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Associations between the misinformation effect, trauma exposure and symptoms of posttraumatic stress disorder and depression

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ABSTRACT

This research aimed to conduct an initial investigation into the relationships between the "misinformation effect" and trauma exposure, posttraumatic stress disorder (PTSD) and depression. Study 1 was a pilot study developing an online misinformation paradigm that could assess the influence of emotion and arousal on memory distortions. Participants (n = 162, M_{age} = 39.90; SD = 10.90) were recruited through TurkPrime. In Study 2 community members (n = 116, M_{age} = 28.96; SD = 10.33) completed this misinformation paradigm and measures of trauma exposure, PTSD, and depression. Study 1 found memory for central details was better for high-arousal than low-arousal and neutral-arousal images. Peripheral memory appeared worse for negative and neutral images than positive images. Study 2 found trauma exposure and PTSD symptoms predicted the misinformation effect; greater trauma exposure was associated with a greater proportion of errors, while PTSD was associated with a lower proportion of errors. Valence and arousal did not influence these associations. These findings have important implications in clinical and legal contexts where individuals with a history of trauma, or who are experiencing symptoms of PTSD or depression, are often required to recall emotionally-laden events. There is a surprising dearth of research into the misinformation effect in clinical populations and further research is required.

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KEYWORDS
Witness memory; misinformation; posttraumatic stress disorder; depression; suggestibility

Posttraumatic stress disorder (PTSD) and depression are characterised by disrupted autobiographical memory. PTSD sufferers display disruptions and distortions in their remembering of the trauma and in their remembering of personal events (e.g., Brewin, 2011; Jobson et al., 2014; Williams et al., 2007). Similarly, depression is associated with significant distortions and biases in autobiographical memory, including increased retrieval of negative memories (Leppänen, 2006), intrusive memories (Mihailova & Jobson, 2018), and categorical recollections (Jobson et al., 2018; Williams et al., 2007). While substantial research has focused on autobiographical memory in PTSD and depression, few studies have explored false remembering – that is, the extent to which individuals remember events differently from the way that they occurred (Otgaar et al., 2017). The dearth of research on PTSD, depression and false memories is somewhat surprising given that memory disruptions associated with PTSD and depression are likely to extend to false remembering (Otgaar et al., 2017). Is PTSD and depression associated with an increased susceptibility to false memories of negative or emotionally-related events? The current research aimed to answer this question.

Memory distortions can be broadly categorised into one of two types: *spontaneous false memories*, which can occur without any external pressure, and *suggestion-induced false memories*, which are formed by suggestive pressure (Otgaar et al., 2017). Accumulating research has focused almost solely on spontaneous false memories in PTSD and depression. These studies have predominantly used the Deese-Roediger-McDermott paradigm (DRM, Deese, 1959; Roediger & McDermott, 1995), an experimental paradigm in which participants are instructed to remember lists of semantically related words (e.g., awake, bed, rest), which are also semantically related to a non-presented target word (e.g., sleep), the "critical lure". After studying these lists, participants' memories for the lists are tested and participants often falsely recognise or recall the critical lure. Spontaneous false remembering has been accounted for by errors and deficits in

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source-monitoring (Johnson et al., 1993), fuzzy trace theory (Brainerd et al., 2008), and activation monitoring theory (Roediger et al., 2001, see also Otgaar et al. for an overview).

Those who have experienced trauma, in particular those with PTSD, are prone to falsely recalling or recognising verbal and visual critical lures at a higher rate than non-trauma-exposed healthy controls (Bremner et al., 2000; Zoellner et al., 2000). For those with PTSD, these effects appear to be stronger when the lists are trauma-related (Brennen et al., 2007; Goodman et al., 2011; Moradi et al., 2015), suggesting that individuals with PTSD have specific impairments in trauma-related source monitoring (Moradi et al., 2015). However, not all researchers have found increased spontaneous false memories in PTSD, especially when the to-be-remembered material is non-trauma related (Hauschildt et al., 2012; Jelinek et al., 2009). Patients with depression also have elevated spontaneous false memories for emotionally charged words, especially depression-relevant words, compared to healthy control participants (Howe & Malone, 2011; Joormann et al., 2009; Moritz et al., 2005; Yeh & Hua, 2009). A recent systematic review and meta-analysis revealed that trauma history, PTSD and depression were associated with increased susceptibility to spontaneous false memory, but only when the stimuli were negative or disorder-related (Otgaar et al., 2017).

Otgaar et al. (2017) account for the heightened rate of spontaneous false memory in PTSD and depression by positing that associative activation is a key mechanism underpinning both false memory and these two psychological disorders. According to associative activation, memories are stored in complex networks of interconnected nodes, and false memories occur when concepts (e.g., “sleep”) that were not contained in the original event (e.g., the list of words: “awake, bed, rest”) are activated by the original event (Otgaar et al., 2017; Roediger et al., 2001). In the instance of PTSD and depression, basic activation levels are already prone to processing emotionally-related information (Ehlers & Clark, 2000; Foa et al., 1989; Foa & Kozak, 1986) and network model interpretations suggest that symptoms are causally linked to other symptoms, including memory-related symptoms (i.e., semantic and phonological information, memories of related adverse past experiences and associated emotions; see Fried & Cramer, 2017; Otgaar et al., 2017). Therefore, Otgaar and colleagues suggest that those suffering from PTSD or depression automatically and swiftly activate associative networks when confronted with emotional stimuli and experiences that align with their disorders. Consequently, this rapid, automatic activation results in an increased likelihood of generating false memories for emotional material (see Otgaar et al., 2017).

While there is growing consensus that trauma exposure, PTSD and depression are associated with increased spontaneous false memory, especially for emotionally charged stimuli, no research – as far as we are aware – has explored the effect of suggestive influences on false memory development in these disorders (Otgaar et al., 2017). This is important because spontaneous and suggestion-induced false remembering are not always related (e.g., Calvillo & Parong, 2016; Ost et al., 2013) and researchers have claimed that those with psychopathology may be particularly susceptible to suggestion-induced false remembering (Scoboria et al., 2017). Otgaar et al. (2017) have highlighted an urgent need for research investigating suggestion-induced false memories and psychopathology, as suggestibility has relevance in clinical and legal settings. In clinical settings, many popular treatment techniques focus on asking clients to provide past memories (often trauma-related) which creates opportunities for suggestive prompts and memories to change (Lindsay et al., 2004; Otgaar et al., 2017). It also has relevance in legal settings, such as police investigations and court hearings, as those providing evidence are often victims of trauma and experiencing symptoms of PTSD and depression (Otgaar et al., 2017).

