EMDR Therapy and PTSD:

A Goal-Directed Predictive Processing Perspective

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Abstract

Eye movement desensitization and reprocessing (EMDR) therapy is a widely used evidence-based treatment for posttraumatic stress disorder (PTSD). The mental processes underlying both PTSD and EMDR treatment effects are often explained by drawing on processes that involve the automatic formation and change of mental associations. Recent evidence that contrasts with these explanations is discussed and a new perspective to PTSD and EMDR treatment effects is proposed that draws on automatic inferential processes and can be readily integrated with the dominant (Adaptive Information Processing) model. This new perspective incorporates insights from cognitive theories that draw on predictive processing and goal-directed processes to elucidate (changes in) automatic inferences that underlie PTSD symptoms and EMDR treatment effects. Recommendations for clinical practice are provided based on this new perspective.

Keywords : PTSD, EMDR, predictive processing, maladaptive beliefs, inferences

Posttraumatic stress disorder (PTSD) is a mental health condition that is precipitated by an event that is experienced as traumatic and characterized by symptoms of re-experiencing certain aspects of this event (e.g., emotions such as panic), avoidance, increased arousal, and adverse alterations in mood or thoughts. PTSD is widely prevalent in today's society (Kessler et al., 2017), with a stark increase during pandemics such as the COVID-19 pandemic (Yuan et al., 2021). Eye movement desensitization and reprocessing (EMDR) is a psychotherapeutic approach originally developed for PTSD treatment by Francine Shapiro (1987) who first noticed, when taking a casual walk in the park, that eye movements seemed to reduce disturbing thoughts. The EMDR protocol consists of eight phases (Shapiro, 2018). In short, after probing a client's *history* and building a *therapy plan* (Phase 1), the theory and protocol of EMDR is explained and relaxation techniques are practiced (Phase 2: *Preparation*). Next, the client is asked to think about the distressing event that constitutes therapeutic focus and to recall different aspects of this event (e.g., related images, thoughts, emotions and physical sensations). Negative cognitions are identified and positive alternative cognitions are selected and the client rates how true these cognitions feel (Phase 3: *Assessment*). At this point, side-to-side eye movements are evoked (Phase 4: *Desensitization*) and the previously identified positive cognitions are strengthened (Phase 5: *Installation*). This process continues until no more maladaptive thoughts or physical reactions are reported when asked to scan for them (Phase 6: *Body scan*). At the end of each session, effects that might occur between sessions are discussed and self-calming techniques to manage possible stress can be practiced (*Phase 7: Closure*). Finally, in subsequent sessions, the therapist checks for progress and imaginary techniques can be used to go through possible related future events and reinforce healthy coping strategies (Phase 8: *re-evaluation* with future template).

EMDR is recognized by the World Health Organization (WHO) as a first-choice treatment for PTSD (WHO, 2013) and widely used in clinical practice (Castelnuovo et al., 2019). In part, this

popularity relates to the results of meta-analyses looking at the efficacy of EMDR for the treatment of PTSD. In adults, meta-analyses typically found similar effectiveness of EMDR compared to standard treatment with proven efficacy (i.e., cognitive behavioral therapy [CBT]) (Khan et al., 2018; Seidler & Wagner, 2006; Van Etten & Taylor, 1998; Watts et al., 2013) and with medium to large effects on PTSD symptoms compared to control conditions (Cuijpers et al., 2020). In children, a meta-analysis by Rodenburg et al. (2009) even found slightly better outcome effect sizes of EMDR when compared to CBT. There is also initial evidence for the effectiveness of web-based EMDR (that can be implemented during the COVID-19 pandemic; e.g., Lenferink et al., 2020). Although we are fully aware that research is being conducted on whether EMDR can also be successfully applied to other mental disorders (for a review, see Valiente-Gomez et al., 2017), we focus on the effects on PTSD because, to our knowledge, EMDR has not (yet) been recognized as an evidence-based treatment for other mental disorders in prominent guidelines (e.g., WHO, APA, NICE-guidelines).

Crucially, there is still room for improvement of EMDR treatment, as can, for instance, be seen in the fact that there is high heterogeneity in EMDR effect sizes (Cuijpers et al., 2020; Dimaggio, 2019). While this heterogeneity may partly relate to methodological differences (Maxfield & Hyer, 2002), better guidance to improve EMDR treatment is likely of importance as well. According to recent recommendations in psychological science, this might require a focus on the mechanisms underlying behavior change to improve treatment protocols (Nielsen et al., 2018). Although there is a need for additional research with well-defined clinical as well as non-clinical samples with large sample sizes and rigorous methodological control, recent research suggests that several different mechanisms likely contribute to EMDR effects (Landin-Romeo et al., 2018). Notably, however, part of the mechanisms underlying EMDR effects have originally been interpreted in terms of changes in associative memory processes (Shapiro; 1995, 2018; Solomon & Shapiro, 2008) and this interpretation is typically incorporated in EMDR training for future therapists (Kennard, 2020; Marich, 2015). Yet, ideas about

associative underlying processes may not fit well with current (propositional) theorizing in psychological science (Corneille & Stahl, 2018; Lissek & Van Meurs, 2015; Mitchell et al., 2009). We propose that psychological science and clinical practice may strongly benefit from development (and testing) of shared disciplinary theories (see Jamieson & Pexman, 2020, for related argumentation). To this end, the aim of the current paper is to integrate EMDR theory and practice with recent theories in cognitive science that present a strong evidence base. This paper is the result of a collaboration between an EMDR therapist and a theoretical psychologist.

In the following section, we discuss the dominant theorizing about EMDR treatment effects that underlies current EMDR training (the AIP model). We then explain how recent theories in general (cognitive) psychology can be used to update this model. Finally, we provide recommendations for EMDR therapists.

