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Original Article

Does Remembering Cause Forgetting in Chronically Stressed People?

A Study of Ugandan Civil War Refugees With and Without PTSD

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Abstract. People suffering from Posttraumatic Stress Disorder (PTSD) often have reduced episodic memory performance as well as intrusions and flashbacks of traumatic events. Hippocampal and prefrontal dysfunctions are assumed to be responsible. Using a modified retrieval-induced forgetting paradigm, we investigated episodic memory performance in a group of German participants and in civil war victims with and without PTSD in Northern Uganda. Retrieval-induced forgetting is an adaptive mechanism in memory and refers to the fact that retrieval of target elements impairs subsequent recall of related material. Retrieval-induced forgetting depends on medio-temporal and prefrontal functions and acute stress eliminates the effect. Here, using a pictorial retrieval-induced forgetting paradigm, retrieval-induced forgetting was found in a German group, but not in Ugandan refugees, neither in those with nor without PTSD. As both groups were exposed to multiple, often severely traumatic events, stress exposure in both Ugandan groups may account for this finding. Specific to Ugandan refugees with PTSD, an elevated false alarm rate during recognition testing was found, although even refugees without PTSD had higher false alarm rates than the German group. In the civil war victims, stress-induced memory dysfunction may impair hippocampus-mediated contextual binding, eliminating retrieval-induced forgetting and reducing the ability to differentiate between old and new pictures. Traumatic stress may additionally disrupt prefrontal inhibition mechanisms, leading to an inability to suppress false alarms.

Each time we remember an item or event, memory for this item or event is strengthened (Carrier & Pashler, 1992; Hogan & Kintsch, 1971; Roediger & Karpicke, 2006) and the likelihood of its successful future recollection increases. This mechanism is very powerful, has long been known to psychology (Gates, 1917), and is intuitively plausible to the layperson. Less intuitive, however, is the fact that by remembering certain aspects of an episode, other parts of that episode are automatically suppressed, a phenomenon known as retrieval-induced forgetting (e.g., Anderson, Bjork, & Bjork, 1994).

Retrieval-induced forgetting effects have been demonstrated in both free recall (e.g., Amir, Badour, & Freese, 2009; Anderson et al., 1994) and recognition (e.g., Hicks & Starns, 2004; Spitzer, Hanslmayr, Opitz, Mecklinger, & Bäuml, 2009), in classical laboratory experiments with newly learned material (e.g., Ciranni & Shimamura, 1999) as well as with individual emotional autobiographical memories (Barnier, Hung, & Conway, 2004) and even in social situations (Cuc, Koppel, & Hirst, 2007). Social sharing of even very salient memories, such as memories of the 9/11 attacks, has been demonstrated to reduce the availability of related, initially similarly salient memories. This and related findings lend momentum to the hypothesis that retrieval-induced forgetting may play a key role in the construction of collective memories (Coman, Manier, & Hirst, 2009).

Across the life-span retrieval-induced forgetting effects have been found in first and fourth graders (Zellner & Bäuml, 2005), young adults (Anderson, Bjork, & Bjork, 2000), and also in elderly people (Aslan, Bauml, & Pastotter, 2007; Gomez-Ariza, Pelegrina, Lechuga, Suarez, & Bajo, 2009). On a neural level, medio-temporal structures appear critical for retrieval-induced forgetting as the effect is abolished in people with medio-temporal lobe lesions (Conway & Fthenaki, 2003). Moreover, recent neuroimaging studies point to an involvement of prefrontal brain structures (Kuhl, Dudukovic, Kahn, & Wagner, 2007; Wimber, Rutschmann, Greenlee, & Bäuml, 2009). Overall, a growing body of literature shows that retrieval-induced forgetting is a very basic mechanism of human memory control that secures access to selected material and suppresses nonselected competing information.

Although a widely reported mechanism, in some populations retrieval-induced forgetting may not arise. Phenomenologically, patients with Posttraumatic Stress Disorder (PTSD) who suffer from recurrent disturbing memories of traumatic events can be suspected to have deficient

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retrieval-induced forgetting. In these patients, recall of certain, often peripheral, details of an episode instead of suppressing related information, appears to trigger recall of additional elements that the patients experience in the form of flashbacks or intrusive thoughts. Experimentally, recent research has shown that acutely experienced stress disrupts retrieval-induced forgetting in students, the reduction in the retrieval-induced forgetting effect being inversely related to participants' cortisol levels (Koessler, Engler, Riether, & Kissler, 2009).