The aim of the current research, therefore, was to conduct an initial investigation into the relationship between suggestion-based false memory and trauma exposure, PTSD and depression. Suggestion-based false memory is commonly investigated using the misinformation paradigm (Loftus, 2005; Loftus et al., 1978). Participants are presented with scenes, and following a delay, they are exposed to misinformation about the details in the scenes (e.g., “What did the man in the red car do when he saw the policeman coming?” when the car was silver). Finally, participants’ memories for the original scenes are tested allowing researchers to assess whether participants incorporate the misleading post-event information into their memory reports (the *misinformation effect*). We present two studies using a variant of this paradigm. In Study 1, we aimed to develop and pilot a misinformation procedure for testing the influence of emotion and arousal on memory distortions. In Study 2, we aimed to investigate the association between the misinformation effect, trauma exposure, PTSD symptoms and depression symptoms using the procedure developed in Study 1. Based on the associative activation mechanisms outlined above, we hypothesised that trauma exposure, PTSD symptoms and depression symptoms would be associated with greater susceptibility to suggestion-induced false memories, especially for emotion-related material (Otgaar et al., 2017).

Study 1

Following an extensive review of the misinformation literature, we decided to adapt the misinformation procedure used by Van Damme and Smets (2014) which combines rich visual stimuli (photographic images) with a simple three-part procedure. First, participants view a series of images from the International Affective Picture System (IAPS; Lang et al., 2008) that differ on emotion and arousal ratings. The participants describe the content of each image out loud for 30 s. Two images are positive, one with high and one with low arousal ratings. Two images are negative, again, one with high and one with low arousal ratings. Two images are neutral, one with low arousal and one with average arousal. Second, participants answer either four misleading or four non-misleading (control) questions about central and peripheral events depicted in the images. Previous research has shown that participants may be more likely to incorporate misleading information about central details in negative events than in positive events, but the same pattern does not hold for peripheral details (e.g., Porter et al., 2003, 2010). Finally, participants' memories for the details in the images are tested. Once the procedure is over, participants complete a manipulation check in which they rate each image on valence and arousal using the Self-Assessment Manikin (SAM, Bradley & Lang, 1994).

For the current study, we made four substantial modifications to Van Damme and Smets (2014) procedure to enhance the robustness of the paradigm. First, to maximise statistical power and control, we converted the procedure from a mixed-design to a completely within-participants design, and we doubled the number of critical test items from 4 to 8 items. Second, we collected participants' arousal and valence ratings using the Affective Slider (Betella & Verschure, 2016) rather than the SAM. The Affective Slider is equivalent to the SAM in the self-assessment of arousal and pleasure but has the added advantages of not requiring written instructions and can be easily used on digital devices. Third, we did not ask our participants to describe the events depicted in the photographs out loud because it could alter the way they would naturally attend to and encode the scene. Finally, we adapted all parts of Van Damme and Smets' paradigm to make it suitable for online rather than in-person testing.

Method

Design

The study was pre-registered (https://aspredicted.org/ug6zf.pdf). The design was a 6 (Image type: positive valence + low arousal; positive valence + high arousal; negative valence + low arousal; negative valence + high arousal; neutral valence + low arousal; neutral valence + average arousal) × 2 (Item type: misled, control) × 2 (Information type: central, peripheral) design, with all factors being within-participants.

Participants

To determine our target size, we used G*Power 3.1 and $f = .20$ ($f = .40$ reported by Van Damme & Smets, 2014), with an alpha of .05 and power of 80%. The required sample for a repeated within-factors ANOVA was 36 people. In line with sample size recommendations for complex interactions, we quadrupled this overall n to adequately power the simple effects tests (Giner-Sorolla, 2020; Heo & Leon, 2009), thus our target became $N = 144$. We expected a non-compliance rate of approximately 15% so aimed to collect data from at least 166 people so we could meet our target sample size even after excluding participants who fell within our exclusion criteria. Participants were excluded if they: were aged under 18 years or over 65 years; self-reported their vision as being "very poor" or "poor"; self-reported as having a colour-vision deficiency; self-reported any technical difficulties viewing the photos; scored 3SD above/below the mean in the memory test on the control items; and provided an inaccurate or nonsensical response to the question "Please briefly describe the tasks you were asked to complete in this study".

We used TurkPrime (Litman et al., 2017) to recruit adults from Canada, the United Kingdom and the United States on Amazon's Mechanical Turk platform. Participants received $1.50 for completing the study. In total, 167 people completed the study, of which, we excluded five participants from the analyses according to the following exclusion criteria: self-reported "poor" vision ($n = 2$), an inadequate response to the question assessing task description ($n = 2$), and technical difficulty in completing the task ($n = 1$). The final sample consisted of 162 adults ($M = 39.9$; $SD = 10.9$, range = 19–64 years, 44% women). No participants reported a colour-vision deficiency.

Materials

Images. The image stimuli were identical to those used by Van Damme and Smets (2014); six colour photographs that systematically differ in valence and arousal, all drawn from the *IAPS* (Lang et al., 2008). As outlined in Van Damme and Smets, stimuli were selected from the IAPS if the image contained people and depicted a clear, visible background, and was within their six categories (positive pictures with high arousal, positive pictures with low arousal, negative pictures with high arousal, negative pictures with low arousal, neutral pictures with low arousal, and neutral pictures with average arousal). Van Damme and Smets then selected one picture from each of the first four categories to maximise differences in both valence and arousal, while ensuring that the pictures were approximately matched on both dimensions (i.e., positive and negative images were matched on arousal, and pictures with low and high arousal were matched on valence). The researchers calculated the average valence and arousal of the four selected images and a neutral image was chosen to match these values. Finally, they selected the neutral picture with a similar arousal level as the two low-arousal pictures. Table 1 provides details of the selected images, including a brief description, the IAPS number, and mean IAPS valence and arousal ratings.

Critical items. We used a similar approach to Van Damme and Smets (2014) to select critical items and to distinguish between central and peripheral details in the images. Guided by research on the emotional "core" of

Table 1. Characteristics of the six emotional images.