Dominant theorizing about EMDR treatment effects

The AIP Model. Current EMDR training typically involves reference to a theory proposed by Shapiro to explain the clinical effects of EMDR therapy on PTSD symptoms most prominently and to develop (and improve) EMDR protocols (Shapiro; 1995, 2018): the Adaptive Information Processing (AIP) model. The current EMDR protocol is strongly based in (and explained in reference to) this model of PTSD and EMDR treatment effects (Hase, 2021). The AIP model postulates that information is processed and stored in associative memory networks. In these networks, information about experiences (i.e., memories) are linked together via associative connections (i.e., associations) to form coherent associative networks. These networks are considered to be “adaptive” in the sense that they only retain information that is useful for the organism, for example information that helps to select and conduct future actions that increase the likelihood of survival. Importantly, however, traumatic events can disrupt the system, such that maladaptive memories consisting of diverse aspects of these events

(e.g., images, sounds, or smells) are left unprocessed and stored in a maladaptive form. These maladaptive memories can influence behavior, leading to PTSD symptoms such as flashbacks and intrusive thoughts (Shapiro, 2018).

The AIP model postulates that EMDR treatment can help resolve PTSD by stimulating the processing of maladaptive memories. When clients focus on a traumatic event during eye movements (or other dual attention techniques), this can enable the processing of the maladaptive memories (e.g., because the eye movements might improve communication within the brain or decrease vividness and emotionality of memories because working memory is occupied [working memory hypothesis]: Andrade et al., 1997; Barrowcliff et al, 2004; Engelhard et al., 2010). As a result, during eye movements, new associations can be formed between the maladaptive memory representations and more adaptive memories, allowing for adaptive reprocessing (Solomon & Shapiro, 2008).

Associative theorizing in EMDR treatment effects. The AIP model provides an explanation of EMDR effects on PTSD treatment that includes reference to associative mental processes. This is unsurprising given that explanations of fear, anxiety, and stress-related disorders in general, and PTSD specifically, traditionally draw on associative mental processes (see Dalgleish, 2004, Boddez et al., 2020, for reviews). Dominant models (e.g., Foa et al., 1989; see also Brown, Zandberg & Foa, 2019) typically explain PTSD as follows. When a traumatic event takes place in a certain context, formerly neutral stimuli (conditioned stimuli: CSs, e.g., a car) that are present are now paired with an unpleasant event (unconditioned stimulus: US, e.g., a car accident). Much research has investigated effects of stimulus pairings (i.e., conditioning effects) and these effects have often been explained in reference to associative processes. Specifically, CS-US pairings may lead to the automatic formation of a mental association between the mental representations of the CS and of the US and its associated responses (unconditioned responses: URs, e.g., fear response (Hofmann et al., 2010). After a traumatic event, when contacting a CS (in real life or in memory), activation may spread to US/UR representations such

that the CS may come to evoke similar responses (conditioned responses: CRs), leading to PTSD symptoms. In contrast to other anxiety disorders, in PTSD, stimuli that were safe before have become associated with representations of danger via the traumatic event. This may lead to three typical (characteristics of) PTSD symptoms: high intensity of (fear) responses, fear responses that are widely generalized to different contexts, and a low threshold for activation of these responses.

Given the associative dominance in explaining PTSD, many treatments are inspired by and interpreted within this framework. Similar to the AIP model, cognitive theories of effects of PTSD therapies that focus on exposure typically refer to changes in mental associations (for extensive reviews, see Lissek & van Meurs, 2015; Brewin & Holmes, 2003). From this perspective, encountering a CS or thinking about a CS in the clinical context will activate its representation. Because the US is not present in this context, CS exposure can change the associative network. Specifically, some (early) theories assume that prolonged exposure to a CS weakens CS-US associations or replaces the associations with more adaptive ones (e.g., Foa & Kozak, 1986). Other (more recent) theories, postulate that the original CS-US associations remain intact, but that new, inhibitory, CS-US associations are added to the network such that the client learns that the CS, under certain circumstances, is not associated with the US (e.g.: Bouton, 1993, 2004; Craske et al., 2006, 2014; Foa & McNally, 1996).

Solomon and Shapiro (2008) pointed out that there are important differences between the AIP model and associative theories of exposure-based treatments. Most importantly, the latter theories explain effects of exposure in terms of corrective information that is provided by the therapeutic situation itself (i.e., the absence of the US when contacting the CS). In contrast, the AIP model assumes that exposure is not enough to produce a change in associations because CS and US representations are strongly associated and activation of the CS representation therefore always leads to activation of the US representation. Instead, it is important that eye movements are evoked when thinking about the traumatic event. This produces a change in associations because it enables adaptive information

processing (i.e., integration of the maladaptive CS-US associations within adaptive memory networks). The AIP model assumes that CS-US associations are not unlearned, but that new associations are formed with other, more adaptive, information (memory reconsolidation).

Updating theories of EMDR treatment effects

Propositional versus associative theories. Recent years have seen a surge of popularity in theories of psychopathology that draw on propositional or belief-based processes (Paulus et al., 2019). These theories argue that the formation and activation of propositional information (which can be defined as "making inferences") underpins maladaptive behavior. Propositional information differs from associative information because it can represent relational information and has a truth value (e.g., the belief that 'driving a car will lead to a car accident') rather than merely specifying a link between mental representations (e.g., the link between 'driving a car' and 'accident' representations). Thus, in contrast to associations, propositions can encode variations in the type of relation between a CS and US (e.g., the difference between the belief that driving a car *will lead* to an accident or *can avert* an accident) and support inferential reasoning (i.e., the act to use propositional information to construct information that is compatible with it) (Mitchell et al., 2009). Importantly, associations therefore cannot capture beliefs (i.e., representations that have truth value and can encode specific relations) (see De Houwer et al., 2020; Hummel, 2010; for discussions). These differences come with important implications and there might therefore be several reasons why propositional theories of PTSD may have added value compared to associative theories.