Dysregulation of the glucocorticoid (e.g., cortisol) and adrenaline releasing hypothalamic-pituitary-adrenergic (HPA) axis is assumed to play a key role in the development and maintenance of PTSD (e.g., see further Yehuda, 2002). Extreme levels of cortisol release during a traumatic event can be neurotoxic to the hippocampus (McEwen, 1999). Reduced hippocampal volumes are assumed to be related to impaired episodic memory, primarily regarding the ability to bind individual details to context cues which is the very ability that retrieval-induced forgetting depends on (Bäuml, 2006). Reduced hippocampal volumes and hippocampal dysfunction have been reported in PTSD, although it is unclear whether these are a consequence of chronic stress or PTSD or a risk factor for its development or perhaps both (cf. Bremner, 2001; Gilbertson et al., 2002; Sapolsky, 2002).

Although perhaps less well investigated than the hippocampus, the prefrontal cortex is also a target site for the effects of stress hormones as it is likewise densely populated with glucocorticoid receptors and indeed several studies indicate prefrontal cortex dysfunctions in PTSD (Koenen et al., 2001; Vasterling, Brailey, Constans, & Sutker, 1998). Prefrontal cortex is assumed to be involved in behavior control functions such as response inhibition and in memory it plays an important role in retrieval monitoring (Henson, Shallice, & Dolan, 1999) which may explain its activation during retrieval-induced forgetting (see above). PTSD patients' higher levels of intrusions during free recall as well as more false alarms in recognition memory tasks have also been related to prefrontal dysfunction (Vasterling et al., 1998).

Retrieval-induced forgetting may be altered in people who have experienced severe traumatic stress for a number of reasons, but only one very recent study has addressed the issue empirically: Amir and colleagues (2009) investigated retrieval-induced forgetting in trauma-exposed North American undergraduates. Three hundred fifty college students were screened for traumatic events and PTSD symptoms. Seventeen of these fulfilled PTSD criteria as reflected by a Posttraumatic Diagnostic Scale (PDS; Foa, Cashman, Jaycox, & Perry, 1997) score of at least 11, and 15 reported at least one traumatic event, but did not fulfill criteria for a diagnosis. Sixteen students reporting neither traumatic events nor PTSD-related symptoms served as the control group. The three groups participated in a typical verbal retrieval-induced forgetting experiment. They learned words belonging to different categories (e.g., Fruit – Banana, Drink – Beer, etc.) and retrieval-practiced some of the words from some of the categories via category plus word stem cued recall (e.g., Fruit – Ba_____). During final recall they were quizzed about all initially learned words by way of a category-name-cued recall (e.g., Drink – _____; Fruit – ____; etc.). Results showed standard retrieval-induced forgetting in the non-traumatized control group with a recall enhancement for the practiced material and recall suppression for the non-practiced items from the practiced categories in comparison to items from never-practiced categories. By contrast, neither of the trauma-exposed groups showed retrieval-induced forgetting. Specifically the PTSD group also showed a smaller benefit from retrieval practice than the other two groups. Thus, this study indicates that American undergraduates with traumatic life events and/or qualifying for a diagnosis of PTSD have altered retrieval-induced forgetting.

Fortunately, most industrialized societies are relatively safe and the likelihood of experiencing traumatic events is comparatively low. However, the more different traumatic events an individual experiences, the more likely is the development of PTSD (Neuner et al., 2004). Consequently, in war-torn societies that suffer from violent conflict, PTSD prevalence is high (Karunakara et al., 2004), posing considerable threats for collective social and cognitive functioning, and perhaps even jeopardizing the formation of consistent and positive collective memories (Coman, Brown, Koppel, & Hirst, 2009). Therefore, the experimental study of relevant cognitive phenomena in non-Western societies and their possible alteration by traumatic stress are needed to scientifically assess the cognitive and ultimately social consequences of violence and trauma.

The present study examined retrieval-induced forgetting in trauma victims with and without PTSD in a crisis region in East Africa (Northern Uganda) affected by ethnic conflict, civil war, and terror. Most of the Ugandan participants had been abducted as children by a guerrilla group called the "Lord's Resistance Army." Typical traumatic events included the abduction itself, rape, beatings and maltreatment, being threatened at gunpoint, witnessing torture, mutilations, killings and abductions of others, or being forced to commit crimes and acts of violence. Since this population differs on many educational, cultural, and social factors from populations normally studied in industrialized countries, a language-free recognition memory-based pictorial retrieval-induced forgetting paradigm was created. Photographs belonging to different categories (e.g., flowers and faces) were presented for learning. Then, participants were presented with partly occluded versions of some of the pictures for retrieval practice with the instruction to recall what the original picture looked like. A final old-new recognition memory test on all initially presented pictures and an equal number of thematically similar distractors followed (see Figure 1). The design was first tested in a group of German students and then used with the Ugandan internally displaced persons (IDPs). At the time this study was planned and conducted, we expected a significant retrieval-induced forgetting effect in the German group and in IDPs without PTSD, but not in the Ugandan IDPs with a PTSD diagnosis. Based on Amir et al.'s (2009) recent results, however, an absence of retrieval-induced forgetting in both Ugandan groups is conceivable due to both groups' exposure to severe stress. Finally, we anticipate poorer discrimination performance in PTSD, reflected in a higher false alarm rate.

