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Involuntary versus Voluntary Episodic Memories:

The Effects of Encoding Factors and Emotion

Julie A. Niziurski[1, 2] & Dorthe Berntsen[1]

[1]Center on Autobiographical Memory Research, Department of Psychology and Behavioral Sciences, Aarhus University, Denmark

[2] Mathematics and Cognitive Psychology, Department of Experimental Psychology, Heinrich Heine Universität, Düsseldorf, Germany

Address for correspondence:

Julie A. Niziurski

Universitätsstr. 1

Mathematical and Cognitive Psychology

40225 Düsseldorf, Germany

Phone: +49 211 81-10586

Email: Julie.Niziurski@hhu.de

Abstract

Contrasting views exist as to how involuntary (spontaneous) versus voluntary (intentional) episodic memories are shaped by factors at encoding. However, there is limited systematic experimental research addressing this question. The present study uses measures obtained at encoding to predict frequencies and qualities of voluntary and involuntary memories of emotional scenes. The valence and contents of the scenes affected how frequently the scenes were recalled, similarly for involuntary and voluntary recall. Intensity, negative valence, and the degree to which a scene was perceived to tell a story at encoding were the most consistent predictors of all retrieval qualities, irrespective of retrieval method. Involuntary memories had shorter retrieval times, suggesting less effort. The present findings add to the accumulating evidence that involuntary episodic memories derive from the same episodic memory system as voluntary memories and that the two ways of remembering past events are similarly influenced by emotion at encoding.

Keywords: Involuntary Memory; Voluntary Memory; Emotion

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Involuntary versus. Voluntary Episodic Memories:

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Involuntary episodic memories are memories of past events that come to mind spontaneously without preceding attempts of retrieval. In contrast, voluntary episodic memories come to mind with deliberate effort on the part of the rememberer (Berntsen, 1996, 2009).

Although experimental research on everyday involuntary memories is limited, diary studies on involuntary autobiographical memories suggest that involuntary memories differ from voluntary memories in how they are retrieved (i.e., by involving less effort) but are similarly affected by factors at encoding, such as emotional arousal (Berntsen, 2009, 2010; Hall & Berntsen, 2008). Brain imaging studies show that involuntary and voluntary retrieval share considerable overlap in regions associated with retrieval success, but that voluntary retrieval has a unique association with dorsal frontal regions associated with retrieval effort (Hall et al., 2014; also see Hall et al., 2008; Kompus et al., 2011). Relatedly, reaction time data consistently show involuntary memories to be retrieved faster compared with voluntary memories (Berntsen, Staugaard, & Sørensen, 2013; Schlagman & Kvavilashvili, 2008; Staugaard & Berntsen, 2014), suggesting involuntary memories require less cognitive effort.

