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Emotional Memory: No Source Memory Without Old–New Recognition

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Findings reported in the memory literature suggest that the emotional components of an encoding episode can be dissociated from nonemotional memory. In particular, it has been found that the previous association with threatening events can be retrieved in aversive conditioning even in the absence of item identification. In the present study, we test whether emotional source memory can be independent of item recognition. Participants saw pictures of snakes paired with threatening and nonthreatening context information (poisonousness or nonpoisonousness). In the source memory test, participants were required to remember whether a snake was associated with *poisonousness* or *nonpoisonousness*. A simple extension of a well-established multinomial source monitoring model was used to measure source memory for unrecognized items. By using this model, it was possible to assess directly whether participants were able to associate a previously seen snake with poisonousness or nonpoisonousness even if the snake itself was not recognized as having been presented during the experiment. In 3 experiments, emotional source memory was only found for recognized items. While source memory for recognized items differed between emotional and nonemotional information, source memory for unrecognized items was equally absent for emotional and nonemotional information. We conclude that emotional context information is bound to item representations and cannot be retrieved in the absence of item recognition.

Keywords: emotional source memory, emotional context retrieval, old–new recognition, threat, fear-relevant stimuli

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A substantial body of evidence suggests that emotional and nonemotional information is processed differently. Emotional information is of fundamental importance for the organism's primary goals of survival and reproduction. It is often essential to respond quickly to negative stimuli to avoid harm. Therefore, the processing of this information has to be prioritized (Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001; Wentura, Rothermund, & Bak, 2000). Furthermore, the processing of emotional and nonemotional information involves different brain circuits (Kensinger, 2007). This raises the possibility that the processing of emotional and nonemotional information may be governed by different mechanisms. Thus, it cannot be taken for granted that the rules that apply to nonemotional information in a certain paradigm can be generalized to emotional information without empirical testing.

There is evidence in the fear conditioning literature showing that the learning of the emotional significance of a stimulus can be dissociated from the cognitive learning of stimulus relationships (Öhman & Mineka, 2001). LeDoux's model of fear learning (Phelps & LeDoux, 2005) implies that a stimulus that has previously been paired with an aversive stimulus can elicit a fear response without being fully identified because the amygdala receives fast, direct input from the thalamic pathway before the stimulus is processed in higher cortical areas. The association to aversive events can be retrieved from emotion-processing brain regions even if the stimulus cannot be recognized. In a study of Öhman and Soares (1998), participants were able to indicate whether a snake was associated with a negative event even though they were not able to correctly recognize the masked stimulus. Such dissociations were not obtained for emotionally neutral stimuli such as flowers or mushrooms. Despite these findings, aversive conditioning without stimulus identification has remained a controversial topic (Lovibond & Shanks, 2002).

In the memory literature, several studies have supported the idea that the retrieval of the emotional components of an experience may be independent of the retrieval of nonemotional details of the same learning episode. Although such dissociations are not always clearly obtained (Johnson, Kim, & Risse, 1985; Todorov & Olson, 2008), it has been shown that preferences and aversions can be retrieved from brain regions specialized in the processing of emotional information even when the stimuli eliciting these emotional responses are not explicitly remembered due to brain lesions in memory-related brain areas (Blessing, Zoellig, Dammann, & Martin, 2010; Tranel & Damasio, 1993). This is reminiscent of a famous anecdote of Claparède about an amnestic patient being able to acquire negative reactions toward her doctors despite being unable to recognize them (Nicolas, 1996).

The purpose of the present paper is to explore whether participants retrieve emotional context information without recognizing the stimulus in the source memory paradigm. *Source memory* originally referred to the ability of a person to remember the source from which information originated (e.g., who told you something),

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but it is now generally used to refer to memory for the association between a stimulus and context information (Johnson, Hashtroudi, & Lindsay, 1993). Recently there has been growing interest in emotional source memory (Bell & Buchner, 2012; Boywitt, 2015; Buchner, Bell, Mehl, & Musch, 2009; Doerksen & Shimamura, 2001; Kroneisen, Woehe, & Rausch, 2015; Meyer, Bell, & Buchner, 2015; Mieth, Bell, & Buchner, 2016). Henceforth, the term *emotional source memory* is primarily used to refer to memory for the association between an item and positive or negative emotional context information. Emotional source memory has sometimes been shown to be characterized by a negativity or threat advantage (Buchner et al., 2009), but it is generally more strongly determined by the strength of the emotional response at encoding (Bell & Buchner, 2011), as well as by the degree to which stimuli violate expectations (Bell & Buchner, 2012). The source memory advantage for emotional information is not always due to a vivid recollection of the encoding episode but is instead due to emotional tagging: The emotional implications of the source information are retrieved even when the more specific details of the encoding episode are forgotten (Bell & Buchner, 2012). Recent evidence suggests that source memory for threatening information shows an enhanced resistance against extinction (Suzuki, Honma, & Suga, 2013), just like prepared fear learning (Öhman & Mineka, 2001).

In the typical source memory test, participants see two types of stimuli: old stimuli that they have seen before and new stimuli. First, each stimulus has to be classified as old or new. If a stimulus is classified as old, participants are asked to make a source judgment. Depending on the source dimension that is to be remembered, they are asked to identify, for example, the font color or the modality in which the stimulus was presented at encoding. A common assumption is that source memory depends on item recognition. For instance, the most widely used multinomial source monitoring model (Bayen, Murnane, & Erdfelder, 1996) implements this assumption and implies that source memory for unrecognized items does not exist: In the absence of old–new recognition, source classification is assumed to be determined exclusively by guessing. This restriction exists because there is little evidence of source memory for unrecognized items when the sources carry no emotional meaning (Malejka & Bröder, 2016). For instance, Kurilla and Westerman (2010) have shown that source accuracy does not differ between nonidentified and identified stimuli. However, they used a nonstandard memory test in which only word fragments were presented. The term *nonidentified* was used to refer to word fragments that could not be solved in the sense of being completed to form a word from the study phase. Above-chance source memory was only found for those items that had been recognized with high confidence. Thus, these findings provide no evidence for source memory without item recognition. Recently, Starns, Hicks, Brown, and Martin (2008) reported that participants had above-chance source memory for falsely rejected items when they had been encouraged to adopt an extremely conservative decision criterion for the old–new recognition judgments. However, this study has been criticized by Malejka and Bröder (2016), who attribute this finding to a methodological artifact. Specifically, Starns et al. required their participants to make a source judgment if they had classified an item as old or if they had falsely rejected a previously presented item, but not if they had correctly rejected a new item. Malejka and Bröder argue that the source memory test after old–new recognition misses may have served as an implicit feedback that the old–new recognition judgment was false, which could have stimulated the participants to engage in a second retrieval attempt. In Malejka and Bröder's study, source discrimination for unrecognized items was at chance when the implicit feedback about the accuracy of the old–new recognition judgment was avoided.