Image description	Image abbreviation	IAPS number	IAPS valence	IAPS arousal	Current study valence rating	Current study arousal rating
Family	PosLow	2360	7.70	3.66	7.46 [7.08, 7.84]	4.83 [4.41, 5.25]
Rollercoaster	PosHigh	8490	7.20	6.68	7.97 [7.59, 8.35]	7.81 [7.42, 8.20]
Cemetery	NegLow	9220	2.06	4.00	1.54 [1.25, 1.83]	3.18 [2.74, 3.62]
Soldiers	NegHigh	9163	2.10	6.53	1.02 [0.76, 1.27]	5.74 [5.12, 6.36]
Man smoking	NeutLow	2749	5.04	3.76	4.68 [4.28, 5.08]	3.74 [3.34, 4.15]
Boxer	NeutAve	8232	5.07	5.10	3.71 [3.28, 4.14]	5.56 [5.09, 6.04]

Note: Mean ratings provided with 95% confidence intervals in brackets. PosLow = positive valence, low arousal; PosHigh = positive valence, high arousal; NegLow = negative valence, low arousal; NegHigh = negative valence, high arousal; NeutLow = neutral valence, low arousal; NeutAve = neutral valence, average arousal. Higher scores refer to more positive valence (happiness) and higher arousal. The IAPS valence and arousal ratings were made on the 9-point Self-Assessment Manikin pictorial scale (Lang et al., 2008), whereas participants in the current study provided valence and arousal ratings on a digital self-report Affective Slider (Betella & Verschure, 2016). To enable comparison to the IAPS ratings, the mean responses on the Affective Slider have been divided by 9.

events (e.g., Kensinger, 2009; Kensinger et al., 2007), we defined central information as the "source of the emotion and all details in the immediate surroundings" (Van Damme & Smets, p.313). Peripheral details were defined as any details that fell outside of this area.[1] We conducted our own pilot study to classify the details in each image. Using the "hotspot" question format within Qualtrics (an online survey platform), we overlaid each image with a 5×7 grid and presented each of the 6 images to an independent sample of 25 adults with the following instructions:

> Click on as many boxes as you need to highlight the area of the photo that is central to the scene. By "central" we mean the area that represents the emotional core of the photo. There are no right or wrong answers. We are interested in which area(s) you think contains the key emotion that the scene evokes.

Respondents had unlimited time to respond. For the analysis, we considered a region to be central if at least 60% of respondents clicked on that region. Between 2 and 4 regions on each image met this criterion. We constructed a loop around the central regions in each image to create an enclosed central area (see Figure 1) which comprised, on average, 22% (range 8%–45%) of the total image.

For each image, we selected 8 critical details, 4 of which were central details (i.e., fell within the central area) and 4 of which were peripheral details (i.e., fell outside the central area). For each critical item, we then created a control (non-misleading) question and a misleading question to be used in the misinformation phase, along with a true/false statement about the critical item to be used in the memory test. For example, for the item "roller coaster name" in the roller coaster image, the control question was, "Could you read the words on the front of the roller coaster?" and the misleading question was, "Could you read the words 'The Titan' on the front of the roller coaster?" (the roller coast was actually called "The Beast"). Participants could respond with "Yes" or "No" on the misinformation phase questions. The memory test question for this item was, "The name of the roller coaster was 'The Beast' (True/False?)". The correct response for the memory test statements was "True" for half of the questions and "False" for the other half. In total, we had 48 control questions, 48 misleading questions, and 48 memory test statements (i.e., 1 of each question type for each critical item). The control and misleading questions, and the memory test, are available on the Open Science Framework (OSF) page for this study, https://osf.io/r9kzp/.

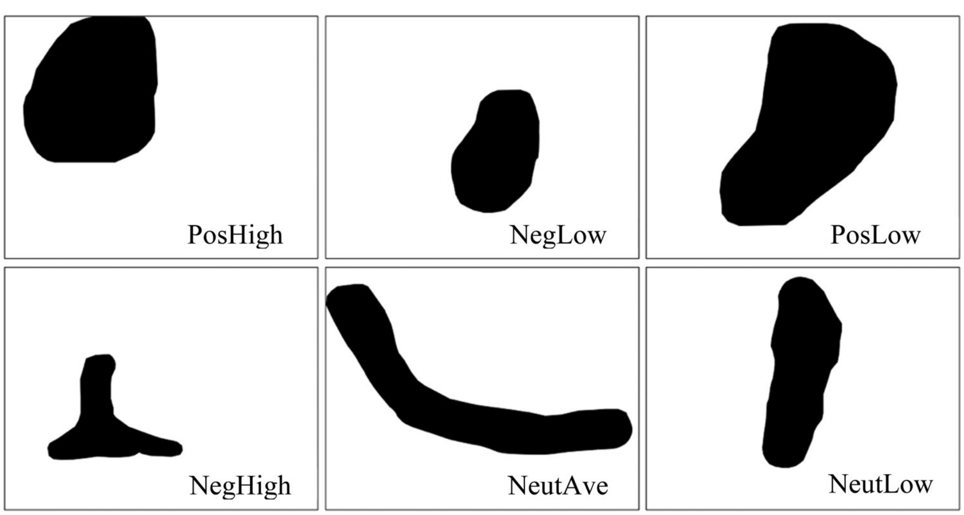

Figure 1. Central regions of each photo.

Procedure

Studies 1 and 2 were approved by the Humanities and Social Sciences Research Ethics Committee at Warwick University (Ref: 158 18–19) and the Human Research Ethics Committee at Monash University (Project number: 19984). The entire study was conducted online and proceeded in three phases.

Phase 1 – viewing images. Participants were informed that the study aimed to investigate how people perceive and describe emotional events. They were asked to provide demographic details and information about their vision (relevant to our exclusion criteria). Next, participants viewed each of the six IAPS images, one-by-one, for 30 s each. The photos were presented in one of two predetermined orders, and participants were randomly assigned to see the first order (PosHigh, NegHigh, NegLow, NeutLow, NeutAve, PosLow) or second order (NeutLow, PosHigh, NeutAve, PosLow, NegLow, NegHigh). Participants were instructed to

> Look at each of the following photos as if you unexpectedly witness the event and imagine that you are describing the event to someone. Please pay close attention to these photos because you will be asked questions about them later.

Participants then completed a 2-minute filler task of solving logic puzzles before completing the Positive and Negative Affect Scale[2] (PANAS, Watson & Clark, 1994). A growing body of research suggests that mood can affect suggestibility so we included the PANAS for exploratory analyses (Forgas et al., 2005; Hess et al., 2012; see Supplemental Material for analyses). Given we used a within-participants design, participants' negative affect was unlikely to account for any trends observed in the memory performance data.

Phase 2 – misinformation task. In Phase 2 we presented participants with misleading information about the details depicted in the six images. Participants were told,

> We will ask you some questions about the photos you viewed earlier. … As this task is about perception, you simply have to respond "yes" or "no" for each question. We will also provide the title of each photo (e.g., "roller coaster") to indicate which image the questions are referring to.

Participants answered eight questions – one for each critical item – about each of the six images they had viewed earlier (48 questions in total). Participants were randomly assigned to one of two sets of questions. We counterbalanced the combinations of item type (central, peripheral), information type (control, misled) and question set so that, across the two sets of questions each central and peripheral item appeared once as a misleading item and once as a control item. For example, for the *roller coaster name* item, half of the participants were asked the misleading question ("Could you read the words 'The Titan' on the front of the roller coaster?") and half were asked the control question ("Could you read the words on the front of the roller coaster?"). The response options were always "yes" or "no". Participants were asked about each image in the same order in which they viewed the images in Phase 1. Participants then completed another 2-minute filler task of logic puzzles.