These findings contradict a theoretical view rooted in the clinical literature, according to which involuntary and voluntary memories have access to different information, based on factors present at the encoding of an event, such as emotional intensity (Brewin, 2014; Dalgleish, 2004; Ehlers & Clark, 2000; Horowitz, 1975; 1986; van der Kolk & Fisler, 1995; for reviews see Brewin & Holmes, 2003; James et al., 2016). This view hold that the voluntary memory for a trauma (a highly intense event) “should be unrelated, or if anything inversely related” to the involuntary memory for the same trauma (Brewin, 2014, pp. 76). According to this view, a highly intense and emotional event should lead to an impoverished encoding for voluntary memory of the event, but an improved accessibility for involuntary memory of the same event (Hall & Berntsen, 2008; Rubin, Boals, & Berntsen, 2008). Notably, this view arguing for two separate memory systems for voluntary and involuntary memory lacks the evidence for such systems in a cognitive theory of memory (see Berntsen & Rubin, 2014; Rubin, Boals, & Berntsen, 2008 for further discussion). In contrast to this two-systems interpretation, an alternative view based on experimental research, would predict that factors at encoding, such as emotional intensity, would affect memory in general (e.g., Bradley, Greenwald, Petry, & Lang, 1992; Cahill, Gorski, & Le, 2003; Dolcos, LaBar, Cabeza, 2004) regardless of retrieval mode (e.g., Berntsen & Rubin, 2008; 2014; Hall & Berntsen, 2008). Thus, a highly intense and emotional event will lead to an increased accessibility for both voluntary and involuntary retrieval (Rubin, Boals, & Berntsen, 2008). Consistent with this view, it is often found that voluntary and involuntary memories, even in clinical populations, do not differ in such aspects as access to negative information (Rubin, Boals, & Berntsen, 2008; Watson et al., 2012; see Berntsen, 2009 for review). Surprisingly, these contrasting views have received little attention in terms of systematic experimental research examining voluntary and involuntary memories on the basis of emotion manipulated at encoding. In the present study, we included subjective ratings of intensity, self-relatedness, and narrative at encoding as well as objective differences in valence, in order to test how these factors at encoding affect voluntary and involuntary retrieval, thus examining if voluntary and involuntary retrieval respond differently to these manipulations--suggesting they are of two separate systems--or respond similarly, suggesting they reflect the same underlying memory system.

Effects of Encoding Factors on Memory

The level of processing framework suggests that the more elaborately a stimulus is processed, the better the memory is maintained (Craik & Lockhart, 1972; see Craik, 2002; Roediger, Gallo, & Geraci, 2002, for reviews). One important encoding factor, viewed as a deeper level of processing, is self-reference. Research has shown that when information is related to the self, the information is more elaborately processed, and a stronger memory trace is created (Bellezza, 1984; Klein & Kihlstrom, 1986; Klein & Loftus, 1988; Maki & Carlos, 1993). However, most of these studies have been limited to voluntary recall (see Krans, 2013 for exception).

A related encoding factor, though less researched, is the perceived narrative structure of an encoded stimulus (Hall & Berntsen, 2008). This is a theoretically relevant encoding factor, as it is possible that material with a narrative structure would be more accessible for top down voluntary retrieval, compared with involuntary retrieval, due to its more schema-driven character (e.g., Owens, Bower, & Black, 1979; also see Hall & Berntsen, 2008).

To our knowledge, only two studies have experimentally examined the impact of encoding factors on involuntary and voluntary recall. First, Hall and Berntsen (2008) had participants encode and rate pictures of highly negative scenes. Participants were then given a diary to record involuntary and voluntary memories for the following five days. The scenes that were frequently remembered during the diary period were those that induced the greatest emotional reaction at encoding, irrelevant of retrieval method. Additionally, stimuli with a narrative content were better remembered voluntarily than involuntarily. This is consistent with the view that voluntary retrieval, to a greater extent than involuntary retrieval, relies on a schema-based search that benefits from a narrative structure of the to-be-remembered material (e.g., Owens et al., 1979; Pichert & Anderson, 1977). However, narrative content was only examined through post hoc objective coding done by independent raters (Hall & Berntsen, 2008).

Second, in a series of experiments, Staugaard and Berntsen (2014) used an experimental paradigm manipulating involuntary and voluntary recall of negative and neutral stimuli. Participants encoded scene-sound pairings and later their memories for these pairings were tested. At retrieval, the sounds were used as cues to elicit memories for the scenes that were originally paired with each

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sound. Involuntary and voluntary retrieval showed the same pattern with regards to how they were cued and how the stimuli were remembered. Interestingly, Staugaard and Berntsen (2014) found that negative stimuli were only remembered more frequently than neutral stimuli after longer (>= 24-hour) delays, a pattern that was true irrelevant of retrieval method.