Although it seems comparatively well established that nonemotional source memory depends on old–new recognition, it is a priori unclear whether this finding generalizes to emotional source memory. Specifically, it seems possible to postulate that memory traces of previous associations with emotional (e.g., threatening) information are stored in other (emotion-processing) brain systems than the memory traces of previous associations with nonemotional information such as font color or location (Smith, Henson, Rugg, & Dolan, 2005). It is well established that emotional memory can be dissociated from nonemotional memory (May, Rahhal, Berry, & Leighton, 2005; Rahhal, May, & Hasher, 2002). Given that feedback from emotion-processing brain regions such as the amygdala can influence decision-making judgments, it seems conceivable that the emotional residue of a previous learning episode may inform source judgments even when the stimulus cannot be successfully recognized.

In the present study, we used an experimental paradigm that seems ideally suited to examine this question. We paired pictures of snakes with threatening and nonthreatening information about the poisonousness or nonpoisonousness of the snakes. In a memory test, the old snake pictures were presented together with new snake pictures, and participants were required to make an old–new recognition judgment and a source judgment. The same paradigm was used in a previous experiment to examine fear-relevant illusory correlations in the participants' guessing biases (Meyer, Buchner, & Bell, 2015). In this previous study, the multinomial source monitoring model of Bayen et al. (1996; Figure 1) was applied to distinguish between old–new recognition, source memory, and various guessing biases. Source memory was equally good for poisonous and nonpoisonous snakes. Source guessing represents the probability with which participants guessed that an animal was poisonous if this information was no longer remembered. It seems noteworthy that the younger adults' guessing bias was in line with the probability-matching account of source guessing (Arnold, Bayen, Kuhlmann, & Vaterrodt, 2013; Bayen & Kuhlmann, 2011; Kuhlmann, Vaterrodt, & Bayen, 2012; Spaniol & Bayen, 2002): If the poisonousness was not remembered, source guessing corresponded to the probability with which snakes were associated with poisonousness during the encoding phase (.50). However, participants with snake fear, particularly older adults with reduced cognitive resources, tended to overestimate the snake–poisonousness contingency. Older adults' source memory for the poisonousness of the animals was comparatively well preserved and did not differ from that of younger adults. These findings coincide with the typical findings in the emotional memory literature (e.g., May et al., 2005; Rahhal et al., 2002). Given that a multinomial model was used that was incapable of measuring source memory in the absence of item memory, we do not know whether participants may have been able to remember the threatening (poisonous) contexts of unrecognized items. Hence, it seems straightforward to repeat the experiment but to use a source memory model that takes context memory for unrecognized items into account.

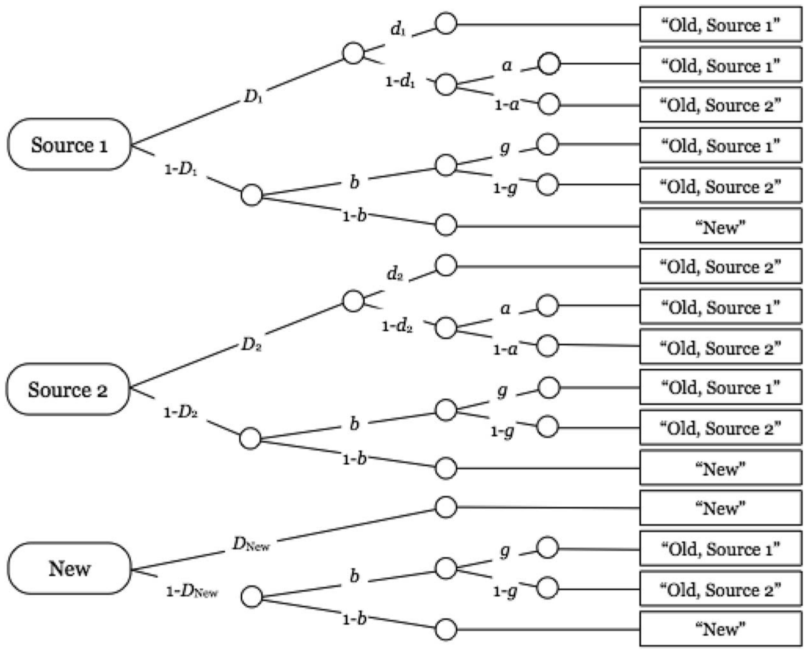

Figure 1. Bayen, Murnane, and Erdfelder's (1996) original source monitoring model. The rounded rectangles on the left side represent the types of items presented in the source memory test (Source 1 items [poisonous snakes], Source 2 items [nonpoisonous snakes], and new items). The rectangles on the right side represent participants' responses. The letters along the links represent the probabilities with which certain cognitive states occur (D = probability of recognizing an item as old or new; d = conditional probability of remembering the source of the item given that the item was correctly recognized; b = probability of guessing that an unrecognized item is old; a = probability of guessing that an item that is correctly recognized as old was associated with Source 1 and not Source 2; g = probability of guessing that an unrecognized item was associated with Source 1 and not Source 2).