Phase 3 – memory test. In Phase 3, participants completed a surprise memory test of 48 statements that evaluated their memory for the eight critical details in each of the six images. They were told, "We are testing your memory for these photographs. You will be presented with eight statements for each photo (48 statements in total) and asked to rate them as TRUE or FALSE". For example, the statement for the *roller coaster name* item was, "The name of the roller coaster was 'The Beast'" (True/False?). We created two versions of the memory test, which were identical, except that the sets of statements were presented in the same order in which participants viewed the images. Participants were given the title of each image (e.g., "Roller Coaster") to indicate which image the questions referred to. The memory test was self-paced.

The experiment concluded with a manipulation check: Participants were asked to rate the valence and arousal of each image using the Affective Slider (Betella & Verschure, 2016). Participants were asked to briefly describe the tasks they completed, and to indicate if they experienced any technical difficulties. Finally, they were asked what they thought the true purpose of the study was before viewing a debriefing statement.

Data analysis

Analyses were conducted using IBM SPSS Statistics 26. We calculated the mean proportions of correct responses for central details and peripheral details for each Image type (PosLow, PosHigh, NegLow, NegHigh, NeutLow, NeutAve) by Item type (misled, control). Then to assess memory performance the mean proportions of correct responses were analyzed using a 6 (Image type: PosLow, PosHigh, NegLow, NegHigh, NeutLow, NeutAve) $\times$ 2 (Item type: misled, control) $\times$ 2 (Information type: central, peripheral) repeated measures Analysis of Variance (ANOVA) with all factors within-participants.[3]

Results

Valence and arousal manipulation check

The final two columns in Table 1 show participants' mean valence and arousal ratings for each image (divided by 9 to enable comparisons with the IAPS norms). Participants' ratings aligned well with the IAPS ratings. Two separate within-participants ANOVAs confirmed that the images influenced emotion and arousal in the expected directions. Participants rated the images as significantly different on both arousal, $F(5,\ 805) = 66.23$, $MSE = 536.90$, $p < .001$, $\eta^2 = .29$, and valence, $F(5,\ 161) = 331.20$, $MSE = 335.18$, $p < .001$, $\eta^2 = .67$. The results of all relevant posthoc comparisons were as expected. Arousal was rated significantly higher for high-arousal than for low-arousal images (NegHigh vs NegLow, $t(161) = 8.42$, $p < .001$; PosHigh vs

PosLow, $t(161) = 5.33$, $p < .001$). Valence was rated significantly higher for positive than for negative images (PosLow vs Neg Low, $t(161) = -14.46$, $p < .001$; PosHigh vs NegHigh, $t(161) = 13.04$, $p < .001$). Arousal ratings were significantly higher for the NeutAve than for the NeutLow image, $t(161) = 13.46$, $p < .001$.

Memory performance

Figure 2 shows the mean proportions of correct responses for central details (top panel) and peripheral details (lower panel) for each Image type by Item type (misled, control) (see also Supplemental Table 1). The ANOVA revealed a significant main effect of Item type, $F(1, 161) = 42.80$, $p < .001$, $MSE = 4.76$, $\eta_p^2 = .210$: participants correctly remembered a greater proportion of control items ($M = .69$, 95% CI [0.65, 0.74]) than misled items ($M = .62$, 95% CI [0.58, 0.67]) confirming the expected misinformation effect. Exposure to misinformation led to a memory impairment of 11%, on average.[4]

The analysis also revealed significant main effects of Image type, $F(5, 805) = 30.8$, $p < .001$, $MSE = 3.35$, $\eta_p^2 = .161$, and Information type, $F(1, 161) = 4.92$, $p = .028$, $MSE = .476$, $\eta_p^2 = .030$. These main effects were qualified by a significant interaction between Image Type and Information Type, $F(5, 805) = 15.4$, $p < .001$, $MSE = 1.36$, $\eta_p^2 = .088$. No other interactions were observed.

To clarify how the type of event influenced participants' susceptibility to misinformation, we analyzed the data for central and peripheral details separately. We conducted a 6 (Image type) × 2 (Item type) repeated-measures ANOVA on the proportion of correct responses for central details and for peripheral details.

Central details. For central details, there were significant main effects of both Image type, $F(5, 805) = 27.2$, $p < .001$, $MSE = 2.86$, $\eta_p^2 = .144$ (with mean proportion of correct responses being greater for control items than misled items), and Item type $F(1, 161) = 17.9$, $p < .001$, $MSE = 1.95$, $\eta_p^2 = .100$, but no interaction, $F(5, 805) = 1.35$, $p = .240$, $MSE = .13$, $\eta_p^2 = .008$. This finding suggests that the magnitude of the misinformation effect for central details was similar across all of the images. This finding contrasts with those of Van Damme and Smets (2014) who found a significant misinformation effect only for the images with high arousal or negative valence (i.e., NegHigh, PosHigh and NegLow images).

Follow-up analyses for item type, which included post-hoc comparisons with Bonferroni adjusted confidence intervals, revealed that memory for central details was better for high-arousal images than for low-arousal and neutral-arousal images, regardless of emotional valence. Specifically, participants correctly recalled a high and similar proportion of central details in the PosHigh and NegHigh images ($M_{Diff} = .03$, $t(805) = -1.33$, $p = .552$). They recalled significantly fewer correct central details in all of the other images: PosHigh vs NegLow, $M_{Diff} = .18$, $t(805) = -7.42$, $p < .001$; PosHigh vs NeutLow, $M_{Diff} = .13$, $t(805) = -5.69$, $p < .001$; PosHigh vs NeutAve, $M_{Diff} = .13$, $t(805) = -5.69$, $p < .001$; PosHigh vs PosLow, $M_{Diff} = .15$, $t(805) = -6.06$, $p < .001$; NegHigh vs NegLow, $M_{Diff} = .15$, $t(805) = 6.12$, $p < .001$; NegHigh vs NeutLow, $M_{Diff} = .22$, $t(805) = 8.58$, $p < .001$; NegHigh vs NeutAve, $M_{Diff} = .10$, $t(805) = 4.10$, $p < .001$; and NegHigh vs PosLow, $M_{Diff} = .12$, $t(805) = 4.96$, $p < .001$. The only other significant difference was between the NeutAve and NeutLow images, $M_{Diff} = .12$, $t(805) = 4.03$, $p < .001$.

Peripheral details. For peripheral details, there were significant main effects of both Image type, $F(5, 805) = 20.2$, $p < .001$, $MSE = 1.85$, $\eta_p^2 = .112$ (with mean proportion of correct responses being greater for control items than misled items), and Item type $F(1, 161) = 27.4$, $p < .001$, $MSE = 2.85$, $\eta_p^2 = .146$, but no interaction, $F(5, 805) = 0.62$, $p = .657$, $MSE = .07$, $\eta_p^2 = .004$. This finding suggests that the magnitude of the misinformation effect for peripheral details – like central details – was similar across each of the images.