First, the fact that (during a traumatic event) learning takes place as a result of pairings between stimuli and valenced (unpleasant) events does not necessarily map onto the fact that, at the mental process level, learning is due to the formation of mental associations. In fact, as recent reviews of studies that examined effects of pairings (conditioning effects) point out, evidence for associative explanations of these effects is weak at best (e.g., Corneille & Stahl, 2018; Mitchell et al., 2009).

Instead, (recent) theories postulate that conditioning (e.g., pairing a negative event with a neutral CS) leads to the formation of specific propositions and inferences (e.g., that the CS is negative because it was paired with the negative event) that can produce changes in behavior (i.e., conditioning effects). These theories have shown high heuristic, predictive, and influence value (De Houwer et al., 2019; Van Dessel et al., 2019). From this perspective, the explanation of pairing-based learning in PTSD requires elucidating the specific inferences that give rise to effects. For instance, the pairing of two events (e.g., a car accident and seeing a red warning sign), can lead to a specific set of inferences. First, people might learn the contiguity between the valenced event and the neutral stimulus (e.g., 'the car accident happened when I saw a red warning sign'). Second, people might infer that pairings typically have a specific meaning (e.g., 'things I see when negative events occur predict these negative events'). Third, this may lead to inferences about the previously neutral stimulus (e.g., 'the warning sign predicts negative events') that influence behavior towards this stimulus (e.g., fear responses). Mapping out these inferences may allow for more detail in the explanation of behavior and can inform new ways to influence behavior by targeting specific beliefs and (automatic) inferences (e.g., Wiers et al., 2020). From this perspective, PTSD treatment should not simply target activation of certain aspects of the traumatic memory (e.g., fear responses through confrontation with a CS) to foster change in associative connections, but instead target new learning of adaptive inferences.

A second important benefit of propositional theories relates to the fact that associative theories have difficulty to explain the important role that beliefs seem to play in psychopathology in general, and in PTSD specifically. For instance, a recent review provides strong evidence that PTSD symptoms are strongly related to negative beliefs and that reduction in negative beliefs mediates reduction in PTSD symptoms (Brown, Beli, et al., 2019). From this perspective, change in beliefs plays a key role in the treatment of PTSD such that facilitation of more adaptive cognitive beliefs is a cause rather than a result of resolving traumatic memories. Consequently, the other dominant treatment of PTSD (CBT)

focuses on changing maladaptive beliefs (Monson & Shnaider, 2014) and, crucially, the AIP model (and EMDR treatment) bears much reference to propositional cognitions or beliefs. As noted above, associations cannot capture beliefs, which is an important limitation given the (potentially) important difference between, for instance, holding a strong belief that a stimulus (e.g., a dog) causes a negative event versus prevents a negative event. To deal with this problem, some theorists have proposed dual-process theories that draw on both associative and propositional processes (e.g., McLaren et al., 2014). Although this could be a viable perspective, it requires clear specification of when these different processes would operate and this is currently lacking (Boddez et al., 2020).

A third argument for propositional theories of PTSD relates to dominant theorizing at the implementation or neural level. Mental process theories describe effects or phenomena observed at the behavioral level in terms of underlying processes at the mental level but it can be useful to also examine whether these cognitive processes can be plausibly implemented at the neural level. Whereas associative theorizing (of PTSD) was initially considered to fit well with neurological mechanics (e.g., given the apparent functional fit between an association and a neuron), this idea is often reconsidered (Brewin, 2007), for instance, in light of evidence that properties of synaptic transmission align poorly with the properties of association formation (see Gallistel and Matzel, 2013). In recent years, insights from neuroscience have led to a surge in the popularity of predictive processing (PP) theories (Clark, 2013; Sanborn & Chater, 2016) which postulate that belief-based processes involving causal inferences (i.e., predictions) underlie cognition. PP theories are often thought to provide a good fit to the brain architecture and its various substrates (see Bastos et al. 2012; George & Hawkins, 2009; Shipp, 2016). Although there is still work to be done, further development of PP theories may constitute a promising avenue for describing neurological processes. As such, there is an impressive surge in popularity of the approach to apply PP models to explain behavior and psychopathology (Metzinger & Wiese, 2017).

Goal-directed predictive processing theories. In light of these arguments, it seems valuable

to take a fresh look at the AIP model and explore if this model can be adapted to integrate insights from propositional theories. At first glance, the AIP model seems highly compatible with propositional (PP) theorizing. For instance, the AIP framework (and the EMDR protocol) refer(s) to (and builds on) ideas about the importance of updating beliefs. For instance, it emphasizes changing negative "cognitions" (NCs) in the client's worldview and installing positive "cognitions" (PCs). These cognitions can be described as beliefs (which build on propositional rather than associative processes). While the reference to associative mental processes in the AIP model is also prominent, we believe it may be easily delegated to (goal-directed) propositional (PP) processes.

Recent years have seen initial attempts to explain PTSD and EMDR treatment effects within the PP framework (e.g., Chamberlin, 2019; Linson & Friston, 2019; Wilkinson et al., 2017). However, these theories focus on explanation at the neural level rather than behavioral level and therefore do not provide guidance to predict and influence behavior that can be readily integrated into clear recommendations for clinical practice. In general, PP theories also have many different implementations and often involve reference to several complex constructs and processes. To foster clinical guidance, it may be important to identify key assumptions of prominent propositional (PP) theories at the mental process level that can have value for integration in EMDR theory and practice.