Assessing Source Memory for Unrecognized Stimuli

At the level of observable behavior, source memory for unrecognized items would manifest itself, albeit not exclusively, as a subset of correct source judgments for items previously labeled as new. This behavioral category is usually ignored in typical source memory tasks in which participants are only required to make a source judgment when the item has previously been classified as old. When an item is classified as new, no source judgment is required, and the next trial is started. To assess emotional source memory for unrecognized items, it is obviously necessary to include source judgments of old–new recognition misses, which was done in the present study: The task for participants was to identify the sources of all items, including those that had been classified as new in the old–new recognition test.

Multinomial models have the huge advantage that they can be easily applied to source judgments to obtain a direct estimate of source memory that is not contaminated by old–new recognition or guessing (Bayen et al., 1996; Bröder & Meiser, 2007). Our analysis was based on the well-validated source monitoring model of Bayen et al. (1996) displayed in Figure 1. The model includes a source memory parameter d representing the conditional probability of remembering the source of an item given that the item has been correctly recognized as old (which occurs with probability D). In the form depicted in Figure 1, the model assumes that source judgments for unrecognized items are only determined by guessing (probability g). Fortunately, the model can be easily extended to take different types of memory states into account, such as partial and specific source memory (Bell et al., 2012; Dodson, Holland, & Shimamura, 1998; Klauer & Wegener, 1998), or source memory for different source dimensions (Meiser, 2014; Meiser & Bröder, 2002). Likewise, the model can be extended to account for source memory for unrecognized items.

The resulting model is shown in Figure 2. The first branch of the first model tree is identical to the original model. Participants may recognize a Source 1 item (a poisonous snake) with probability D_1. With the conditional probability d_{R1}, participants may know that the item is a Source 1 item (a poisonous snake). If this does not occur (with the complementary probability $1 - d_{R1}$), participants may guess, with probability a, that the item is a Source 1 item (poisonous) or, with probability $1 - a$, that the item is a Source 2 item (nonpoisonous). If items are not recognized as old with probability $1 - D_1$, participants are assumed to be in a state of uncertainty about the item's status as old or new. In this state, participants may still guess that the item is old with probability b. Here, the model includes parameter d_{N1}, which represents the probability of sensing that the item belongs to Source 1 (that the snake is poisonous), in which case the item is correctly classified as a Source 1 item (poisonous). If participants have no source memory for unrecognized items (with probability $1 - d_{N1}$), Source 1 may still be guessed with probability g. If participants guess that

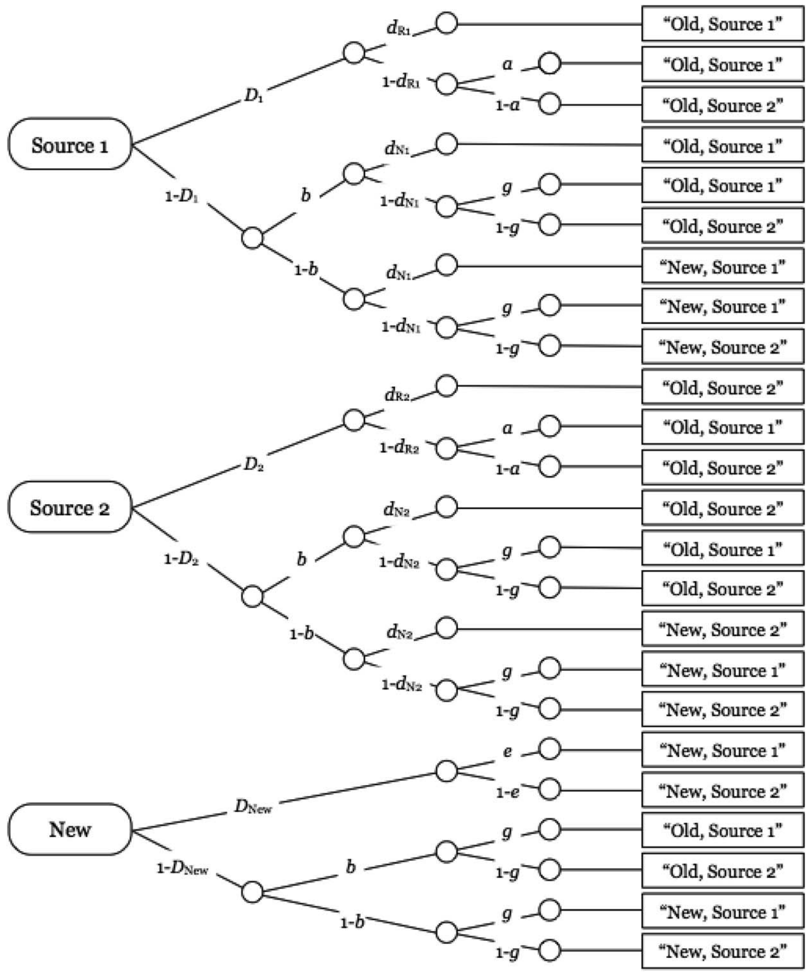

Figure 2. The extended model of recognized and unrecognized source memory. The rounded rectangles on the left side represent the types of items presented in the source memory test (Source 1 items [poisonous snakes], Source 2 items [nonpoisonous snakes], and new items). The rectangles on the right side represent participants' responses. The letters along the links represent the probabilities with which certain cognitive states occur (D = probability of recognizing an item as old or new; d_R = conditional probability of remembering the source of an item given that the item was correctly recognized; d_N = conditional probability of remembering the source of an item given that the item was not recognized; b = probability of guessing that an unrecognized item is old; a = probability of guessing that an item that was correctly recognized as old was associated with Source 1 and not Source 2; g = probability of guessing that an unrecognized item was associated with Source 1 and not Source 2; e = probability of guessing that an item that was correctly recognized as new was associated with Source 1 and not Source 2).