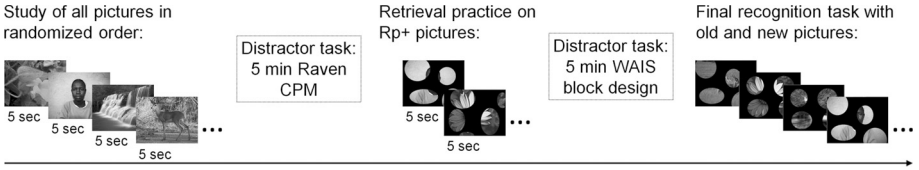

Figure 1. Experimental procedure. The experiment consisted of three phases which were separated by two distractor tasks. First (left) a series of pictures belonging to different categories was learned. After 5 min of Raven Coloured Progressive Matrices, a cued retrieval-practice phase followed (middle). Participants had to recall the entire picture with the help of partly occluded exemplars. After another 5 min of distractor task, a final recognition test, were all initially presented pictures were re-presented together with similar new pictures, followed. For final recognition pictures were again partly occluded.

Methods

German Participants

Thirty-one healthy German students (26 females) from the University of Konstanz with a mean age of 23.32 (SD = 2.53) were tested to validate the present pictorial retrieval-induced forgetting design. All participants were free of medication and had been screened with the German Version of the Beck Depression Inventory (BDI; Hautzinger, Bailer, Worall, & Keller, 1994) and the State Trait Anxiety Inventory (STAI; Laux, Glanzmann, Schaffner, & Spielberger, 1981). Mean BDI score was 3.87 (SD = 4.06), mean STAI-S score was 32.77 (SD = 7.42), and mean STAI-T score was 36.53 (SD = 8.67). All obtained scores were within the normal range (cf. Hautzinger et al., 1994; Laux et al., 1981) and were similar to scores of other student samples from our laboratory. None of the German participants had traumatic events comparable to the Ugandan samples and all participants were free of PTSD or partial PTSD diagnosis (cf. Twamley, Hami, & Stein, 2004). Participants provided written informed consent and received a small financial compensation (5€ ~ US$7.20) for their participation.

Ugandan Participants

Forty-seven Ugandan participants (36 females) with a mean age of 20.79 (SD = 4.15) participated in this study. They were all inhabitants of two IDP camps (Awer and Parabongo) near the city of Gulu in Northern Uganda. The participants had all been clinically diagnosed in a large ongoing study on mental health and organized violence. For PTSD diagnosis, the PDS (Foa et al., 1997) was used. The PDS is normally applied as a self-report instrument, but due to local circumstances was administered with the assistance of trained interviewers. The PDS has good psychometric properties with a Cronbach's Alpha of .92, a test-retest reliability of .83, and a kappa of .74 between the PDS and the SCID. The analysis of the convergent validity reveals a kappa of .65 between PDS and SCID (Foa et al., 1997; Odenwald et al., 2007). The PTSD group (N = 24) had a mean score of 19.63 (SD = 4.99, range 15–33) on the PDS (with 15 being the cutoff for a PTSD diagnosis; cf. Odenwald et al., 2007) and fulfilled all PTSD criteria according to DSM-IV, whereas all of the Non-PTSD group members (N = 23) had a mean PDS score of zero. Both groups exhibited a high number of traumatic events. People in the non-PTSD group had on average 10.91 (SD = 7.22) traumatic experiences and people in the PTSD group had on average 20.92 (SD = 10.45) traumatic events. This difference was significant ($F(1, 45) = 14.45$, $p < .001$). All participants had similar education levels with 2 years of formal schooling at some point in their lives. They spoke the Ugandan dialect of Luo. During the experiment, which took place in the participants' huts, a trained local interpreter translated the experimenter's standardized instructions and the subjects' answers. Participants provided informed consent and received a payment of 3,000 Ugandan Shillings (USh 3,000 ~ US$1.80).