For follow-up analyses of the image type main effect, post-hoc comparisons with Bonferroni adjusted confidence intervals revealed that participants correctly recalled more peripheral details in the PosHigh image than in any other image: PosHigh vs NegLow, $M_{Diff} = .11$, $t(805) = -5.02$, $p < .001$; PosHigh vs NeutLow, $M_{Diff} = .18$, $t(805) = -7.66$, $p < .001$; PosHigh vs NeutAve, $M_{Diff} = .09$, $t(805) = -3.63$, $p = .003$; PosHigh vs PosLow, $M_{Diff} = .16$, $t(805) = -6.99$, $p < .001$; and PosHigh vs NegLow, $M_{Diff} = .18$, $t(805) = -7.66$, $p < .001$. Participants recalled a similarly low proportion of peripheral details in the NegHigh and NeutLow images, $M_{Diff} = .02$, $t(805) = -0.90$, $p = .738$. Indeed, fewer peripheral details were recalled in the NegHigh image than in the NegLow, $M_{Diff} = .09$, $t(805) = -4.28$, $p < .001$, PosLow, $M_{Diff} = .21$, $t(805) = -8.56$, $p < .001$, and NeutAve, $M_{Diff} = .12$, $t(805) = -5.61$, $p < .001$, images. Also, fewer peripheral details were recalled in the NeutLow image than in the NegLow, $M_{Diff} = .07$, $t(805) = 2.81$, $p < .001$, and NeutAve images, $M_{Diff} = .10$, $t(805) = 3.97$, $p < .001$.

Discussion

Study 1 aimed to pilot a misinformation procedure for testing the influence of emotion and arousal on autobiographical memory distortions. First, we found participant valence and arousal ratings for each image aligned with the IAPS ratings and that the images influenced emotion and arousal in the expected directions. Second, participants correctly remembered a greater proportion of control items than misled items confirming the expected misinformation effect. Third, we found that memory for central details was better for high-arousal images than for low-arousal and neutral-arousal images, regardless of emotional valence. This pattern of results aligns with Van Damme and Smets (2014) findings – they also observed better memory for central details in the high-arousal images than for the low-arousal images. Fourth, we found that peripheral memory appears to be worse for

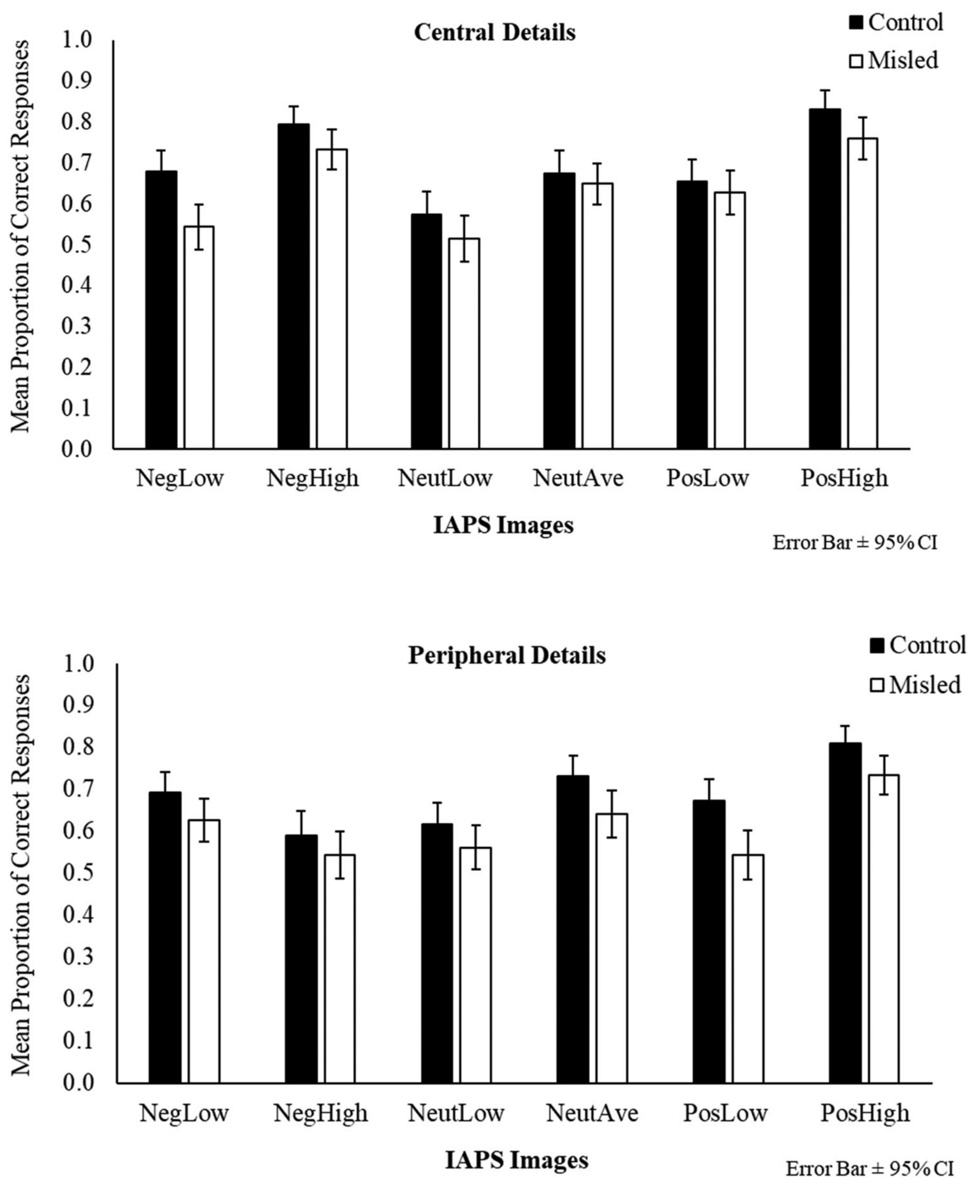

Figure 2. Study 1: mean proportion of correct responses for each image type by item type (control vs. misled) and information type (central details in top panel and peripheral details in lower panel).

negative and neutral events than for positive events, particularly when negative emotion is combined with high arousal. These findings also square well with those of Van Damme and Smets (2014). Therefore, this misinformation paradigm appears appropriate for testing the influence of emotion and arousal on memory distortions.