Present Study

The two previous experimental studies (Hall & Berntsen, 2008; Staugaard & Berntsen, 2014) had some limitations. First, both lacked the use of a broader emotional spectrum. Hall and Berntsen (2008) used only negative stimuli and Staugaard and Berntsen (2014) used only negative and neutral stimuli. Second, Hall and Berntsen (2008) did not control the retrieval phase which was a diary study. Third, Staugaard and Berntsen (2014) only measured intensity at encoding and therefore lacked analysis of other possible encoding characteristics. Fourth, both studies examined the effects of encoding factors on the frequency of memory retrieval, but ignored other characteristics measured at the time of retrieval, such as vividness and specificity.

The present study attempted to remedy these issues. Using the experimental design of Staugaard and Berntsen (2014), the present study had control over the encoding and retrieval of the presented stimuli, and used negative, neutral, and positive stimuli. The present study used many of the same encoding measures as Hall and Berntsen (2008) to predict frequency and retrieval qualities, but with experimental control during both encoding and retrieval, we could examine these relationships more systematically. In addition, the present study asked participants for their ratings of the narrative of the stimuli during encoding, an improvement from the post hoc coding used in Hall and Berntsen (2008). By using ratings obtained at encoding to predict ratings of the same emotional material at retrieval, the present study was able to investigate the claim that involuntary and voluntary memories are similarly affected by encoding factors (e.g., Berntsen & Rubin, 2008).

Method

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Participants

Fifty participants were recruited through the Center on Autobiographical Memory Research's participant database. Participants were randomly assigned to either the involuntary (n = 28) or voluntary (n = 22) retrieval condition[1].

As previously mentioned, we expected few differences between involuntary and voluntary retrieval in the way they were affected by encoding factors and emotional valence of the scenes to be remembered. In order to establish that we had enough power to detect theoretically relevant interaction effects, we based a power analysis on effect sizes from Watson and colleagues (2013), who reported a group interaction with involuntary versus voluntary retrieval with regards to level of specificity. We chose this strategy because previously reported effects of involuntary versus voluntary retrieval are generally limited to main effects, with few interactions with third variables reported. We used G-Power (Faul et al., 2007) to conduct an ANOVA between factors power analysis with a power of .80 and determined that we would need a total of 32 participants to detect an interaction with involuntary and voluntary retrieval. As we had 50 participants in the present study, we had sufficient power to detect differences. Participants received a movie ticket for their participation.

Materials

Thirty-six scenes from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008) were used as the visual stimuli. Scenes were chosen based on their ratings of valence and arousal. Of the 36 scenes, 12 were negative (M = 1.89), for example, a severed hand and a dead dog, 12 were neutral (M = 4.47), for example, a turtle and a hammer lying on the floor, and 12 were positive (M = 7.85), for example, a beach and a rollercoaster. The negative and positive scenes were chosen so that they were both high in arousal, M = 6.17 and M = 6.00, respectively, and equal to one another, t (22) = 0.63, p = .54, Cohen's d = .26. The neutral scenes were low in arousal

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(M = 4.04) and were significantly lower compared to both the negative, t (22) = 6.38, p <.001, Cohen's d = 2.60, and positive, t (22) = 5.44, p <.001, Cohen's d = 2.22, scenes. All scenes were unique in that they were easily distinguishable from one another and easy to describe in a few words.

Sounds were paired with the IAPS scenes during encoding and these same sounds were used during the retrieval phase as cues. Sounds were selected to appear either unique or repeated to the participants. The principle of encoding specificity predicts that the cues that are specific (unique cue) to an encoded event will help to trigger recall of the event at a later time (Tulving & Thompson, 1973). However, a singular cue may be associated with multiple events (repeated cue), therefore the principles of cue overload and the importance of cue distinctiveness imply that the more events or memories a cue is associated with, the less likely one specific event or memory will be triggered by the cue (Watkins & Watkins, 1975; see also Hunt & Smith, 1996; Mäntylä, 1986; Rubin, 1995; Staugaard & Berntsen, 2014; Tulving, 1974). Therefore, during the retrieval phase of the present experiment, the unique sounds should appear more distinct compared with the repeated sounds and thus elicit more memories.