A first key assumption of propositional theories is that the mental system constitutes a network of beliefs about the world. These beliefs are combined to make inferences about events in a person's internal and external environment and these inferences underlie thoughts, emotions, and behavior. In PP theories specifically, causal inferences (i.e., predictions) about the external world directly feed into perception, whereas behavior is explained as 'active inference' that involves predicting one's own behavior (Friston et al., 2017).

Second, an important hallmark of propositional, and most prominently PP, theories lies in the

fact that these inferences are highly automatic and depend on well-defined general principles of biological systems such as entropy reduction (Friston, 2010). From this perspective, beliefs are activated in reference to certain contextual stimuli and automatically give rise to new predictions. PP theories postulate that a person's belief network consists of different "belief modules" that evoke predictions in specific contexts. These modules have a hierarchical structure such that beliefs from higher hierarchical levels (i.e., beliefs that generate more predictions) can 'overrule' beliefs from lower levels because they are assigned more weight ('gain'). Higher hierarchical levels contain more generative beliefs (i.e., beliefs that generate more predictions and that are more generally applicable), whereas lower hierarchical levels contain beliefs that are only applicable to certain situations or aspects of the world (Friston, 2008; Sanborn & Chater, 2016). Beliefs can be updated and assigned higher or lower generative power on the basis of a process that minimizes disorder (or prediction error) to allow for better prediction.

Third, context-dependent inferences about desired outcomes (i.e., goals) play a prominent role in propositional theories. Specifically, beliefs about desired outcomes give rise to inferences about actions that can achieve these outcomes, which transfers to behavior. Whereas dual-process theories typically relate psychopathology and maladaptive behavior that contrasts with important (e.g., health-related) goals to stimulus-driven (associative) processes that do not take into account these goals (Wiers et al., 2018), propositional theories often argue that goals determine all behavior (Dweck, 2017; Moors et al., 2017). From this perspective, the activation of beliefs about one contextually activated wanted outcome can give rise to inferences that lead to (pathological) behavior that may contrast with other personally relevant goals. Such goal-directed inferential processes can be explained in reference to PP principles (Kaye & Krystal, 2020; Van de Cruys & Van Dessel, 2021). For instance, due to the modular structure of a person's belief network this person may sometimes predict engaging in behavior that contrasts with consciously reported important beliefs (e.g., Otgaar et al., 2013). Harmful or

pathological behavior can then occur because one predicts that engaging in this behavior can achieve a valued outcome. These predictions do not take into account all goals or relevant beliefs that a person has (Boddez et al., 2020; Moors et al., 2017) but instead are contextually activated (i.e., they are under the control of contextual antecedents) and emerge from the system's basic operation to minimize prediction error (Moutoussis et al., 2017).

The basic principles noted above can be summarized in a goal-directed PP (GDPP) perspective that explains behavior (and thoughts and emotions) as the result of three inference steps. First, internal or external cues lead to the registration of (homeostatic) wanted states (i.e., goals) (e.g., a signal that there is not enough water in the blood leads to the goal to hydrate). Second, to reduce prediction error between wanted and actual states, inferences are made about the outcomes of contextually relevant actions (Friston et al., 2017; Pezzulo et al., 2015) (e.g., we infer that drinking water helps us hydrate). Finally, given a sufficient match between predicted action outcomes and current goals, one predicts engaging in the action (e.g., drinking) and the action is elicited. In the following sections, we explain how this goal-directed PP perspective can be readily applied to EMDR theory and practice.

A GDPP perspective to PTSD. In the AIP model, it is already postulated that beliefs ('cognitions') are stored in specific memory networks (or belief modules in PP terms). In PTSD, when a traumatic event occurs, this event is considered to be stored in its own memory network, unable to connect with other networks that hold adaptive information, which can disrupt the mental system and lead to selective retrieval of trauma-related information. Taking a GDPP perspective, this process can be explained in more detail. Specifically, a traumatic event may elicit strong prediction error in a person's mental system because there is an unexpected large difference between the current (unsafe) state and the expected (safe) state. This prediction error is given high value (high gain modulation of the prediction error signal or 'attention': Friston, 2009; Chamberlin, 2019) because it contrasts with the goal to be safe and survive (a key homeostatic goal represented at a very high level). As a result,

the unpredicted threatening situation will elicit intense emotion (high expected uncertainty may directly relate to negative emotion: Van de Cruys, 2017) such as fear, which can be seen as an embodied simulation of an unsafe predicted experience (Barrett, 2017). A person's belief network will then be immediately updated on the basis of prediction error minimization to allow predicting this unexpected state if it were to re-occur. Importantly, however, the event may not be readily integrated in current belief modules due to its inconsistency with highly generative beliefs, which may lead the system to be in a state of "mental distress" (Van de Cruys & Van Dessel, 2021). Thus, a new module may be formed in which the mental system might integrate as much sensorial input as possible to ensure ample opportunity to (later) update the belief network to allow better prediction of the current state. This new belief module might immediately be represented at a high hierarchical level given the high expected utility (reduction of strong prediction error) for future predictions.

After the traumatic event, any type of (visual, auditory,…) stimulus that was present during trauma might promote reconstruction of memories of the traumatic event given the important predicted consequences of the retrieval of this event (remembering can be seen as a special type of behavior that depends on the same goal-directed inferences as other behavior: Vanaken et al., 2021). These stimuli may cue the prediction of similar events and, because preventing this event is considered highly important, these predictions may cause PTSD-like symptoms such as fear and avoidance, two key symptoms of PTSD (American Psychiatric Association, 2013). Hypervigilance may also occur such that cues that potentially lead up to the fearful event receive much attention because they lead to the prediction of an unsafe state that strongly contrasts with the current state (attention is tied to the expectation of prediction error: Feldman & Friston, 2010). The observation that experiences during the traumatic event such as dissociative experiences and emotional responses are strong predictors of PTSD symptoms (Ozer et al., 2003) can be easily accommodated within this framework as these experiences are a direct result of the strong prediction error during trauma that gives rise to the disorder.