Study 2

Study 2 examined the relationships between trauma exposure, PTSD symptom severity, and depression symptomatology with susceptibility to the misinformation effect. To this end, we asked participants to complete a set of psychopathology measures before completing the misinformation paradigm used in Study 1. We hypothesised that the misinformation effect would be positively associated with greater trauma exposure (Hypothesis 1), PTSD symptom severity (Hypothesis 2), and depression symptomatology (Hypothesis 3). We also explored whether these associations were influenced by valence and arousal of presented information. While these analyses were somewhat exploratory, we expected that these associations would be stronger for the negative images (particularly negative high arousal) than the positive and neutral images.

Design

The study was pre-registered (https://aspredicted.org/ng2bg.pdf). We employed a correlational cross-sectional design to investigate the associations between the misinformation effect and trauma exposure, PTSD symptoms and depression symptoms. Exploratory analyses included investigating whether these associations differed depending on the valence and arousal of the image type. The materials and the data are available on the OSF page, https://osf.io/r9kzp/.

Participants

We determined our target sample size using G*Power 3.1. Our estimate was based on the regression analysis. We used a small to moderate effect size ($f^2 = .11$) (Otgaar et al., 2017), an alpha of 0.05, and 80% power and estimated that the study required around 104 participants. To obtain a demographically diverse sample, we recruited adult participants in both Australia and in the UK via advertisements placed on social media sites (e.g., Facebook, Gumtree, university online noticeboards). In addition to the exclusion criteria outlined in Study 1, participants were excluded if they only completed Session 1 or completed Session 2 more than one week after Session 1. In total, 144 people completed the study, of which, we excluded 32 participants from the analyses; self-reported "poor" vision ($n = 8$); only completed Session 1 of the study ($n = 13$); completed Session 2 more than one week after Session 1 ($n = 10$); and technical difficulty in completing the task ($n = 1$). Our sample therefore included 112 participants who were aged 18–64 ($M = 29.0$; $SD = 10.3$, 56% women).

Materials

Trauma exposure and PTSD symptoms. We used the Life Events Checklist for DSM-5 (LEC-5) and PTSD Checklist for DSM-5 (PCL-5) (Weathers et al., 2013) to assess trauma exposure and PTSD symptoms. The LEC-5 is a self-report measure used to screen for potentially traumatic events in a participant's lifetime. Participants indicate varying levels of exposure to each type of trauma on 6-point nominal scales (Weathers et al., 2013). We calculated the total number of experiences each participant had endorsed as experienced or witnessed to provide an index of trauma exposure. The PCL-5 is a 20-item self-report measure that assesses PTSD symptoms. A total symptom severity score is obtained from summing scores for each of the 20 items and scores can range from 0 to 80, with higher scores indicating higher levels of PTSD symptom severity. The PCL-5 has good psychometric properties and a cut-off score of 33 is indicative of probable PTSD (Blevins et al., 2015; Weathers et al., 2013). In the current study we found good internal consistency (Cronbach $\alpha = .95$).

Depression. The Hospital Anxiety and Depression Scale (HADS, Zigmond & Snaith, 1983) is a 14-item self-report scale that assesses symptoms of anxiety and depression. Given the focus of the study, we only used data from the Depression subscale. The HADS is a widely used measure to assess the presence and severity of depression symptoms in the community. The scores for depression can range from 0 to 21, with higher scores indicating greater symptom severity. Scores 0–7 represent the non-clinical range, 8–10 represents "borderline clinical" range and scores of 11 or above indicate "clinical concern" (Zigmond & Snaith, 1983). The HADS has good psychometric properties (Bjelland et al., 2002). In the current study internal consistency was good ($\alpha = .80$).

Procedure

Following informed consent, participants completed the online study across two sessions. In Session 1, using the online platform Qualtrics, participants completed the PCL-5, LEC-5 and HADS. In Session 2, which was at least 24 h (but less than a week) after completing Session 1, participants completed the misinformation paradigm, as described in Study 1.

Data analysis

Analyses were conducted using IBM SPSS Statistics 26. Comparison of standardised scores ($Z > \pm 3.29$) identified that there were no univariate outliers. Shapiro-Wilk's test of normality was significant for all variables, indicating non-normal distributions and thus we used bootstrapping (Field, 2013). As in Study 1, we first calculated the proportion of correct responses for each Image type (the six images) by Item type (misled, control). We then calculated the overall mean proportion of correct responses for misled and control items (i.e., averaged across the six images). These totals were used in two linear hierarchical regression models with 5000 bootstrapped samples to assess the ability of trauma exposure (Hypothesis 1), PTSD symptoms (Hypothesis 2) and depression symptoms (Hypothesis 3) in predicting proportion of correct responses on the memory test. We included age and gender in the first block, given age (e.g., Bornstein et al., 2000; Chan et al., 2009; Dodson & Krueger, 2006; Searcy et al., 2001) and gender (e.g., Dewhurst et al., 2012; Nielsen et al., 2013) can influence the misinformation effect. In the second block we included trauma exposure, PTSD symptoms and depression symptoms.

To assess our exploratory analyses, similar linear hierarchical regression models to that outlined above were conducted, but in this instance proportion of correct responses for each image type was the outcome variable (as outlined in Study 1 each image differed in emotion and arousal). Finally, we conducted exploratory clinical analyses. We compared those who met probable PTSD diagnosis on the PCL-5 ($n = 33$) with those who had low levels of PTSD symptomatology (<10 on the PCL-5[5]; $n = 36$) using a 2 (Group; PTSD vs non-PTSD) × 2 (Item type; misled vs control) mixed ANCOVA (with age and gender as covariates). We also planned to compare those who were in the clinical range for depression with those who were in the non-clinical range. However, there were too few participants in the depression clinical range to conduct this analysis.

Results

Sample characteristics

Sample characteristics are presented in Table 2. We found that 33 (29.46%) participants exceeded the PTSD clinical cut-off on the PCL-5. In terms of depression symptomatology, 77 (68.75%) participants were in the normal range; 22 (19.64%) participants were in the borderline range; and 13 (11.61%) participants were in the clinical range.

Memory performance

Summary data for memory performance is presented in Table 2. As in Study 1, participants correctly remembered a greater proportion of control items ($M = .64$, 95%CI[.62, .66]) than misled items ($M = .54$, 95%CI[.52, .57]), again confirming the expected misinformation effect, $t(111) = 7.46$, $p < .001$, 95%CI [.07, .13].