Experimental Procedure

All participants were tested in single sessions with one session taking ~ 45 min. Investigators introduced themselves and gave some general information about the study to the students or explained to the Ugandan participants the reason of the visit in general terms. Possible questions were answered before the start of the experiment. The experiment consisted of a study phase, a retrieval-practice phase, and a final test phase. Pictorial material was used in all three phases. Between study and retrieval-practice phase, a 5-min probe of Raven Coloured Progressive Matrices (CPM; Bulheller & Häcker, 2006) was incorporated as a distractor task. As a second distractor task, a 5-min run with the Wechsler Adult Intelligence Scale-Revised (WAIS-R; Tewes, 1991) performance subscale of block design followed the retrieval practice and preceded the final test phase. The sequence of the experimental events is depicted in Figure 1.

Material

Colored pictures from four different semantic categories (antelopes, faces, flowers, and waterfalls) were used as stimulus material. Each category comprised six exemplars resulting in 24 relevant pictures for the study phase. Additionally, filler pictures stemmed from two further categories (birds

and elephants). These were only used to counterbalance the sequence of the pictures and to control for primacy and recency effects. For the recognition task in the final test phase 24 (six per category) new lure pictures were shown in addition to the 24 old, well-known pictures from the study phase. All pictures were printed on cardboard cards of about 9×13 cm size that were presented by the experimenter during the study. One sample picture from each of the relevant categories can be seen in Figure 1.

Study Phase

In order to counterbalance the sequence of the pictures across participants, two differently randomized study lists had been generated. Each list consisted of 24 block-randomized pictures. Each block consisted of four items and contained one exemplar from each category. No two pictures from the same category were presented in sequence. The list started and ended with a picture from one of the filler categories, resulting in 28 study pictures overall. The experimenter showed the items from one of these lists to the participant. Each picture was shown for 5 s and the participants were asked to look carefully at the picture and to memorize it for later. All pictures were presented a second time in the same order.

Retrieval-Practice Phase

The participants retrieval-practiced half of the six exemplars from two of the four relevant categories. This resulted in six relevant retrieval-practiced (Rp+) pictures, the remaining unpracticed pictures from the practiced categories (Rp−), and the control pictures from the completely unpracticed categories (Nrp). By using four different retrieval-practice lists, the assignment of categories and items to retrieval practice or no retrieval practice was counterbalanced across subjects and groups. At the beginning and at the end of each list, filler category pictures were presented to avoid successive presentation of items of the same category and to control for primacy and recency effects. The typical word stem completion task in verbal retrieval-induced forgetting (e.g., Anderson et al., 1994) was replaced by the presentation of partly occluded pictures in our pictorial retrieval-induced forgetting design. All "to-be-retrieval-practiced" pictures were partly occluded using a black rectangle with the size of the picture and four or five transparent ellipses, through which parts of the picture could be seen. Six different such masks were generated and randomly assigned to each of the items. Examples of two masked pictures are shown in Figure 1.

The participants were asked to use the masked pictures as cues to recall and imagine the whole picture from the study phase. Previous work has shown that a retrieval-attempt in the retrieval-practice phase is sufficient to cause the retrieval-induced forgetting effect. Retrieval success itself is not necessary (Storm, Bjork, Bjork, & Nestojko, 2006). Each item was shown for 5 s and the experimenter repeated the presentation of the masked pictures once again in the same order. After the retrieval-practice phase there was a 5-min run of the WAIS-R (Tewes, 1991) block design subtest.

Final Test Phase

During the final test, all 24 initially learned old pictures and 24 new lure pictures, six lure pictures per category, were successively shown in a randomized order. All presented items were partly occluded with the masks from the retrieval-practice phase. Masks and pictures were randomly paired, but for Rp+ pictures, the masks on the final test differed from the ones used during retrieval practice. Retrieval-induced forgetting on this final test is measured as the difference in recognition performance between Nrp minus Rp− items. The retrieval-practice effect is reflected in the difference between Rp+ minus Nrp items.

For the final test, four differently randomized lists of old and new pictures were created. Lists were counterbalanced across the participants and samples. The presentation always started with two masked filler items. Old and new pictures were presented randomly under the constraints that (1) the same number of old and new items was shown in the first 24 and last 24 test trials; (2) no two old items from a given category were ever tested before at least one lure item from the same category was tested, and vice versa; (3) no items requiring the same correct response (target or lure) appeared more than four times in a row; and (4) pictures of the same category were not presented successively. After presentation of each picture, participants were asked to judge the item as old or new. In Uganda, the interpreter translated the participant's answer and the experimenter took the responses down on a prepared data sheet. After the final test phase, all participants were informed about the aim of the study. After answering any remaining questions about the study, the participants received their financial compensation.

Distractor Tasks

Two distractor tasks were used in the study. The first distractor task intervened between study and retrieval practice and the second one followed the retrieval-practice phase.