the item is new (with probability $1 - b$), the probability of sensing the source is again given by d_{N1}, which implies that source memory for unrecognized items is stochastically independent of old–new guessing. In the case of no source memory for an unrecognized item, participants may guess, with probability g, that the item is a Source 1 item (that the snake is poisonous) or with probability $1 - g$ that the item is a Source 2 item (that the snake is not poisonous). Analogous considerations hold for the model tree for Source 2 items (nonpoisonous snakes). Finally, if a new item is recognized as new (with probability D_{New}), participants may guess Source 1 (poisonous) and Source 2 (nonpoisonous) with probabilities e and $1 - e$, respectively. If participants do not recognize a new item as new (with probability $1 - D_{New}$), they are again in a state of uncertainty and may guess, with the probabilities b or $1 - b$, that the item is old or new, respectively, and with the conditional probabilities g or $1 - g$ that the item is a Source 1 or a Source 2 item, respectively. Compared to the original source monitoring model (Bayen et al., 1996), the extended model has three additional parameters (d_{N1}, d_{N2}, and e), but it also adds three independent data categories to be used for parameter estimation (Source 1 responses to unrecognized Source 1 items, Source 1 responses to unrecognized Source 2 items, and Source 1 responses to correctly classified new items; the Source 2 responses are redundant given all other responses). Thus, the extension does not change the model in terms of the parameter counting rule (Bamber & van Santen, 2000). What is more, the parameters can be directly estimated from these data categories using similar assumptions to those of the original model. Hypotheses can be tested by implementing restrictions on the parameters (Batchelder & Riefer, 1999; Erdfelder et al., 2009). Here, we were particularly interested in testing the assumption that source memory for unrecognized items does not exist even when threatening sources are used, which translates into the restriction that $d_{N1} = 0$. One advantage of the multinomial model is that it provides the possibility to elegantly test the hypothesis of source memory for unrecognized items separately for threatening and nonthreatening sources, which is not easily possible using other methods.

Hypotheses

Based on the literature showing that people sometimes seem to be able to retrieve a former association with threatening information without identifying a stimulus, we wanted to test the hypothesis that source memory for threatening information can be retrieved even in the absence of old–new recognition. An alternative, equally interesting possibility is that the retrieval of threatening information requires successful item recognition, just like the retrieval of nonemotional source information.

Although our hypothesis is specifically about threatening contexts (poisonousness), it seems possible that nonthreatening information (nonpoisonousness) is also well remembered. It seems possible to speculate that participants, to some extent, expect snakes to be poisonous. If this expectation is violated, the information that the snake is nonpoisonous may serve as a safety signal, which may be experienced as emotional information as well. The previous research of our group suggests that both positive and negative information is well remembered if it is unexpected (Bell & Buchner, 2012). Specifically, memory may depend on the degree to which the emotional evaluation of a stimulus changes as a function of the context information (Bell & Buchner, 2011). This type of emotional context information may be retained in the form of an emotional tag, which can be readily retrieved at testing (Bell et al., 2012). Thus, it seemed conceivable that participants may have good source memory for positive context information for the nonpoisonous snakes, and it seemed interesting to examine whether positive context information can be retrieved in the absence of item memory as well, although such a hypothesis is not directly supported by the literature.

Experiment 1

The experiment was similar to the experiment of Meyer, Buchner, and Bell (2015) with some exceptions. Most importantly, participants were required to provide source judgments for stimuli that were identified as new.

Method

Participants. The data of one participant had to be removed because he failed to correctly remember the color–poisonousness mapping. The remaining sample consisted of 41 students at Heinrich Heine University Düsseldorf (24 of whom were female; mean age of 24, $SD = 4$).

Stimuli and procedure. Stimuli were 32 pictures of snakes that were taken from the International Affective Picture System (Lang, Bradley, & Cuthbert, 2008) and the Geneva Affective Picture Database (Dan-Glauser & Scherer, 2011). The stimuli were edited to a size of 640 × 480 pixels and a resolution of 300 pixels per inch. The colors of the snakes were changed to yellow and red using Photoshop CS5. All snakes were presented in front of a green background.

In the encoding phase, each participant saw a different set of 16 randomly selected snakes in a different, randomly determined order. Eight of these snakes were presented in red, and eight were presented in yellow. Half of the participants were told that all red snakes were poisonous and that all yellow snakes were nonpoisonous, and the other half were told that yellow snakes were poisonous and that red snakes were nonpoisonous. Each picture appeared at the center of the screen. After 1 s, participants were required to rate each snake on a threat rating scale ranging from 0 (*harmless*) to 7 (*threatening*) using a response box. Each picture stayed on the screen for another 7 s. If participants failed to rate the picture within this time interval, they were instructed to respond faster.

In the source memory test, the 16 (old) snake pictures were randomly intermixed with the remaining 16 (new) snake pictures. These 32 pictures were presented in a random order. All snakes were presented in grayscale on a uniform gray background. In each trial, participants were first asked to classify the snake as old or new and were then prompted to classify the snake as poisonous or nonpoisonous by pressing one of two buttons on a response box. The test was self-paced.

At the end of the experiment, participants were asked to indicate the color of the poisonous snakes to check if the color–poisonousness mapping was correctly represented.

A post hoc power analysis was performed using multiTree (Moshagen, 2010). Given $\alpha = .05$, 41 participants, and 32 observations in the source memory test, an effect of size $w = .11$ (i.e., a small effect) could be detected in the multinomial analysis with a power of $1 - \beta = .96$.

Results

Threat ratings. Threat ratings were significantly higher for poisonous snakes ($M = 5.50$, $SD = 1.20$) than for nonpoisonous snakes ($M = 3.57$, $SD = 1.72$), $t(40) = 6.31$, $p < .01$.

Old–new recognition. Old–new recognition in terms of P_r (the two-high threshold model's sensitivity parameter, which is often referred to as the corrected hit rate and computed as the hit rate minus the false alarm rate) did not differ between poisonous snakes ($M = 0.36$, $SD = 0.26$) and nonpoisonous snakes ($M = 0.38$, $SD = 0.26$), $t(40) = 0.55$, $p = .58$.