Thirty-six sounds were selected from Staugaard and Berntsen (2014). All sounds were 4s in length. Eighteen unique sounds were easily distinguishable from one another. Eighteen repeated sounds came from the same two categories, cars and city sounds. The individual sounds in each category were difficult to differentiate. Sounds were chosen to be neutral and unrelated to any of the visual stimuli.

Design and Experimental Procedure

The experiment was a 3 (Valence: negative vs. neutral vs. positive) x 2 (Cue: unique vs. repeated) x 2 (Retrieval: involuntary vs. voluntary) mixed design with valence and cue as the within-subject variables and retrieval as the between group variable. The experiment was created

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using E-Prime 2.0 Professional (Psychology Software Tools, Pittsburgh, PA). The program was based on the design from previous studies (Berntsen, Staugaard, & Sørensen, 2013; Staugaard & Berntsen, 2014) but was modified to include three types of emotionally valenced scenes. The experiment included three phases, which all participants completed in one one-hour session: encoding, retrieval, and recognition. Each phase is described in detail below.

Encoding. During encoding, participants were presented with 36 scene-sound pairings, one at a time. Each trial began with a fixation cross at the center of the screen. Then a scene would appear on the screen and a sound would play simultaneously for 4s. Participants would then answer five questions regarding the scene-sound pairing, which were all answered using a 5-point Likert scale. First, they were asked to rate how emotionally intense they found the scene, where 1= not at all intense and 5 = very intense. Second, they were asked "Do you experience a bodily reaction when you think of the scene (e.g., Palpitations, anxiety, tension)?", 1= not at all and 5 = greatly. Third, participants rated how negative or positive they thought the scene was, 1 = negative and 5 = positive. Forth, they were asked "Can you relate this scene to yourself?", 1 = not at all and 5 = greatly. The fifth and final question was "Does this scene tell a story?", 1 = not at all and 5 = greatly. All questions were answered using the number keys on the keyboard. After answering all five questions, the participants were again presented with the same scene-sound pairing for 4s. After the second viewing, the fixation cross would again appear on the screen, thus signaling a new trial. This procedure was repeated until all 36 scene-sound pairings had been presented.

The 36 scene-sound pairings were semi-randomly presented to each participant. There were two encoding lists that participants could potentially study. Each participant studied only one list. The scenes and sounds were the same on both encoding lists; however, the pairings were different. For each type of scene, negative, neutral, and positive, half of them were paired with unique sounds and half were paired with repeated sounds. For example, of the 12 positive scenes,

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six were paired with unique sounds and six were paired with repeated sounds. If a scene was paired with a unique sound on List 1, then it was paired with a repeated sound on List 2. To illustrate, if the positive scene of a beach was paired with a unique sound (e.g., a cuckoo clock) on List 1, then the same scene of a beach was paired with a repeated sound (e.g., a car sound) on List 2.

Retrieval. The retrieval phase is the only phase of the experiment that differed depending on the retrieval group, involuntary or voluntary. This is consistent with the procedure used in previous work based on this paradigm (e.g., Staugaard & Berntsen, 2014)

Involuntary. In the involuntary retrieval condition, participants were told that they were going to complete a star location task. Participants were instructed that they would see a star on either the left or the right side of the screen. At the same time, they would hear a sound in either their left or right ear. Their task was to determine which side of the screen the star was on. Participants would press "1" if the star was on the left side and "2" if the star was on the right side. This task was chosen to be used in the involuntary condition as previous research has shown that involuntary memories often occur during mundane tasks (Berntsen, 1998, 2009; Schlagman & Kvavilashvili, 2008). This task has also been successfully used in previous versions of the paradigm (i.e., Berntsen, Staugaard, & Sørensen, 2013; Staugaard & Berntsen, 2014).