After the study phase the participants solved matrices from the CPM for 5 min. In each test item, the participants were asked to identify the missing segment (among six presented alternatives) that was required to complete a larger pattern. The experimenter took down the number of performed and solved items.

Five minutes of the WAIS-R block design intervened between retrieval-practice and final test phase. The test required the participants to put sets of cubes together to match different 2D patterns on printed cards. The first test item was used for demonstration to explain the task. As in the first distractor task, the experimenter wrote down the number of performed and correctly solved test items.

Data Analysis

For data analysis, proportions of recognized items were calculated. Due to inhomogeneity of variance, all proportions were arcsine transformed as suggested by Winer (1971) to stabilize the variances and to normalize the data before repeated-measures analyses of variance (ANOVAs) were calculated. For a better display in graphics the arcsine values were retranslated to proportions using the sine transform (cf. Zar, 1984). Because particularly in populations with excessive false alarm rates, false alarms may affect and possibly obscure memory effects, all effects of interest were analyzed both for hit and recognition rates as indexed by hit rates minus false alarm rates using ANOVAs. Significant effects were followed up with two-tailed t tests.

Results

German Participants

Retrieval-Practice Effect

Perhaps due to their overall very high performance, the German participants did not exhibit a significant retrieval-practice effect. Recognition memory on Rp+ items was not higher than on Nrp items, either for hit rates ($F(1, 30) < 1$) or for recognition rates as indexed by hit rates minus false alarm rates ($F(1, 30) < 1$). Figure 2 depicts Rp+, Nrp as well as Rp− recognition rates, the latter being critical for retrieval-induced forgetting as detailed in the following paragraph.

Retrieval-Induced Forgetting Effect

A retrieval-induced forgetting effect was found in the German sample. Hit rate for Nrp items was significantly higher than for Rp− items ($F(1, 30) = 6.36$; $p < .05$) and although somewhat attenuated, the effect was still visible in the false-alarm-corrected recognition rates ($F(1, 30) = 3.86$; $p = .059$), indicating that the manipulation also induced a small response bias which contributed to the retrieval-induced forgetting effect. See Figure 2 for false-alarm-corrected Nrp and Rp− recognition rates.

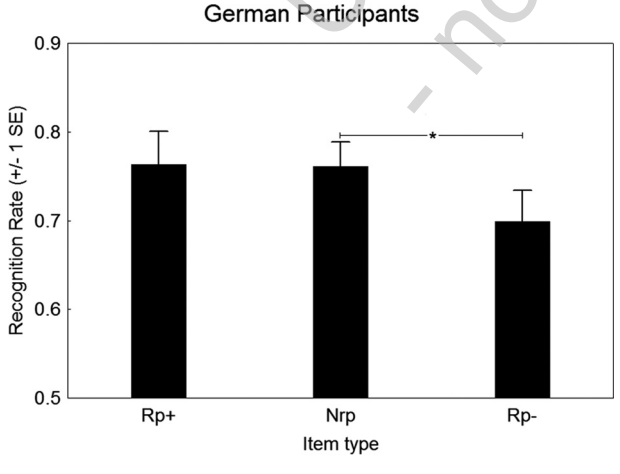

Figure 2. Recognition rates for retrieval-practiced (Rp+) items, non-retrieval-practiced items for never-practiced categories (Nrp), and unpracticed items from practiced categories (Rp−) in the German group.

Ugandan Participants

Hit Rate

Hit rates did not differ between Ugandans with and without PTSD ($F(1, 45) < 1$). However, hit rates in both Ugandan groups were lower than in the German group (all three groups: $F(2, 75) = 13.66$; $p < .0001$, Ugandan Non-PTSD vs. German: $t(52) = -5.62$, $p < .001$; Ugandan PTSD vs. German: $t(53) = -3.72$; $p < .001$).

False Alarm

False alarm rates for the three groups of participants are shown in Figure 3. As expected, false alarm rate was significantly higher in the PTSD than the Non-PTSD group ($F(1, 45) = 5.07$; $p < .05$). Additionally, both Ugandan groups had significantly higher false alarm rates than the German sample ($F(2, 75) = 73.91$; $p < .0001$; Ugandan Non-PTSD vs. German: $t(52) = 8.61$; $p < .001$; Ugandan PTSD vs. German: $t(53) = 12.96$; $p < .0001$).