In contrast to the notion in typical instantiations of the AIP model that newly learned memories and beliefs about the traumatic event are frozen in time, in the GDPP perspective, it is unlikely that processing is halted for a long time (as there would be high entropy in the general belief network). Instead, the system will continuously attempt to integrate traumatic event memories in current belief networks. Thus, when trauma stimuli promote the prediction of similar events, prediction error will immediately follow because the event does not reoccur and the relevant beliefs and predictions will lose their impact (i.e., they are represented at a lower level such that they are activated in fewer contexts and contribute less to behavioral prediction). Notably, however, people at risk for PTSD might not update predictions in this manner. Instead, these people may be characterized by having maladaptive beliefs readily available that can be easily integrated with traumatic event memories. For instance, they might believe that unpleasant events are likely to occur and that it is only their avoidance behavior that prevents reliving these events. As a result, they may infer that they should continue to avoid the fearful situation, thereby preventing any (adaptive) updating of predictions. This idea is in accordance with other theories of PTSD and PTSD therapies, such as Foa's emotional processing theory (1986) (which formed the basis for her work with prolonged exposure: Foa, Hembree & Rothbaum, 2007). Avoidance beliefs may maintain the fear and avoidance symptoms of PTSD but may also lead to other symptoms (Hetzel-Riggin & Meads, 2016). For example, depression-like symptoms such as negative affect and decreased interest in activities might occur when one predicts that one cannot escape fearful events and that it is therefore crucial to conserve energy in order to deal with such events should they occur (Beck & Bredemeier, 2016; Pulcu & Browning, 2019).

From this perspective, why some people do and others do not develop PTSD relates to the generative beliefs available in a person's belief network (as established based on a person's learning history). After the traumatic event, people who have highly generative adaptive (e.g., resilience-related or self-efficacy) beliefs readily available in their network, such as the belief that they are able to deal

with negative events, may easily update negative trauma-related predictions, preventing the development of PTSD. In contrast, people with highly generative maladaptive beliefs (Ellis et al., 2017), such as the belief that they are unable to deal well with negative events and should avoid stimuli or thoughts related to such events, may predict they will respond to the negative events with avoidance. These people will have more difficulty updating predictions about the likeliness of the traumatic event reoccurring, leading to PTSD symptoms (Figure 1). Notably, these maladaptive beliefs may also promote etiology of other disorders such as depression and anxiety, given the role of highly generative maladaptive beliefs (e.g., of low self-confidence or worthlessness) in a person's network that may also underlie these types of disorders (Beck & Bredemeier, 2016). This might explain the high rate of comorbidity with PTSD (Brady et al., 2012).

The GDPP perspective provides a new view on how PTSD arises and develops. It extends the original AIP model idea that the issue lies in memories stored in distinct modules but indicates that these memories are not necessarily stored in a maladaptive (associative) format that precludes rational processing (Shapiro, 2018). Instead, the processes underlying PTSD can be seen as rational in the sense that they logically stem from the belief-based mechanisms that underlie all inferential processing. The often observed dissociations between verbal report (e.g., that one is not guilty, that the trauma is unlikely to re-occur) and feelings (e.g., feeling guilty, feeling anxious about the event re-occurring) that might seem irrational can be explained in reference to the contextual retrieval of beliefs related to current goals (rather than in reference to dissociative processes and systems: Shapiro, 2018). For instance, contextual cues may lead to trauma-related beliefs that are automatically retrieved and integrated in predictions about unwanted outcomes (e.g., giving rise to anxious feelings) even if they contrast with more adaptive beliefs that are activated when asked to think about the likelihood of the trauma reoccurring.

A GDPP perspective to EMDR. How might EMDR treatment achieve its effects on PTSD

symptoms? The GDPP perspective can be used to take a new look at the processes underlying EMDR treatment effects. We first discuss desensitization, eye movements, and reprocessing and then assess the role of generalization in EMDR.

Desensitization in EMDR treatment. During EMDR Phase 3-4 (assessment and desensitization), the client is asked to think of aspects of the traumatic event (e.g., visual information, feelings, or thoughts) while eye movements are evoked. At the mental level, thinking about the traumatic event while in a (safe) clinical setting can lead to prediction error when maladaptive feelings (e.g., fear) and responses (e.g., avoidance) are predicted but they are not present as predicted. This prediction error can lead to updating of predictions of PTSD symptoms (e.g., fear and avoidance) and trauma-related beliefs (Sinclair & Barense, 2019). For instance, when recalling the event, clients may learn to predict that they do not need to avoid the CS to be safe and that they do not always avoid the CS but are able to successfully confront the event. These updated predictions can then generalize to real life cues (CSs) and contexts (if they are transmitted to a higher hierarchical module – see Generalization in EMDR).