Source memory. To obtain an identifiable base model, we capitalized on the fact that old–new recognition did not differ between poisonous and nonpoisonous snakes, and we added the usual assumption of two-high threshold models (Bayen et al., 1996; Snodgrass & Corwin, 1988) that item recognition does not differ between old and new items ($D_1 = D_2 = D_{New}$). Consistent with previous studies (Arnold et al., 2013; Bayen & Kuhlmann, 2011; Bell, Mieth, & Buchner, 2015; Dodson et al., 1998; Kuhlmann et al., 2012; Mieth et al., 2016), we assumed that source guessing does not vary as a function of item recognition ($a = g = e$). The base model with these assumptions fit the data well, $G^2(2) = 2.38$, $p = .30$ (see the online supplemental material for the raw number of response frequencies and the parameter estimates of the old–new recognition and guessing parameters). As in the study of Meyer, Buchner, and Bell (2015), the parameter representing the probability of guessing that a snake is poisonous rather than nonpoisonous approximately corresponded to .50, $\Delta G^2(1) = 1.03$, $p = .31$, which is evidence of probability matching (Arnold et al., 2013; Bayen & Kuhlmann, 2011; Kuhlmann et al., 2012; Spaniol & Bayen, 2002). Furthermore, source memory for recognized items did not differ significantly between poisonous and nonpoisonous snakes, $\Delta G^2(1) = 2.41$, $p = .12$. These findings replicate the findings of Meyer, Buchner, and Bell (2015). The next step was to test whether the source memory parameters are significantly different from zero. The standard χ^2 goodness-of-fit test is not valid when the null hypothesis predicts a parameter value at the boundary of the parameter space (zero in the present case). Therefore, it was necessary to use the parametric bootstrap option of multiTree (Moshagen, 2010) to obtain an estimate of the p value from the simulated exact distribution (see Klauer & Oberauer, 1995, for a similar treatment of this problem). However, the same conclusions are reached when using the conventional maximum likelihood estimates. If participants had no source memory for recognized items, it would be rather unsurprising to find that source memory for unrecognized items would not be different from zero as well. Therefore, we start by testing whether source memory for recognized items existed. Indeed, source memory for recognized items was clearly different from zero for both poisonous, $\Delta G^2(1) = 6.40$, bootstrapped $p < .01$, and nonpoisonous snakes, $\Delta G^2(1) = 19.80$, bootstrapped $p < .01$. Source memory for unrecognized items, in contrast, did not differ from zero for poisonous snakes, $\Delta G^2(1) < 0.01$, bootstrapped $p = .96$, and for nonpoisonous snakes, $\Delta G^2(1) < 0.01$, bootstrapped $p = .95$ (see Figure 3).

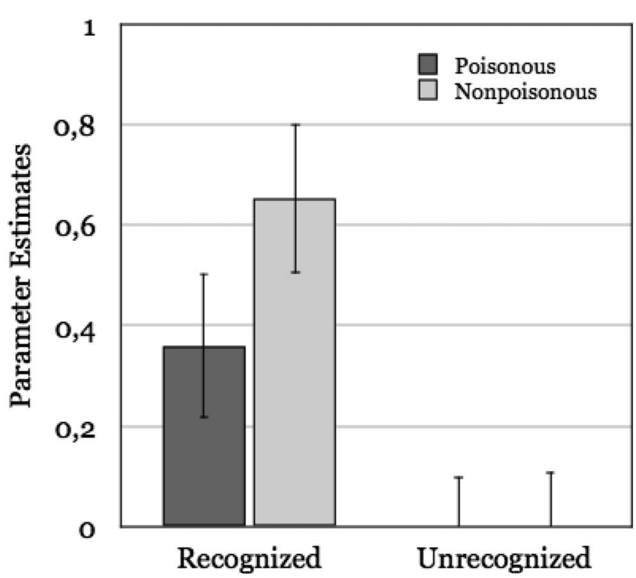

Figure 3. Estimates of the source memory parameters for recognized items (d_R) and estimates of the source memory parameters for unrecognized items (d_N) of the source memory model for recognized and unrecognized items obtained in Experiment 1. The error bars represent bootstrapped standard errors.

Discussion

Based on our literature review, our primary aim was to test the hypothesis that people may have above-chance source memory performance for threatening context information even when item recognition fails. The idea was that people may experience a feeling of threat or fear when looking at a poisonous snake even when they do not remember that the snake has been previously encountered. The results clearly disconfirmed this hypothesis: There was no evidence of emotional source memory in the absence of old–new recognition. Thus, it seems that the general principle implemented in many source memory models that source information is bound to item information and can therefore not be retrieved in the absence of item recognition is valid even for threatening context information.

Experiment 2

Before drawing firm conclusions, we thought it important to replicate the findings of Experiment 1. Experiment 2 was identical to Experiment 1, with the only difference being that participants were required to classify the snakes as poisonous and nonpoisonous during encoding, just as in the source memory test. Given that participants were required to give the same response during encoding and testing, we expected that source memory would increase due to transfer-appropriate processing. Thus, Experiment 2 provides even better conditions than Experiment 1 for detecting source memory for threatening context information in the absence of item recognition if it existed.

Method

Participants. The data of one participant had to be removed because he failed to correctly remember the color–poisonousness mapping. The remaining sample consisted of 40 students at Heinrich Heine University Düsseldorf (22 of whom were female; mean age of 27, $SD = 5$).

Stimuli and procedure. The stimuli and procedure were identical to those of Experiment 1, with the only exception being that participants were not required to perform a threat rating at encoding. Instead, they were required to classify each snake as poisonous or nonpoisonous using the same response buttons as in the subsequent source memory test.

Given the same assumptions as explained in the Method section of Experiment 1, an effect of size $w = .11$ (i.e., a small effect) could be detected in the multinomial analysis with a power of $1 - \beta = .95$.