Retrieval-Practice Effect

Using hit rates, a Group (Non-PTSD, PTSD) × Item type (Rp+, Nrp) ANOVA revealed that Rp+ pictures were better recognized than Nrp pictures ($F(1, 75) = 6.49$; $p = .01$) indicating a retrieval-practice effect. No significant main effect for the factor group ($F(1, 45) = 1.00$; $p > .30$) and

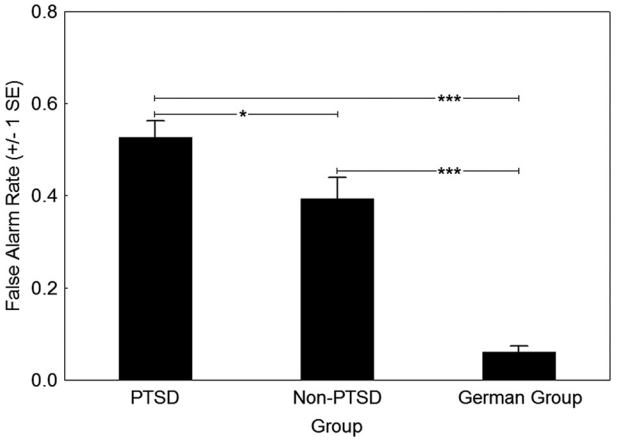

Figure 3. False alarm rates in the Ugandan PTSD group, the Ugandan Non-PTSD group, and the German group.

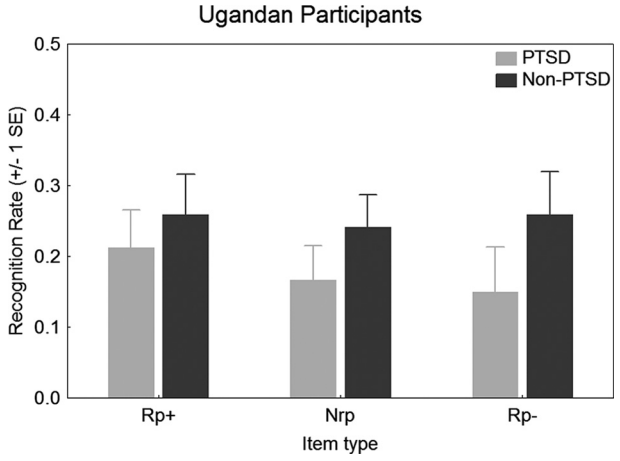

Figure 4. Recognition rates for retrieval-practiced (Rp+) items, non-retrieval-practiced items for never-practiced categories (Nrp), and unpracticed items from practiced categories (Rp−) in the two Ugandan groups (PTSD and Non-PTSD).

no significant interaction between the two factors occurred ($F(1, 45) = .11$; $p > .70$).

The analysis of the false-alarm-corrected recognition data likewise produced no significant effects. We found neither a significant main effect for the factor item ($F(1, 45) < 1$), nor a main effect for the factor group ($F(1, 45) = 1.26$; $p > .20$) and no significant interaction between the two factors ($F(1, 45) < 1$). Recognition rates for the different item types in the two Ugandan groups are shown in Figure 4.

Retrieval-Induced Forgetting Effect

Using hit rates, a Group (Non-PTSD, PTSD) × Item type (Nrp, Rp−) ANOVA revealed no significant effects. The main effect for factor group ($F(1, 45) < 1$) and item type ($F(1, 45) = 2.35$; $p > .10$) as well as the interaction between both factors failed to reach significance ($F(1, 45) < 1$).

Figure 4 illustrates the results for false-alarm-corrected recognition rates. Statistical analysis revealed neither a main effect of group ($F(1, 45) = 3.01$; $p > .05$), nor a main effect for factor item type ($F(1, 45) < 1$) which would be indicative of retrieval-induced forgetting, or a Significant group × Item type interaction ($F(1, 45) < 1$) indicating different effects in the two groups.

Distractor Tasks

Raven CPM

Since only 5 min of the Raven CPM were used as a distractor task, performance was analyzed comparing between groups the number of items completed and the rate of correctly solved items during the time given. One-way ANOVAs with factor group (PTSD, Non-PTSD) revealed no group differences, Ugandan PTSD and Non-PTSD participants did not differ in the number of completed items ($F(1, 45) = 1.03$; $p > .30$) and performed equally well in terms of percentage correctly completed items on the Raven CPM ($F(1, 45) < 1$). However, the German students, not surprisingly performed much better, they solved about twice as many items on average (32 vs. 16; $F(2, 75) = 154.24$) and were also more correct in selecting the proper missing item (95% correct vs. 65% correct; $F(2, 75) = 88.85$). Still, the Ugandans performed well above chance, because, given the six alternatives each CPM item offers, chance level is at about 16%.

Block Design

Ugandan participants turned out to have had conceptual difficulties understanding and performing the task within 5 min, therefore the data were not further analyzed.