After making sure that they understood the star location task, we then added that if, while completing this task, "an image suddenly appears in your memory, press the "3" key instead of the "1" or "2" key." Some participants questioned what we meant by "image", to which we responded, "anything you might have seen or experienced before". If participants pressed the "3" key, then the star-location task was interrupted, and participants were asked questions about the memory that came to mind. First, participants were asked to describe the memory. There was no character limit on the memory descriptions; however, most participants used a few keywords phrases--that is, less than 10 words--to describe the memory. All responses were typed into the program using the computer's keyboard. After describing the memory, participants were then asked six questions: 1. "How specific is the memory?" 2. "How intense is the memory?" 3. "Do you experience any bodily reactions to the memory?" 4. "How vivid is the memory?" 5. "Does the memory affect your mood?" 6. "How would you categorize the memory?". The sixth question was answered about the valence of the memory, negative, neutral, or positive. All questions were rated on a 5-point Likert scale, 1 = not at all and 5 = greatly, except for the category of the memory, which was rated on a 3-point scale matching the valence categories used in the experiment (negative, neutral, and positive). After participants answered the last question, they were instructed that they were to return to the star-location task.

Each trial began with a fixation cross and the presentation of a sound in one of the ears. While the sound was playing, participants could respond if they had a memory by pressing "3"; however, they could not press "1" or "2" until the star appeared. The star appeared after a 1.5s pause after the initial playing of the sound and the star remained on the screen until a response was made. Participants could still press "3" to indicate an involuntary memory, even when the star was on the screen. All sounds were presented in a random order to all participants. Participants heard the same 36 sounds that were presented during the encoding phase and an additional 18 filler sounds, which should not elicit any memories. Each sound was played twice, once in each ear. Therefore, the involuntary condition comprised of 108 trials.

Voluntary. As in the involuntary group, the sounds from encoding were used as cues in the voluntary group. Participants in the voluntary retrieval group were instructed that they were going to hear the same 36 sounds from the encoding. Participants were told that they were to try to remember the scene that was paired with the sound that was playing. Participants pressed "1" if they could remember the scene and "2" if they could not remember the scene. If the participants pressed "1" then they were asked to describe the scene and answered the same 6 questions as the

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involuntary group. Each sound played for 4s and the program would not continue to the next sound until a response had been made. The sounds were randomly presented and participants completed 36 trials. No filler sounds were used in this condition as the voluntary group were explicitly told they were completing a memory task, whereas in the involuntary group, we did not want it to be evident they were completing a memory task and thus we included previously unheard sounds as to mask the memory task.

Recognition. All participants completed the same recognition task. Participants were presented with two scenes on the computer screen. One of the scenes they had seen during encoding and the other was its mirror image. Participants were instructed to choose which scene they remembered seeing during encoding. Participants pressed "1" if they thought it was the scene on the left and "2" if they thought it was the scene on the right. After selecting the scene, participants were asked to rate their confidence of their selection on a 5-point Likert scale. Participants completed 36 trials, one for each scene. Trials were randomly presented to each participant.

Procedure. Participants were invited to participate in the study via the Center on Autobiographical Memory Research's participant database. With their written invitation, participants were given a brief description of the study, which informed them that they may be exposed to unpleasant stimuli, but did not give any rationale or further explanation of the main purpose of the study. After arriving at the laboratory, participants were seated in front of a computer with a screen that said "Welcome to the experiment. Please turn off your cell phones." Participants were given an information sheet, which contained their rights as a participant as well as a consent form. After all questions had been answered, participants signed the consent form, and the experimenter gave the oral instructions for the encoding phase of the experiment. Participants also read all instructions prior to initiating each phase on the computer. However, oral instructions were also given prior to the retrieval phase. The experimenter remained in the room during the

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experiment and participants were encouraged to ask questions at any time should any arise. After completing the recognition phase, participants were debriefed and compensated for their participation. The study was approved by the local ethics committee.