Regarding proportion of correct responses for control items, we found that when age and gender were included the overall model was not significant, $R^2 = .03$, $F(2, 107) = 1.44$, $p = .240$. When PTSD symptoms, depression symptoms and trauma exposure were added to the model, the overall model was still not significant, $R^2\ \Delta = .06$, $F(3, 104) = 2.16$, $p = .097$. We found that PTSD symptoms were uniquely significantly associated with proportion of correct responses on control items, $\beta = -.25$, $SE = .001$, $t = -2.176$ $p = .040$, 95%CI[−.003, −.0001], with greater PTSD symptomatology being associated with a lower proportion of correct responses. Trauma exposure, $\beta = .02$, $SE = .004$, $t = .22$, $p = .825$, 95%CI[−.01, .01], and depression symptoms, $\beta = .01$, $SE = .004$, $t = .12$, $p = .913$, 95%CI[−.01, .01], were not significantly associated with proportion of correct responses on the control items.

Regarding misled items, we found that when age and gender were included the overall model was not significant, $R^2 = .01$, $F(2, 107) = .27$, $p = .767$. When PTSD symptoms, depression symptoms and trauma exposure were added to the model, the overall model was still not significant, $R^2\ \Delta = .03$, $F(3, 104) = .92$, $p = .434$. Contrary to our hypotheses, trauma exposure, $\beta = -.15$, $SE = .01$, $t = -1.42$, $p = .165$, 95%CI[−.02, .003], PTSD symptoms, $\beta = -.03$, $SE = .001$, $t = -.26$, $p = .781$, 95%CI[−.002, .001], and depression symptoms, $\beta = -.02$, $SE = .004$, $t = -.14$, $p = .903$, 95%CI[−.01, .01], were not significantly associated with proportion of correct responses on the misled items.

Table 2. Sample characteristics for Study 2.

Variable	*M* (*SD*)	Range
Age	29.01 (10.54)	18–64
Gender *n* (%)		
Male	42 (37.5%)	–
Female	69 (61.6%)	
Non-binary	1 (0.9%)	
Education *n* (%)		
Secondary	22 (19.6%)	–
Post-secondary	8 (7.1%)	
Undergraduate	57 (50.9%)	
Postgraduate	19 (17.0%)	
Other	6 (5.4%)	
Index trauma		
Accident	29 (25.9%)	–
Natural disaster	6 (5.4%)	
Non-sexual assault	27 (24.1%)	
Sexual assault	12 (10.7%)	
Life-threatening illness	21 (18.8%)	
Unexpected death	14 (12.5%)	
War and conflict	1 (0.9%)	
Other	1 (0.9%)	
Time since trauma – years	6.15 (5.84)	0–22
Trauma exposure	4.43 (2.78)	0–14
PCL-5 – PTSD total	21.95 (19.47)	0–65
Depression	5.36 (3.87)	0–15
Mean proportion correct responses		
Control items	.64 (.12)	.33–.88
Misled items	.54 (.14)	.25–.92
PTSD group control items	.59 (.11)	.33–.75
PTSD group misled items	.52 (.11)	.25–.71
Non-PTSD group control items	.67 (.12)	.42–.88
Non-PTSD group misled items	.53 (.14)	.25–.88

Note: PCL-5 = PTSD Checklist for DSM-5; PTSD = Posttraumatic stress disorder.

Valence and arousal

While we found that trauma exposure significantly predicted correct responses on misled items for the neutral emotion low arousal image (smoking), $\beta = -.24$, $SE = .01$, $t = -2.38$, $p = .018$, 95%CI[−.05, −.01], overall the exploratory hierarchical regression models for each image type found no evidence to indicate that trauma exposure, PTSD symptoms nor depression symptoms predicted the proportion of correct responses on misled items for valenced or high arousal images (see Supplementary Material).

Exploratory clinical analyses

We found that there was a Group × Item Type Interaction,[6] $F(1,65) = 4.20$, $p = .044$ $\eta_p^2 = .06$. The Group main effect was also significant, $F(1,65) = 4.18$, $p = .045$, $\eta_p^2 = .06$, but the Item type main effect was not significant, $F(1,65) = .43$, $p = .513$, $\eta_p^2 = .01$ (see Table 2). Follow-up analyses revealed that the non-PTSD group had a significantly greater proportion of correct responses on the control items than the PTSD group, $F(1,65) = 9.24$, $p = .003$, $\eta_p^2 = .12$. However, the two groups did not differ significantly for the misled items, $F(1,65) = .29$, $p = .594$, $\eta_p^2 = .004$. Both groups did not differ significantly in terms of proportion of correct responses on the control and misled items; PTSD group, $F(1,30) = 1.61$, $p = .214$, $\eta_p^2 = .05$; non-PTSD group, $F(1,33) = 1.53$, $p = .225$, $\eta_p^2 = .04$.

Discussion

Study 2 examined the relationships between trauma exposure, PTSD symptom severity, and depression symptomatology with susceptibility to memory distortions. We found that, when controlling for age and gender, greater PTSD symptoms were associated fewer correct responses on control items. However, contrary to our hypotheses, trauma exposure, PTSD symptoms and depression symptoms were not significantly associated with proportion of correct responses on misled items. When considering each image type, which differed in level of arousal and emotion, we found no evidence that trauma exposure, PTSD symptoms nor depression symptoms predicted proportion of correct responses on valanced or high arousal images. Finally, in terms of our exploratory clinical analyses, we found that those with PTSD reported fewer correct responses on control items than the non-PTSD group, but the two groups did not differ significantly in terms of correct responses on misled items.

General discussion

This research aimed to develop and pilot a misinformation paradigm that could be used to assess the influence of emotion and arousal on memory distortions (Study 1) and to then use this paradigm to examine the relationships between the misinformation effect and trauma exposure, symptoms of PTSD and depression (Study 2). Study 1 found that participants correctly remembered a greater proportion of control items than misled items confirming the expected misinformation effect using this paradigm. Memory for central details was better for high-arousal images than for low-arousal and neutral-arousal images, regardless of emotional valence. Peripheral memory was worse for negative and neutral events than for positive events, particularly when negative emotion was combined with high arousal. Study 2 found that, when controlling for age and gender, PTSD symptoms significantly predicted proportion of correct responses on control items. However, there was no evidence to indicate that trauma exposure, PTSD symptoms nor depression symptoms, were associated with proportion of correct responses on misled items. There was also no evidence to suggest that arousal or valence influenced the associations.

Study 1 demonstrated that the misinformation procedure appeared appropriate for examining the influence of emotion and arousal on memory distortions. Overall our findings replicated the findings of Van Damme and Smets (2014); memory performance was better for central details in high-arousal images than for low-arousal images and peripheral memory appeared worse for negative and neutral events than for positive events. Therefore, it appears that arousal may aid the remembering of central details of an image, while valence influences the remembering of peripheral details.