Discussion

The present study investigated episodic memory performance in Ugandan IDPs with and without PTSD as well as in German students. The study was motivated by the fact that the incidence of traumatic events as well as the prevalence of PTSD is very high in Northern Uganda, whereas there is practically no empirical research on the cognitive effects on afflicted individuals and societies. Recently, mechanisms of retrieval-induced forgetting have been implicated in the formation and regulation of collective memories in social groups (Cuc et al., 2007). At the same time, both phenomenological evidence from PTSD patients' clinical symptoms and experimental evidence (Amir et al., 2009) suggested impaired retrieval-induced forgetting in trauma victims. A novel picture recognition memory-based retrieval-induced forgetting design was used to investigate recognition memory in general and the retrieval-induced forgetting effect in particular. The design was first tested in a German student population, where retrieval-induced forgetting, that is a negative effect of retrieval practice of parts of studied material on the later recall of related material, was found. A response bias partly contributed to the effect as retrieval-induced forgetting was attenuated for the false-alarm-corrected recognition performance compared to the hit rate.

The design was then used in Ugandan IDPs with and without PTSD. First, the impact of PTSD and traumatic stress on overall memory accuracy as evidenced by hit and false alarm rates was tested. Second, the effects of traumatic events and/or the presence of PTSD on retrieval-induced forgetting were analyzed. While a retrieval-induced forgetting effect was found in the healthy German comparison group, the Ugandan participants did not show retrieval-induced forgetting, either the ones with or the ones without a PTSD diagnosis. This result held both for hit rates and the false-alarm-corrected recognition rates. However,

considerably elevated false alarm rates were particularly characteristic of the Ugandan PTSD group. Participants with a PTSD diagnosis had higher false alarms both in comparison with the Ugandan Non-PTSD group and, even more so, with the German group. The apparent retrieval-practice effect in the Ugandan group also proved to be mainly due to an elevated false alarm rate, perhaps indicative of a very global processing strategy in the Ugandans. Since targets and distractors in the recognition test stemmed from the same categories, poorer processing of pictorial detail in the stress-exposed Ugandans may contribute to the effect.

Regarding false alarms the results are consistent with previous reports of less accurate recognition with higher levels of commission errors in PTSD (Vasterling et al., 1998). Since in the present study the Ugandan PTSD and Non-PTSD group differed, it seems that exceptionally high false alarm rates are related to the PTSD diagnosis itself rather than the experience of traumatic events. On the other hand, since both Ugandan groups had much higher false alarm rates than the Germans, but had also experienced much more life stress and traumatic events, the impact of traumatic stress on recognition accuracy may not be entirely restricted to a PTSD diagnosis. This would also appear to be suggested by experimental studies demonstrating higher levels of false memory after stress induction (Payne, Nadel, Allen, Thomas, & Jacobs, 2002). From a neuropsychological perspective, high level of false alarms in recognition memory is particularly compatible with prefrontal (Butler, McDaniel, Dornburg, Price, & Roediger, 2004), but also with hippocampal dysfunction (Weiss et al., 2004). Both structures are densely populated with glucocorticoid receptors, making them prime target sites for stress effects (Joels, 2001; McEwen, 2003; Sanchez, Young, Plotsky, & Insel, 2000).

However, obviously the German group and the two Ugandan groups differed on many more aspects beside the presence and intensity of past and current life stress. There are huge cultural and educational differences between the groups and the performance on the distractor tasks reflects some of these differences: Although the two Ugandan groups did not differ in their Raven CPM performance, not surprisingly, they performed much worse than German students, who solved nearly all the items within 5 min, the test having been designed for IQ testing in children. Likewise, while German students had no problems understanding the block design task, many Ugandan participants had difficulty understanding the task. Therefore, some of the considerable cultural and educational differences may have contributed to group differences in false alarm rates or retrieval-induced forgetting.