Note that effects of exposure-based treatments (and of specific CBT treatments) can be explained in a similar manner (and the procedural similarity may explain why they can have similar effects: Cusack et al., 2016). However, exposure-based therapy protocols typically prescribe that clients should be asked to recall the traumatic event and stay focused on the details of this event, whereas, in EMDR protocols, clients are asked to recall the traumatic event and note any thoughts they might have, even if they seem irrelevant. The fact that the client is allowed to wander off (and also to make eye movements) could help reduce avoidance responses because it may facilitate a feeling of safety (leading to prediction error) and reduce strong focus on the traumatic event (leading to more flexible integration of trauma-related and other beliefs) (Chamberlin, 2019). Notably, this explanation contrasts with dominant associative perspectives of exposure therapy effects, which argue that a strong

focus on the CS is crucial for positive therapy outcome because this leads to changes in CS-US associations (e.g., Craske et al., 2014). Note that EMDR and exposure-based therapy are comparable in their approach (Salkovskis, 2002; see Schubert & Lee, 2009, for an explanation of their critical differences) but EMDR therapy includes additional components such as eye movements (or dual attention techniques) but also installation of positive cognitions or discussing a future template. These additional components may further foster belief in treatment effectiveness compared to exposure-based therapy which might explain why it is more effective to receive EMDR therapy after exposure-based therapy rather than vice versa (Van Minnen et al., 2020).

Eye movements in EMDR treatment. While there are many procedural differences between EMDR and other (e.g., exposure-based) therapies, the most notable is of course the fact that (during the desensitization phase) eye movements are evoked (but note that recently alternative dual attention techniques are also sometimes used). While there has been much research on the effects of eye movements, there is still some controversy surrounding these effects with some studies suggesting that eye movements have an important treatment effect (Lee & Cuijpers, 2012) but others do not. For instance, Cuijpers et al. (2020) looked at 10 dismantling studies that compared EMDR treatment with and without eye movements and found no differences in treatment outcomes. Many findings (see van den Hout & Engelhard, 2012) provide support for a memory model which assumes that eye movements tax working memory such that target memories are reconsolidated as less vivid during eye movements in EMDR treatment (Andrade et al., 1997). In support of this idea, it is often found that, just as eye movements, other tasks that tax working memory while exposing people to negative (or positive) memories ("dual-task" interventions) reduce the vividness and emotionality of these memories and can influence treatment effects (Mertens et al., 2020; Sack et al., 2016).

From a GDPP perspective, performing eye movements but also other (working memory) tasks during trauma recollection directs the retrieval of information in line with the goal to do these tasks.

On the one hand, this can lead to the activation of specific beliefs such as placebo beliefs about the expected outcome of eye movements (Bernstein & Brown, 2018) or about being relaxed (or distracted) when thinking about the trauma (Chamberlin, 2019). These beliefs can then be integrated with activated trauma-related beliefs and relevant predictions can be updated. For instance, there might be prediction error related to the activated belief that one cannot deal with thoughts about the trauma, leading one to now predict being able to think about the event while feeling safe and feeling in control. On the other hand, performing a different task while thinking about the traumatic event may reduce the relative precision of trauma-related predictions, which allows for more flexibility when integrating beliefs with other (adaptive) beliefs (e.g., related to therapy goals). Note that, from this perspective, effects are not necessarily due to limited working memory capacity (as proposed in the memory model). This could explain why memory load is not a clear moderator of dual-task effects (Mertens et al., 2020) and why some tasks (e.g., merely presenting auditory sounds or beeps) are less effective than performing eye movements (van den Hout et al., 2011).

Reprocessing in EMDR treatment. During EMDR Phase 4 (desensitization), beliefs that give rise to maladaptive predictions can thus be put to the test and become "reprocessed". When relevant negative beliefs are identified, these can be falsified in light of the current safe situation (e.g., the belief that the stimulus leads to negative events or that hypervigilance to the stimulus is beneficial). This belief evaluation can lead to the integration of trauma-related beliefs with (adaptive) beliefs from other modules and generate adaptive predictions. During EMDR Phase 5 (installation), the therapist further refers the client to adaptive beliefs (e.g., that they are able to cope with unwanted thoughts or situations) which can elicit prediction error that can be solved by updating maladaptive predictions. As also noted in the AIP model, here EMDR treatment may thus stimulate the learning of more adaptive information in relation to the traumatic memory (Solomon & Shapiro, 2008). The AIP model refers to updating of negative cognitions, which are sometimes defined as 'the negative self-statement associated with the

event' (Shapiro, 2018, pp. 125). Following the GDPP perspective, a broader perspective on negative cognition might be useful, as the self-relatedness of beliefs is not crucial but rather that the updating involves beliefs that contain information that is incompatible with wanted outcomes. A person's belief network, resulting from their learning history, can be very different from that of others (which might explain the high variability in treatment effects: Cuijpers et al., 2020) and this can be taken into account by identifying personally relevant beliefs to target during treatment.

Notably, in the AIP model, it is often assumed that an information processing system is activated (due to eye movements) that facilitates integration with adaptive cognitions via associative learning. This idea can be updated in accordance with the GDPP perspective, such that adaptive integration depends on the extent to which the intervention context evokes prediction error that facilitates more adaptive beliefs and predictions. Here it can be important that the therapeutic context presents evidence that allows the client to build adaptive predictions in the zone of proximal development (i.e., they should be sufficiently consistent with a person's current network) to facilitate updating of predictions based on entropy principles. For some clients, belief revision that alleviates symptoms will therefore be much slower than for others and require many steps. Note that this belief revision may depend on the extent to which one feels safe and able to discuss (and integrate) relevant beliefs in a flexible manner, highlighting the importance of the therapeutic relationship (Hase, 2021).

Generalization in EMDR treatment. Generalization is a crucial goal of therapy and we believe that it should therefore be given more attention in (EMDR) therapy. By default, newly learned predictions (of reduced symptoms) are context-dependent and adaptive predictions might therefore not generalize to situations outside of the therapeutic context. To achieve generalization, it may be crucial that the updated beliefs and inferences are discussed and practiced (such that participants readily apply them). In EMDR (Phase 5-6: installation and body scan), clients are encouraged to infer that they are now clear of negative PTSD symptoms in general. This may facilitate transmission of prediction error

to higher hierarchical levels of the PP network and promote predictions that go beyond the current situation, such as predictions that symptoms will be less likely to occur also outside of the clinical setting. In this regard, it also seems beneficial to use the future template of the EMDR protocol which asks the client to go over important risk situations and imagine them taking desired action.