Study 2 found no support for our hypotheses. While PTSD was associated with fewer correct responses on control items, there was no evidence that trauma exposure, PTSD symptoms nor depression symptoms were associated with proportion of correct responses on misled items. Additionally, we found no evidence to indicate that arousal and valence influenced the associations. Thus, we found no evidence to support the notion that PTSD and depression symptoms are associated with an automatic and swift activation of associative networks, particularly when confronted with emotional stimuli, which in turn increases the likelihood of generating false memories for emotional material (Otgaar et al., 2017). However, the inconsistency of our findings with current theoretical predictions set out by Otgaar et al. (2017) may reflect sample characteristics. Only 29.46% of our sample met probable diagnosis of PTSD and only 11.61% of our sample were in the clinical range for depression. While this number is relatively high for a community sample,[7] it may account for our findings. It may only be within the clinical range in which we see basic activation levels being prone to processing emotionally-related information (Ehlers & Clark, 2000; Foa et al., 1989; Foa & Kozak, 1986), symptoms being causally linked to memory-related symptoms, and automatic and swift activation of associative networks when confronted with emotional stimuli and disorder-aligned experiences (Otgaar et al., 2017).

Additionally, our findings may reflect the lack of personal relevance of the stimuli being used in the study. Theoretically it is proposed that automatic and swift activation of associative networks occur in the contexts of depression and PTSD when individuals encounter emotional stimuli and experiences that align with their disorders (Otgaar et al., 2017). Thus, effects may be observed if the stimuli are more personally-relevant stimuli, such as images of road traffic accidents for those who have experienced a traffic accident. For instance, recent findings indicate heightened spontaneous false memories for accident-related words in motorcyclists when compared to non-motorcyclists (Maulina et al., in press). Related, this study did not investigate potential false memory for the traumatic event itself or indeed trauma images. It is possible that there is something particular about the high emotionality of the trauma event that leads to it being stored in a way that might be open to subsequent distortions (e.g., Nahleen et al., 2021; Strange & Takarangi, 2012). Thus, there may be different aspects of potential "misinformation effects" (i.e., for an index trauma versus subsequent emotional events).

If these PTSD findings are replicable in clinical samples, it may be that while those with PTSD have poorer performance on control items, the increased arousal associated with PTSD may reduce susceptibility to suggestion-induced false memory (i.e., errors on misled items), as found in Study 1. Previous research has demonstrated that high arousal can lead to fewer memory errors than low arousal (e.g., Mirandola & Toffalini, 2016; Van Damme, 2013) and reduces acceptance of misleading information (English & Nielson, 2010). However, the research in this area is mixed, as other studies have found high arousal elicits higher false recall and false recognition (Corson & Verrier, 2007).

Study 2 demonstrates that further research in this area is needed. There is a need for greater theoretical understanding of the misinformation effect in clinical populations. There are also important clinical and forensic reasons to further research in this area (Otgaar et al., 2017). In clinical settings, many evidence-based treatment approaches focus on clients providing past personal memories (often trauma-related and emotional). This creates opportunities for suggestive prompts and memories to change (Lindsay et al., 2004; Otgaar et al., 2017). In legal settings, police investigations and court hearings can provide suggestive influences which can impact memory performance and accuracy (Otgaar et al., 2017). Those providing evidence are often survivors of trauma and experiencing symptoms of PTSD and/or depression. Thus, while there is impressive current understandings of suggestion-induced false memory, the focus of this research has been predominately on healthy community (often student) samples. Given the prevalence of psychopathology, including in legal settings, there is a need to understand how psychopathology influences suggestion-induced false memory in order to guide practitioners and policy.

A potential limitation of the current study is that the effects observed may be fixed to the specific IAPS images that were used. Although efforts were made by Van Damme and Smets (2014), and by us, to systematically control the arousal and emotion the images evoked, and the content of the images, without replicating the observed effects in different stimuli sets we cannot know how well the results will generalise. This is an important question for follow-up research, but we think the procedure presented here (a more robust version of Van Damme and Smets' original paradigm) will be a valuable tool for further research into psychopathology and suggestion-induced false memories. Additionally, as noted above, it is worth noting that the stimuli included in the paradigm did not specifically map onto participants' trauma experiences. Thus, the findings may have differed if the stimuli were personally-relevant to the participants (i.e., images related to traffic accidents are presented to road traffic accident trauma survivors). Finally, the current study investigated the associations between psychopathology and memory distortions in a community sample and psychopathology was assessed using clinical self-report measures. While both the PCL-5 and HADS are routinely used gold-standard self-report measures of PTSD and depression symptomatology, they cannot be used to provide a formal diagnosis. Additionally, only a relatively low number of participants were in the clinically significant range. Thus, further research with is needed to determine whether the findings are generalisable to clinical groups.

Despite these limitations, this research highlighted that arousal and emotion may influence suggestion-induced false memory (Study 1) and while PTSD symptoms significantly predicted proportion of correct responses on control items, there was no evidence to indicate that trauma exposure, PTSD symptoms nor depression symptoms were associated with proportion of correct responses on misled items (Study 2). Importantly, the research clearly demonstrated a need for further research in this area.

Notes

1. Van Damme and Smets (2014) asked five people to draw lines around the central area of each image and then the researchers distinguished between central and peripheral details by calculating the "average central area" of the drawings. Van Damme and Smets do not provide exact details on how this average central area was obtained.
2. Van Damme and Smets (2014) used the Brief Mood Introspection scale (BMIS: Mayer & Gaschke, 1988) to evaluate participants' mood. As they manipulated misinformation and control items between participants, it was important to check that negative affect was similar across their misinformation and control groups. In the current study, we manipulated misinformation and control items within participants to eliminate the risk of confounding the participant's mood with item type.
3. Note: In AsPredicted we outlined that we would use Generalised Estimating Equation for our data analyses. However, following data collection and adapting the approach of Van Damme and Smets (2014), we instead used a 6 (Image type: PosLow, PosHigh, NegLow, NegHigh, NeutLow, NeutAve) × 2 (Item type: misled, control) × 2 (Information type: central, peripheral) repeated measures ANOVA. Also note that it was not possible to factorially split valence and arousal to conduct a 3 (Valence) × 2 (Arousal) × 2 (Item type) × 2 (Information type) ANOVA, because the Boxer image was average arousal whereas all other images were either high or low arousal.
4. 11% was calculated as: proportion correctly remembered control items minus the proportion of correctly remembered misled items, divided by the proportion of correctly remembered control items.
5. This score was selected as it indicated that PTSD symptoms were generally not endorsed by participants. Participants who scored between 10 and 32 on the PCL-5 were excluded as they had sub-threshold symptomatology.
6. When we conducted a 6 (Image type: PosLow, PosHigh, NegLow, NegHigh, NeutLow, NeutAve) × 2 (Item type: misled, control) × 2 (Group: PTSD, non-PTSD) mixed ANCOVA, the only significant finding was the PTSD × Item Type Interaction described in the manuscript.
7. Around 6% of the community have PTSD (National Center for PTSD, 2022) and around 10% of the community have depression (Lim et al., 2018).

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