The lack of a retrieval-induced forgetting effect in both Ugandan groups is consistent with the thesis that the experience of traumatic events, even without the presence of a PTSD diagnosis, is enough to impair retrieval-induced forgetting (Amir et al., 2009). In Western societies retrieval-induced forgetting has been found in 7 year olds as well as in 70 year olds (e.g., Ford, Keating, & Patel, 2004; Gomez-Ariza et al., 2009), suggesting that education and age play a minor role in the occurrence of the effect. Still, this is the first study in an African population, leaving open the possibility that hitherto unknown cultural or educational factors rather than past or current stress levels impair retrieval-induced forgetting. Moreover, although successful recall in the retrieval-practice phase is not necessary for the suppression effect to occur, at least a retrieval attempt is necessary. It would thus be conceivable that the Ugandans for some reason did not try to recall the presented pictures, while the German students did, giving rise to the differential effects. Therefore, we further examined the occurrence of retrieval-induced forgetting and its elimination by traumatic stress in subgroups of the current population: If retrieval-induced forgetting really occurs in a Ugandan IDP population and if life-time stress as reflected by the number of traumatic events affects the pattern of results, at least the most stressed individuals should differ from the least stressed ones. We thus analyzed the retrieval-induced forgetting patterns within the Ugandans, comparing them in terms of number of traumatic events in the highest and the lowest quartiles. The highest quartile consisted of 11 people who had experienced on average 31 traumatic events (range 24–39). Ten of the people in the highest quartile had been diagnosed with PTSD. The lowest quartile consisted of 10 people who had experienced on average four traumatic events (range 0–7, internal displacement alone was not counted as a traumatic event). Two of the people in the lowest quartile had been diagnosed with PTSD. Comparison of the retrieval-induced forgetting patterns between these two extreme groups yielded a significant interaction ($F(1, 19) = 4.98$, $p < .05$). In the lowest quartile, a retrieval-induced forgetting effect was found in that recognition of non-practiced pictures from practiced categories (Rp−) was lower than recognition of control items (Nrp), whereas in the highest quartile the opposite pattern emerged with higher Rp− than control item recognition. The latter reflects the overall pattern when all Ugandan participants were analyzed. Thus, this analysis indicates that retrieval-induced forgetting can be found in Ugandans and that the intensity of traumatic stress as measured by the number of experienced events influences the retrieval-induced forgetting patterns in the present population. This result supports the thesis that, in line with Amir et al.'s results (2009), the absence of a retrieval-induced forgetting in the Ugandan IDPs is at least partly related to previous exposure to traumatic stress. The presently studied population was much more severely traumatized than Amir et al.'s (2009) who recently reported an absence of retrieval-induced forgetting already in trauma-exposed and not just in PTSD diagnosed undergraduates. Moreover, the experience of an experimentally induced social stressor, the Trier Social Stress Test (TSST), presumably via activation of the HPA axis already transiently abolishes retrieval-induced forgetting (Koessler et al., 2009). In comparison with the events experienced by many of the present participants (both with and without PTSD), the TSST with its combination of public speaking and doing calculations in public seems a very mild treatment, although its experimental efficacy and its effects on memory measures other than retrieval-induced forgetting have been amply demonstrated (e.g., Kuhlmann, Piel, & Wolf, 2005). Recent research indicates that retrieval-induced forgetting, although replicable across very different situations (e.g., Ciranni & Shimamura, 1999; Cuc et al., 2007; MacLeod

& Macrae, 2001; Shaw, Bjork, & Handal, 1995) and different age groups (Aslan et al., 2007; Ford et al., 2004; Zellner & Bäuml, 2005), is very sensitive to manipulations of emotional well-being, experimental induction of negative mood eliminating the effect (Bäuml & Kuhbandner, 2007). Obviously, living conditions in an IDP camp alone are more conducive to negative mood than German undergraduate student life. Given this apparent susceptibility of retrieval-induced forgetting to individual mood states or stress, one may come to question the implications of the effect for such complex phenomena as collective memories. On the other hand, cross-cultural studies also show that mildly positive mood states are the default for people in many societies (Diener & Diener, 1996), perhaps supporting the formation of coherent collective memories. Stress on the other hand may hamper this process. While such considerations may prove relevant for future theorizing and empirical studies, answers are clearly beyond the scope of the present research.

The present study cross-culturally confirms poorer memory performance and higher false alarm rates in severely traumatized people diagnosed with PTSD compared to a demographically very similar trauma-exposed comparison group without PTSD. The findings are in line with the thesis that retrieval-induced forgetting is reduced in people who have been exposed to traumatic events, although, as detailed above, interpretation is complicated by the absence of a demographically and educationally matched Ugandan control group with no exposure to psychological trauma whatsoever. Since our initial hypothesis focused on the effects of a PTSD diagnosis, our primary aim was to compare memory performance within IDPs with and without PTSD, the German student sample having been primarily intended for validation of the experiment rather than as a true healthy control group. Given the present data, a major challenge for future studies of cognitive functioning in crisis regions will be to provide such a demographically and educationally matched sample within the studied culture. This proves to be a difficult enterprise, because of the profound effects of civil wars on the afflicted societies and because less afflicted groups often enjoy more formal education and better general living conditions than more afflicted portions of the population. Nevertheless, considering the implications for research and therapy, we believe this to be a worthwhile endeavor.

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