Summary. The GDPP perspective on EMDR treatment effects draws on general cognitive theories in the field, most notably PP theories (Clark, 2013) and goal-directed theories (of fear learning: e.g., Boddez et al., 2020). It aligns well with the AIP model to the extent that EMDR treatment is thought to foster the integration of trauma-related information with more adaptive information. However, an important update to the AIP model might involve that relevant beliefs and predictions (rather than associations) are seen as the main target of therapy (placing the focus on belief updating rather than pairing of events to foster association formation) with additional explanation of how this may lead to change in PTSD symptoms. Specifically, changes arise as a result of prediction errors that promote integration of traumatic information with (new) adaptive information that is sufficiently consistent with the client's belief network. Therapy effectiveness may then depend on the extent to which clients learn to predict reduction in their symptoms and represent these predictions at higher hierarchical levels to foster changes in behavior outside of the therapeutic context. From this perspective, change in adaptive, generalizable predictions of symptom reduction and belief in positive therapy outcome are based on prediction error reduction principles, and central to treatment effectiveness.

Recommendations for clinical practice

Taking a GDPP perspective on PTSD and EMDR effects allows one to formulate novel predictions about how treatment effectiveness can be increased. While it is crucial to test predictions in controlled research, we also think there is value in outlining these predictions to inform clinical practice and improve education (in reference to the AIP model). In the GDPP perspective, the key

determinant of treatment success is the extent to which a client learns to predict EMDR treatment efficacy. The EMDR protocol includes techniques that can be used to achieve this but much is left up to the therapist and some recommendations may steer therapists in a different direction. Here we describe recommendations to foster improved treatment outcomes for different EMDR stages that we hope can aid EMDR therapists who do not find sufficient guidance in the current EMDR protocol.

Recommendation 1: Evoke prediction error between the current and wanted state. In the GDPP perspective, treatment effectiveness is a product of the adaptive updating of predictions on the basis of prediction error minimization. Building on findings from other fields of psychological research (e.g., Van Dessel et al., 2019; Vermeir et al., 2020), we argue that the formation of new (more adaptive) beliefs relies on (momentary) goals. Accordingly, in EMDR Phase 1 (history taking and therapy planning) a therapist may work towards the simulation of a clear treatment goal to evoke prediction error between the current state and the wanted future state and facilitate (goal-directed) updating of predictions. This could be achieved by asking the client to describe in detail what they want from the EMDR therapy, what this would look like or how they would feel, behave and think, or by letting the client close their eyes and use imagination to 'see' desired treatment outcomes as vividly as possible.

Recommendation 2: Point out the credibility of belief updating. When wanted treatment outcomes have been discussed, the therapist may promote the client's prediction that the outcome will come true. In EMDR Phase 2 (Preparation), this could be established by explaining how EMDR can achieve its effects and what has worked in sessions with other clients. Therapists should aim to persuade clients to search for wanted outcomes they can believe in (taking one step at a time). They can also explain the possible role of beliefs and automatic inferences in how we feel and act and point out that changing them to become more in control of their symptoms is entirely feasible when following specific procedures. The aim here can be that clients learn to infer that they will be able to update their beliefs and can go on to achieve the wanted treatment outcome.

Recommendation 3: Nudge adaptive inferences. Merely providing information is often ineffective for changing maladaptive behavior, thoughts, or feelings (Marteau, 2018). In the GDPP perspective, this is understandable given the difference between consciously reported beliefs and the automatic prediction of an impact of these beliefs on behavior, thoughts, or feelings. It might therefore be important that clients "self-generate" inferences in-line with adaptive beliefs to increase the generative nature of these beliefs. 'Letting things come from the client' is already an important recommendation in current EMDR protocols. However, the client should not be left on its own as they require information that allows them to generate adaptive inferences. Therapists can help a client by selecting adaptive inferences that are important and feasible (phrase banks can be used but clients can also come up with adaptive cognitions themselves) and providing relevant information or situations that foster these inferences (a technique called inference nudging: Van Dessel et al., 2021). For instance, a therapist can ask about personal experiences that promote the client's inference that they are able to flexibly change their behavior (e.g., in reference to the positive cognition component of the EMDR protocol). Similarly, cognitive interweaves can be a useful instrument to evoke prediction error during desensitization. When the client gets 'stuck' in a loop of thoughts, the therapist can ask a question to evoke a response that facilitates adaptive processing, for example by using humor or engaging in Socratic dialogue (which essentially nudges the client to make self-generated inferences). One can draw out adaptive predictions and draw attention to them, nudging the client to re-use these predictions and make the underlying beliefs more generative.

Recommendation 4: Note incompatibility between PTSD symptoms and key beliefs and goals. To achieve treatment success, clients should update the predictions that underlie PTSD symptoms (e.g., predictions that they will avoid and fear cars). During Phases 3-4, the therapist may nudge a client to infer incompatibility between PTSD symptoms and the client's internal models (e.g., core beliefs and goals). For example, clients might first be informed that their symptoms depend on automatic

predictions that are supported by maladaptive beliefs. Next, techniques can be used (e.g., cognitive diffusion: Masuda et al., 2004) to promote the inference that these beliefs prevent achievement of important goals and contrast with other relevant beliefs. This evokes prediction error which can lead to belief updating (cf. 'metacognitive therapies' where clients think about their maladaptive mental processes to facilitate change: Wells, 2009).

