly activated C-rep.

The DRT is very helpful for CBT treatment of PTSD. Many researches of the simulated and real trauma have tested and supported the explanations of DRT about PTSD symptoms (especially flashback) and their mechanisms [9,29]. The effectiveness of cognitive interventions (i.e., cognitive tasks such as visual spatial tasks primarily using to inhibit S-rep, enhance C-rep and the interconnection of C-rep and S-rep) during and after the simulated trauma is also confirmed in several researches [62].

5 Overview and Outlook

From the psychodynamic theories, the principles of conditioning in behavioristic psychology, social cognition, information processing to multirepresentations, theories of trauma-related flashback present a trend of multirepresentational theorizing [54] and become much richer and sophisticated, and also the understandings of the nature of traumatic memory are becoming more and more clear. All of them are very important to the prevention and treatment of PTSD.

5.1 Understandings of Flashback

5.1.1 Formation of Flashback

Flashback is originated from the “large dose” impact, caused by the traumatic event, on the body and mind of individuals, which is extremely painful, over alert, information overloaded, incompatible or

conflicting with the existing cognitive models (or assumptions, beliefs, schemas, etc.) and normal cognitive neural activities inhibited. Such impact makes individuals in an abnormal physical and mental state, unable to normally understand, master, digest, assimilate, adequately process, contextualize or integrate the traumatic event and its related information (e.g., sensation, perception, physiological response). Therefore, the nature of flashback can be described as the wandering traumatic information fragments, the associative network of abnormal emotion (primarily fear), or the specific nonverbal situational memory with vivid sensations and perceptions. In addition to the points mentioned above, future theoretical research of PTSD needs to pay attention to some other important concerns. For example, although fear is often in the first place, future research still needs to focus on other emotions (e.g., sadness, guilt, shame, etc.) during and after trauma, as also mentioned by Dalglis et al. [55], because these emotions have complex effects on the formation, maintenance and aggravation of PTSD symptoms. And other important phenomena such as trauma exposure types, inner psychological factors of individuals and complex symptoms in different population also deserve more attention. For example, peer violence or bullying in adolescents as a prolonged relatively “small dose” trauma [64], patients’ sense of self related to the maintenance of symptoms [65] and mourners’ positive intrusive memories of the lost person besides negative intrusive images of the death event [66]. Furthermore, future research needs to pay more attention to the process of physical and mental collapse from various theoretical perspectives, especially the specific process of abnormal information processing (e.g., cognitive neural process). The latest revised DRT is a good start [7,9].

5.1.2 Involuntary Repetition of Flashback

This pathological phenomenon can be understood in two situations. The first one is that the completion or integration, the tendency of automatic processing which is instinctive or unconscious, leads to the involuntary repetition of the traumatic event and its related information before they are integrated or assimilated into the mind or the consciousness or the memory system of patients. So, while the involuntary repetition flashback is unpopular to or not liked by patients, it actually goes in a positive direction. The second situation is that flashback is passively or involuntarily triggered by plenty of internal and external trauma-related cues. In this situation, the abnormal physical and mental state of patients is one of the reasons. For example, the over alert “survival mode” makes patients more sensitive and vulnerable. Another reason is that the traumatic event and related information have not been, after trauma, reprocessed and kept unintegrated, which includes: (1) The negative reinforcement of self-protective cognitive and behavioral strategies (e.g., avoidance) makes patients lose opportunities; (2) The abnormal retrieval process of flashback or the traumatic memory (S-memory) makes patients have little opportunities. Future research in specific abnormal physical and mental state and the abnormal cognitive processing should be combined with that of cognitive neuroscience and perhaps molecularbiology.

5.2 Prevention and Treatment of PTSD

5.2.1 Prevention

According to the explanations of mechanisms of the formation of flashback in above theories of PTSD, the preventive measures or programs should be directed to reduce the impact of adverse factors before, during and after the traumatic event. These preventive measures or programs mainly include two domains. The first one is the improvement of abilities of individuals, which including: (1) Updating their cognitive models (or assumptions, or beliefs) or making them more rich, flexible and mature; (2) Enabling they process the traumatic information much better, reduce the maintenance of symptoms more effectively and be more adaptive to the posttraumatic life. Education of life, death, frustration, rational cognition or life philosophy is helpful for the former, and specific training of context representation, specific memory, writing/journaling or narrative/verbal expression, emotional regulation, problem-solving, social skills and other abilities is for the latter. The education and specific training are more suitable for implementation before and after trauma. The second domain is to help individuals cope with trauma more effectively

including designing and developing three kinds of tasks or programs and their corresponding convenient products (such as APP in personal intelligent devices) and the effectiveness of some of them has been confirmed in many researches in clinical and nonclinical population. Three kinds of tasks or programs are as follows: (1) Specific cognitive task, such as task for visual spatial [62], positive attention bias [67], positive interpretation [68–71] and imagery rescripting [72–76]; (2) Emotional regulation program, such as physical relaxation, mindfulness [77] and meditation; (3) Sleep promotion program (SPP), such as SPP for adolescents in an applied study [78]. These tasks or programs and their products must be suitable for specific culture, religion and daily life, and can be implemented effectively by individuals during and after trauma. So, they can help individuals promoting the traumatic information processing and cognitive reprocessing, keep them in a normal physical and emotional state, and reduce their risk of PTSD. An effective combination of above education, training or task should also be considered in practical application. For example, a combination of program of psychoeducation, mindfulness and journaling are applied to train police trainees how to handle exposure to adversities and minimize potential negative consequences [79]. The preventive measures or programs and the effective combination of some of them mentioned above can be adopted in the applied basic researches of the real and simulated traumatic population, and then the corresponding applied researches will be carried out gradually and cautiously.

5.2.2 Treatment

Targeting at the four groups of core symptoms of PTSD [5], the treatment plans or programs are designed to reduce the re-experiencing, high arousal and high avoidant symptoms and modify the negative changes in cognition and mood, mainly including cognitive reprocessing of traumatic information, extinction of associations of S-R and S-S, and reduction of factors for the maintenance of symptoms. Many cognitive and behavioral methods or techniques are often used in the treatment of PTSD, such as cognitive correction, imaginal exposure and system desensitization. Recent years, eye movement desensitization and reprocessing (EMDR) [80] is successfully used to reduce imagery vividness and emotionality of negative memories [81]. Some of the preventive measures or programs mentioned above also can be used in the treatment of PTSD. Because the cognitive reprocessing of trauma is a traditional theoretical focus, in the future applied basic researches and experimental applied researches, specific cognitive tasks and memory training programs deserve more attention, as well as factors which can affect the training effect, such as individual differences in mindfulness [82] and resilience in the posttraumatic growth (PTG) [83]. In addition, another possible direction in future researches is the development of drugs that can improve the abnormal cognitive neural activities in retrieval of the traumatic memory and cognitive reprocessing.

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