Strategies for Statistical Analyses

As our design indicates, each participant gave a number of responses to a set of stimuli. Therefore, our data is clustered around 50 participants, of whom 40 retrieved memories. There are multiple ways to handle this clustering problem. The first, to examine the frequency of the memories for each scene-sound pairing (i.e., negative scene paired with unique sound, etc.), we conducted a repeated-measures ANOVA using proportional means for each participant. In order to accurately compare the voluntary and involuntary groups, proportional means were calculated for each participant instead of using the raw totals. This is because the involuntary group heard the cueing sounds twice (once in each ear) and therefore had the opportunity to have double the memories compared with the voluntary group, which only heard the sounds once. However, this analysis limited our power as it was based on aggregate scores within the 50 (40) participants. Therefore, for the remaining analyses again examining frequency as well as the qualities of the memories (intensity, vividness, etc.), we conducted mixed model analyses.

Mixed model analysis is another strategy to control for the fact that the recorded memories were clustered around 40 participants. Mixed model analyses partition out variance derived from subject variability by treating subjects as a random effects factor. This allows the analyses to be conducted with individual memories as the unit of analysis (Field, 2014) and thus increased the number of cases in the statistical analyses. The mixed model analyses were run separately for each predictor variable (described below) and each examined a possible interaction with retrieval group. When including an interaction in a mixed model, main effects and the interaction should be reported together, as separating them may result in inappropriate interpretations (Snijders & Bosker, 2004).

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Results

Data Preparation

In total, there were 10 participants who did not retrieve any memories, of which nine were in the involuntary condition. Their data were only included in analyses concerning memory frequency.

The memories recorded during retrieval were coded for their reference to the scenes presented during encoding. This was done by the main researcher, and 20% of the memories were also coded by an independent coder with a 100% interrater agreement. Since we were interested in predicting memories of the previously presented scenes based on their encoding ratings and type of cuing (unique or repeated sounds), we excluded memories that were deemed uncodable (i.e., they were autobiographical or the memory description included multiple scenes). As these responses did not refer specifically to previously presented scenes, they could not be submitted to our analyses. Of all the involuntary memories, 34.40% were deemed uncodable and 13.76% of the voluntary memories were uncodable. In the involuntary condition, we also excluded 26 memories retrieved in response to the filler sounds. Filler sounds were only played in the involuntary condition and served no purpose for the present analyses. As in Staugaard and Berntsen (2014), a number of indiscriminately cued memories were observed. These were scene memories retrieved in response to sounds that the participants had heard during encoding, but in association with a scene different from the one recorded during retrieval. In the voluntary condition there were 91 indiscriminately cued memories (M = 4.14, SE = .63) and 76 in the involuntary condition (M = 2.71, SE = .70). There was no significant difference in the number of indiscriminately cued memories between groups, t (48) = 1.47, p = .15, Cohen's d = .43. Consistent with previous work (e.g., Staugaard & Berntsen, 2014), such memories were included in the analyses for the following reasons: First, they were valid memories of previously presented scenes. Second, participants were not asked to monitor for scene-sound accuracy, which would be against the idea of spontaneous recall. Third, it was not meaningful to distinguish between subjectively similar – although objectively different – repeated cues in our coding scheme (see Staugaard & Berntsen, 2014).

Manipulation Checks

Two analyses were conducted in order to check that the experiment performed correctly. First, the two study lists were analyzed to ensure that participants performed similarly on both lists. The two study lists, List 1 (M = 7.40, SE = 1.25) and List 2 (M = 5.72, SE = 1.39), did not differ in the raw total number of memories they elicited, t (48) = .90, p =.74, Cohen's d = .25. Therefore, neither list studied had an advantage over the other.