Recommendation 5: Facilitate integration of trauma-related and adaptive beliefs. To allow more adaptive predictions, it is important to draw out adaptive beliefs and inferences, which is difficult when clients focus only on the trauma. It can therefore be useful to instruct the client to think of 'anything they want' and to induce eye movements or other dual tasks (utility of tasks can differ between clients). If the client gets stuck in the trauma-module (during a 'loop' with high focus on the precision of maladaptive beliefs which lives little room for flexible updating), the therapist can try to guide the client away by asking questions that allow him or her to 'wander off' (e.g.: 'can you think of any other moment in life that you felt fearful and you managed to stand up'?). This approach fits with the standard EMDR protocol and with some PTSD-therapies for complex trauma that focus on more than the traumatic memories (e.g., Narrative Exposure Therapy). However, keeping a focus on evoking prediction error may aid the therapist to better guide this process to promote integration of beliefs and establish relevant predictions.

Recommendation 6: Practice adaptive inferences and predictions. PTSD clients often report 'knowing' certain things, but when it comes to it, they cannot act upon them. Here the beliefs are consciously reported but do not generate relevant automatic predictions. Therapeutic techniques (e.g.: arrow down technique) might help to change this and therapists can attempt to promote application of adaptive predictions and highlight when the client acted upon an adaptive prediction (facilitating that clients will repeat doing so as they now predict this). The therapist might set up a situation in which the client is likely to make adaptive predictions (e.g., that they do not avoid trauma-associated stimuli)

and have the client practice this repeatedly to facilitate automatic adaptive predictions (in different contexts) (see Wiers et al., 2020, for a discussion of new 'inference training' interventions that have this aim). One could also use imagery or ask the client to imagine acting upon adaptive predictions in their everyday situations to enable adaptive predictions that are as generally applicable as possible. As noted above, the predictions should be self-generated and the therapist can't force this upon them. The therapist should mainly take on the role of evoking and highlighting adaptive predictions (in the zone of proximal development) and setting up environments to practice application of these new predictions (e.g., by giving exercises during clinical sessions such as in the future template part of the EMDR protocol, and by providing homework – with positive expected value).

Concluding remarks

Explaining PTSD and effects of EMDR therapy through the lens of associative theorizing has important limitations. We therefore discussed a new (GDPP) framework that draws on inferential processes inspired by predictive processing and goal-directed theories and applied this model to PTSD and EMDR therapy. This framework fits well with the AIP model and can be used to update this model and help optimize EMDR treatment protocols and inform new research programs.

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Figures

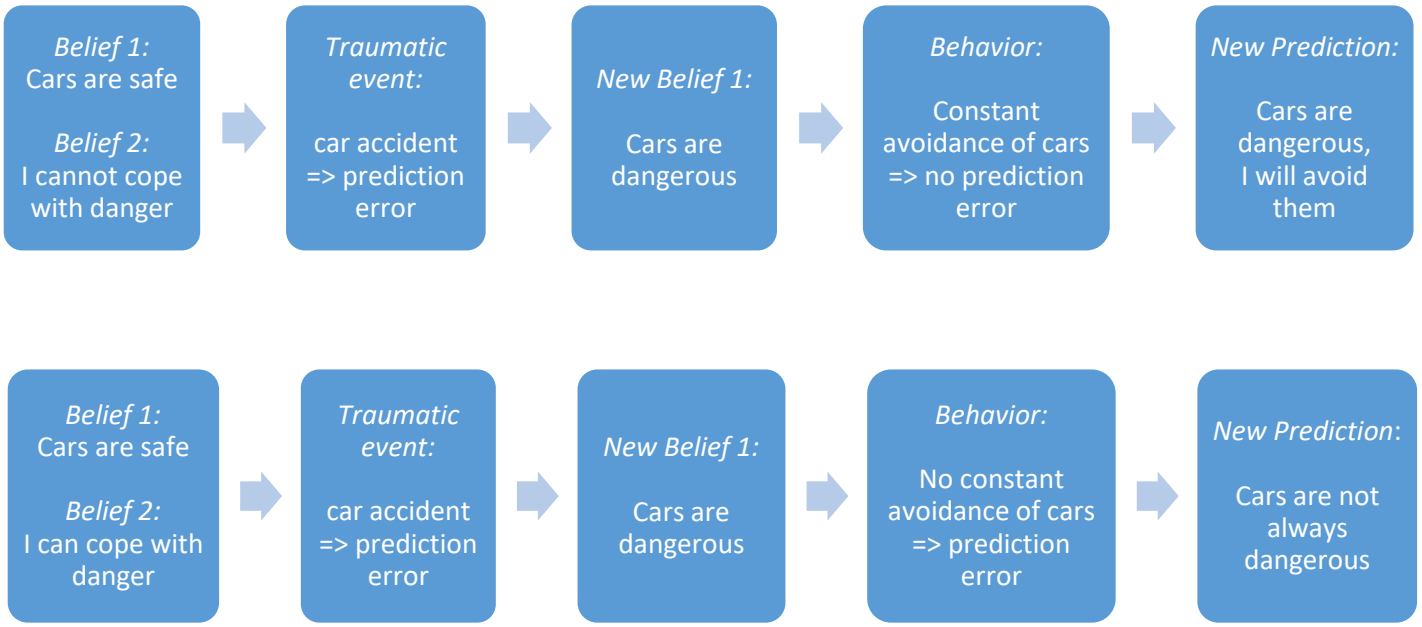

Figure 1. Illustration of the predictions underlying PTSD after trauma in a person with high (top panel) and low risk for PTSD (bottom panel).