Results

Old–new recognition. As in Experiment 1, old–new recognition in terms of P_r (hit rate minus false alarm rate) did not differ between poisonous snakes ($M = 0.31$, $SD = 0.28$) and nonpoisonous snakes ($M = 0.33$, $SD = 0.23$), $t(39) = 0.52$, $p = .61$.

Source memory. The base model was identical to that of Experiment 1 (again capitalizing on the finding that old–new recognition did not differ as a function of poisonousness) and implies that $D_1 = D_2 = D_{New}$ and that $a = g = e$. The base model fit the data well, $G^2(2) = 0.60$, $p = .74$. The parameter reflecting the tendency toward guessing that a snake was poisonous rather than nonpoisonous approximately corresponded to .50, $\Delta G^2(1) = 0.63$, $p = .43$, which is evidence of probability matching (Arnold et al., 2013; Bayen & Kuhlmann, 2011; Kuhlmann et al., 2012; Spaniol & Bayen, 2002). Source memory for recognized items did not differ between poisonous and nonpoisonous sources, $\Delta G^2(1) = 0.49$, $p = .48$. This pattern of results replicates the findings of Meyer, Buchner, and Bell (2015).

As in Experiment 1, source memory for recognized items clearly differed from zero, both for poisonous, $\Delta G^2(1) = 9.10$, bootstrapped $p < .01$, and for nonpoisonous snakes, $\Delta G^2(1) = 17.55$, bootstrapped $p < .01$. In contrast, neither the parameter representing source memory for the threatening context of unrecognized items, $\Delta G^2(1) = 0.59$, bootstrapped $p = .22$, nor the parameter representing source memory for the nonthreatening context of unrecognized items, $\Delta G^2(1) = 0.88$, bootstrapped $p = .17$, was significantly different from zero (see Figure 4). Again, the results are incompatible with the hypothesis that people are able to retrieve emotional source memory in the absence of item recognition.

Discussion

Experiment 2 replicates all findings of Experiment 1. There was no convincing evidence of source memory for threatening contexts in the absence of item recognition. The parameters representing source memory for unrecognized items did not differ significantly from zero. Thus, it seems safe to conclude from the findings of both experiments that successful retrieval of emotional (threatening) context information depends on item recognition.

Given that the two experiments were almost identical, it seemed justified to combine the data of the two experiments to see if evidence in favor of source memory for unrecognized items could be obtained with a larger sample. The base model again fit the data

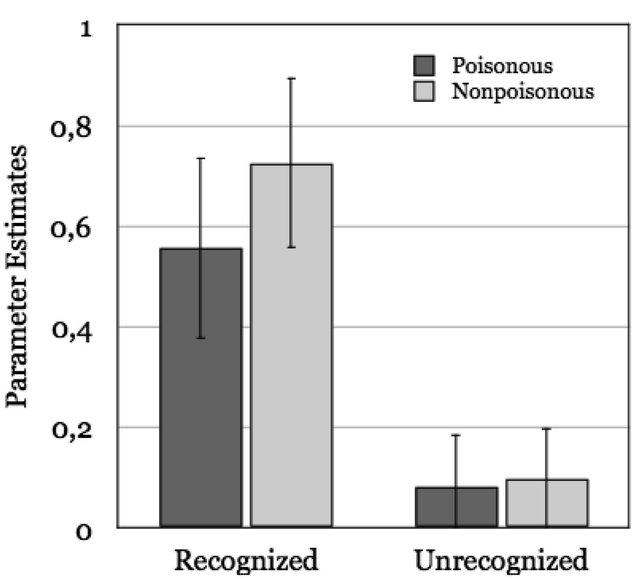

Figure 4. Estimates of the source memory parameters for recognized items (d_R) and estimates of the source memory parameters for unrecognized items (d_N) of the source memory model for recognized and unrecognized items obtained in Experiment 2. The error bars represent bootstrapped standard errors.

well, $G^2(2) = 2.15$, $p = .34$. Source memory for recognized items differed from zero, both in the poisonous condition, $\Delta G^2(1) = 15.73$, bootstrapped $p < .01$, and in the nonpoisonous condition, $\Delta G^2(1) = 38.17$, bootstrapped $p < .01$. The parameters representing source memory for unrecognized items, in contrast, were not different from zero in the poisonous condition, $\Delta G^2(1) = 0.25$, bootstrapped $p = .30$, and in the nonpoisonous condition, $\Delta G^2(1) = 0.11$, bootstrapped $p = .36$.

Experiment 3

In both previous experiments, source memory for recognized items was obtained, but it did not differ between poisonous and nonpoisonous snakes. This finding may be surprising at first sight, but it can be explained by assuming that the information that a stimulus with a threatening appearance is in fact harmless may violate expectations and may be experienced as at least as relevant as the information that such a stimulus is in fact dangerous. This means that both the information that a snake is poisonous and the information that a snake is nonpoisonous may have been perceived as emotional information. In Experiment 3, we contrasted such emotional information with nonemotional information by also presenting nonemotional stimuli (fish) paired with nonemotional source information (information about whether the fish were from Asia or Australia). This allowed us to provide a further test of the hypothesis that emotional in contrast to nonemotional information can be retrieved in the absence of item recognition. If this hypothesis were true, source memory for unrecognized items should be higher for emotional compared to nonemotional stimuli. However, based on the two previous experiments, we may expect that source memory in the absence of item recognition is equally low for emotional and nonemotional information.

Method

Participants. Participants were 39 students at Heinrich Heine University of Düsseldorf (32 of whom were female; mean age of 23, $SD = 3$).

Stimuli and procedure. The snake stimuli were the same as those used in the previous two experiments. The control stimuli were 32 fish taken from the study of Meyer, Buchner, and Bell (2015). Arguably, fish serve as ideal control stimuli because they are scaled animals but at the same time are perceived as nonthreatening (Meyer, Bell, & Buchner, 2015). A randomly selected set of 16 snakes and a randomly selected set of 16 fish were presented in the encoding phase. In contrast to the previous experiments, all snakes were presented in yellow in front of a green background during the encoding phase. The poisonousness or nonpoisonousness of the snakes was conveyed by the words *poisonous* or *nonpoisonous* in black-outlined white 40-point Arial font presented at the bottom of the pictures. Parallel to the snakes, the fish were presented in yellow in front of a green background in the encoding phase. The fish were associated with nonemotional source information: Participants were informed about whether the fish were from Asia or Australia by presenting the word *Asia* or *Australia* in black-outlined white 40-point Arial font at the bottom of the pictures. The order of the stimuli in both the encoding phase and the test phase was completely randomized. All other aspects of the procedure were identical to those of the previous experiments.

Given $\alpha = .05$, 39 participants, and 64 observations in the source memory test, an effect of size $w = .07$ (i.e., a small effect) could be detected in the multinomial analysis with a power of $1 - \beta = .96$.

Results

Threat ratings. Threat ratings were higher for snakes than for fish, $t(38) = 18.95$, $p < .01$. Consistent with Experiment 1, poisonous snakes ($M = 5.66$, $SD = 1.02$) were perceived as more threatening than nonpoisonous snakes ($M = 3.65$, $SD = 1.08$), $t(38) = 10.55$, $p < .01$. As expected, threat ratings were not affected by whether the fish were from Asia ($M = 1.26$, $SD = 0.89$) or Australia ($M = 1.22$, $SD = 0.91$), $t(38) = 0.32$, $p = .75$.

Old–new recognition. There was a descriptive tendency toward better recognition of snakes over fish, but it was not statistically significant, $t(38) = 1.62$, $p = .11$. Old–new recognition did not differ between poisonous snakes ($M = 0.36$, $SD = 0.17$) and nonpoisonous snakes ($M = 0.35$, $SD = 0.22$), $t(38) = 0.10$, $p = .92$, and did not differ between fish from Asia ($M = 0.31$, $SD = 0.27$) and fish from Australia ($M = 0.28$, $SD = 0.23$), $t(38) = 0.97$, $p = .34$.

Source memory. Two sets of the model trees shown in Figure 2 were needed to analyze the results of Experiment 3—one for snakes and one for fish, respectively. As in Experiments 1 and 2, we used a base model that implied that $D_1 = D_2 = D_{\mathrm{New}}$ and that $a = g = e$ for both types of stimuli (capitalizing on the findings that old–new recognition did not differ between poisonous and nonpoisonous snakes and did not differ between fish from Asia and fish from Australia). The base model fit the data well, $G^2(4) = 4.60$, $p = .33$. Other than in the previous experiments, the probability that a snake was associated with poisonousness was significantly above .50, $\Delta G^2(1) = 9.17$, $p < .01$, which indicates that the poisonousness of the snakes was somewhat overrepresented. This could be due to a contrast effect: The snakes may have been perceived as being more threatening compared to the fish, which could have made the participants more prone to schematic misrepresentations of the contingencies (see Meyer, Buchner, & Bell, 2015). The parameter reflecting the tendency toward guessing that a fish was from Asia rather than from Australia approximately corresponded to .50, $\Delta G^2(1) = 0.52$, $p = .47$, which is consistent with probability matching (Arnold et al., 2013; Bayen & Kuhlmann, 2011; Kuhlmann et al., 2012; Spaniol & Bayen, 2002). As in Experiments 1 and 2, source memory for recognized items did not differ between poisonous and nonpoisonous snakes, $\Delta G^2(1) = 0.49$, $p = .49$. Likewise, source memory for recognized items did not differ between fish from Asia and fish from Australia, $\Delta G^2(1) = 0.59$, $p = .44$. Furthermore, source memory for unrecognized items did not differ between poisonous and nonpoisonous snakes, $\Delta G^2(1) = 1.60$, $p = .21$, or between fish from Asia and fish from Australia, $\Delta G^2(1) = 0.70$, $p = .40$. All of the aforementioned restrictions concerning source memory were included into a new base model, which fit the data well, $G^2(8) = 8.99$, $p = .34$. This allowed us to test whether source memory for recognized items differed between emotional and nonemotional material, which was indeed the case, $\Delta G^2(1) = 4.76$, $p = .03$. Source memory for recognized items was significantly different from zero for emotional, $\Delta G^2(1) = 14.01$, bootstrapped $p < .01$, but not for nonemotional material, $\Delta G^2(1) = 0.48$, bootstrapped $p = .19$. More importantly, source memory for unrecognized items did not differ between emotional and nonemotional material, $\Delta G^2(1) = 0.87$, $p = .35$, and was in fact not significantly different from zero for both emotional, $\Delta G^2(1) = 1.35$, bootstrapped $p = .13$, and nonemotional material, $\Delta G^2(1) = 0.00$, bootstrapped $p = .99$ (see Figure 5).

Discussion

The first interesting observation from Experiment 3 is that source memory for recognized items differed between emotional and nonemotional information. In two previous studies, source memory for recognized items was found not to differ between snakes and fish (Meyer, Bell, & Buchner, 2015; Meyer, Buchner, & Bell, 2015). However, in one of these studies, nonemotional source information (color) was associated with both snakes and fish, while in the other study, emotional source information (poisonousness) was associated with both snakes and fish. In the present study, in contrast, the snakes were associated with emotional source information (poisonousness), whereas the fish were associated with nonemotional source information (origin). This pattern of results suggests that source memory for recognized items may vary as a function of the emotionality of the source information, in line with other studies showing memory advantages for emotional in comparison to nonemotional source information (Bell & Buchner, 2012; Buchner et al., 2009; Kroneisen et al., 2015; Mieth et al., 2016). The main purpose of Experiment 3 was to test whether source memory for unrecognized items may differ between emotional and nonemotional information. Consistent with Experiments 1 and 2, source memory for unrecognized items did not differ between emotional and nonemotional stimuli and was in fact absent for both types of stimuli.

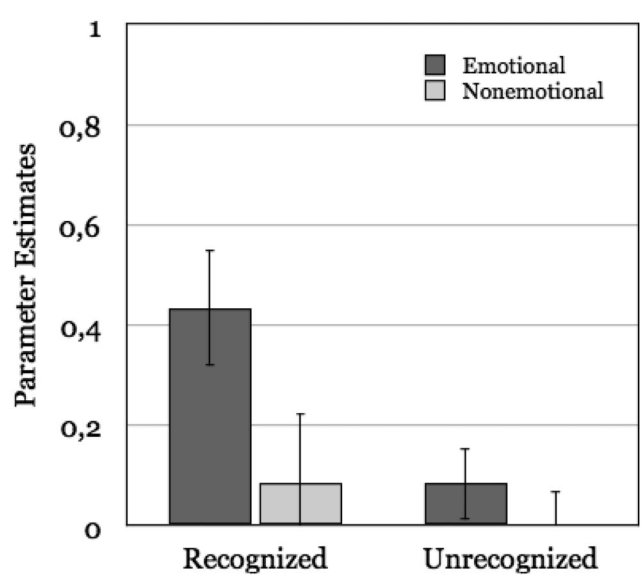

Figure 5. Estimates of the source memory parameters for recognized items (d_{R}) and estimates of the source memory parameters for unrecognized items (d_{N}) of the source memory model for recognized and unrecognized items obtained in Experiment 3. The error bars represent bootstrapped standard errors.

General Discussion

As mentioned at the beginning of the article, there is an increasing interest in examining source memory for emotional context information. In many previous studies, the existence of emotional source memory without item recognition was denied a priori by using measurement models that did not allow for the existence of source memory without item recognition (Bell & Buchner, 2012; Buchner et al., 2009; Kroneisen et al., 2015; Mieth et al., 2016). While this assumption seems reasonable when the context information does not carry emotional meaning (Malejka & Bröder, 2016), it should not be generalized to emotional source memory without empirical testing. A popular idea is that negative feelings are quickly and automatically retrieved from emotion-processing brain regions to warn individuals of danger in the environment. A priori, it seemed possible that these processes may operate in parallel to, and independent of, the processes responsible for item identification. From a functional perspective, the preferential retrieval of emotional context information could be useful because it may generally be more survival relevant to be aware of the fact that a snake is deadly than to remember that it has been encountered before. Therefore, it seemed conceivable that the emotional evaluation of the item at encoding may spill over to the test phase so that these items can be successfully classified as being threatening even when they cannot be successfully recognized. However, this hypothesis should not be uncritically accepted based on imaginative evolutionary storytelling. Therefore, the present study was set up to test whether participants may succeed in retrieving the association between an item and its aversive context information involving emotion-processing brain regions even when item recognition is not successful. We postulated that participants may experience a feeling of threat and thus fear when encountering a snake that was previously associated with poisonousness. However, no evidence in favor of this hypothesis was obtained in three experiments. In fact, the parameter representing source memory for unrecognized items associated with threatening context information (poisonousness) was not different from zero in all experiments. This was true even though the encoding instructions required participants to focus on threat (threat ratings, poisonousness judgments).

The unique contribution of the present study is showing that the assumption of no source memory without item recognition holds even when emotional context information is examined. As outlined at the beginning of the article, it cannot be taken for granted a priori that this relationship—which has been previously obtained with nonemotional material (Malejka & Bröder, 2016)—can be generalized to emotional material. There is an ongoing debate about whether memory of emotional context information is subject to the same principles as memory for nonemotional context information (Bell et al., 2015). For example, it has been demonstrated that older adults have surprisingly good source memory for emotional context information despite a general binding deficit and a corresponding decline in nonemotional source memory (May et al., 2005; Rahhal et al., 2002). The finding of no age differences in source memory has been demonstrated with the stimulus material used in the present study as well (Meyer, Buchner, & Bell, 2015). The finding that emotional source memory is comparatively well preserved in old age may be linked to the fact that it is often not associated with a detailed memory of the encoding episode but is instead due to emotional tagging (Bell et al., 2012). Furthermore, the assumption that emotional context memory is special has some plausibility because it seems likely that the emotional aspects of an encoding episode are retrieved from emotion-processing brain regions. Therefore, it is conceivable that the retrieval of nonemotional context information relies on brain mechanisms that differ from those involved in the retrieval of emotional context information (Smith et al., 2005). The abundance of evidence in favor of a dissociation between emotional and nonemotional source memory makes the present findings even more interesting. Some general rules may apply to all types of source memory. In particular, emotional context information is bound to item representations and cannot be retrieved in the absence of item recognition. One cannot remember that a snake is poisonous without remembering the snake.

Some may find it unsurprising that source memory depends on item memory because it seems obvious that successful source memory requires that the context (e.g., an emotional tag) has to be bound to an item representation. It seems difficult to imagine that participants succeed in using a test item as a cue to retrieve context information if the item is not recognized first. However, there is some evidence that the rule of no source memory without recognition may not hold true for all populations. For instance, Ceci, Fitneva, and Williams (2010) have shown that young children are prone to a specific type of error pattern where they fail to recognize an item but are still able to retrieve context information (e.g., to specify the room to which the item belongs). Ceci and colleagues attributed this finding to an impoverished representation of the items in memory, which could lead to metamemory problems. Thus, it would be premature to conclude that the assumption of no source memory without recognition holds true under all circumstances (e.g., distraction or cognitive load) and for all populations (e.g., children, older adults, and patients suffering from brain damage). Nevertheless, the first empirical test of this issue provided herein clearly weakens the idea that emotional source memory is independent of old–new recognition. When healthy young adults are tested, the retrieval of source information in the absence of item identification seems to play a negligible role at best.

To summarize, we used a straightforward extension of a well-validated multinomial source monitoring model to empirically test the assumption that there may be emotional source memory for unrecognized items. The results show that the principle that above-chance source memory performance is bound to successful item recognition is valid even for threatening context information.

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