Second, performance on the recognition task was analyzed to ensure that participants in both groups did in fact encode the scenes even if they did not retrieve memories for them during the retrieval phase. Both the involuntary (M = .91, SE = .01) and the voluntary (M = .91, SE = .01) groups performed well on the recognition task and did not differ on their mean number of correct responses. The involuntary group also did not differ from the voluntary group in terms of their mean confidence rating, M = 4.31 (SE = .08) and M = 4.30 (SE = .12) respectively. This ensures that while some participants only noted a few memories or none at all, the scenes were properly encoded and could be accurately recognized.

Frequency of Memories

We were interested in examining if the two retrieval groups, involuntary and voluntary, differed in the number of memories retrieved as a function of the valence of the scenes and their associated cues. All 50 participants were included in the analysis. On average, the voluntary group recalled 7.45 memories (SE = .92) and the involuntary group recalled, on average, 5.86 memories (SE = 1.51). As expected, the voluntary group was slower in retrieval (M = 8.38s, SE = .80) compared to the involuntary group (M = 3.95s, SE = .20), t (326) = 5.38, p < .001, Cohen's d = .59.

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This held true even as the participants progressed through the recall phase, as there were no significant differences in reaction time from the first half of the recall trials to the second half for either group. The voluntary group maintained their slower reaction time from the first half of the recall trials (*M* = 9.22, SE = 1.32) to the second half (*M* = 7.18, SE = .44), *t* (162) = 1.26, *p* = .21, Cohen's *d* = .21, and the involuntary group was consistently as fast in their first half (*M* = 3.81, SE = .19) as in their second half of the trials (*M* = 4.12, SE = .37), *t* (162) = -.79, *p* = .43, Cohen's *d* = .12.

Using the proportional means (previously described), we ran a repeated-measures ANOVA with valence (negative, neutral, or positive) and cue (unique or repeated) as the within-subject variables and retrieval (involuntary or voluntary) as the between subject variable (see Figure 1a). There was a main effect of valence, *F* (2, 96) = 16.31, *p* <.001, η_p^2 = .25. Neutral scenes were recalled significantly more frequently (*M* = .22, SE = .03) compared to both the proportion of negative (*M* = .12, SE = .02) and positive (*M* = .11, SE = .03) scenes, *p*s <.001. There was no difference in the proportion of negative and positive scenes recalled, *p* = .70, SE = .02. As expected, there was also a significant main effect of cue, *F* (1, 48) = 46.21, *p* <.001, η_p^2 = .49, with more memories being recalled to unique (*M* = .22, SE = .02) compared to repeated (*M* = .08, SE = .01) sounds, *p* <.001, SE = .02. There was also a significant main effect of retrieval, *F* (1, 48) = 16.45, *p* < .001, η_p^2 = .26, with the voluntary group having more memories (*M* = .21, SE = .03) compared with the involuntary group (*M* = .08, SE = .02), *p* <.001, SE = .03. All of these findings are consistent with Staugaard and Berntsen (2014).

There was a significant interaction of valence and retrieval group, *F* (2, 96) = 6.41, *p* = .002, η_p^2 = .12. The voluntary group remembered a greater proportion of neutral memories compared to negative (*p* = .004, SE = .09) and positive (*p* = .001, SE = .10) memories. There was no difference in the proportion of negative and positive memories recalled, *p* = .23, SE = .05. The

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involuntary group also remembered more neutral memories compared to negative memories (p = .01, SE = .04), but there was no significant difference between the number of neutral and positive memories (p = .16, SE = .05). Similar to the voluntary condition, there was no difference in the number of negative and positive memories retrieved, p = .16, SE = .03 (see Figure 1b).

In order to optimize the level of statistical power and to allow us to analyze the potential effects of more encoding variables, we conducted mixed model analyses to predict frequency based on valence and subjectively rated encoding variables. The mixed models were based on 1800 cases (frequencies of 36 scenes for 50 participants), thus increasing our power from the repeated-measures ANOVA. As predictors of frequency of retrieval, we used the IAPS valence and the encoding ratings of intensity, self-relevance and story. In the analyses on frequency, we included all 50 participants and used a square root transformation on the raw totals to reduce noise in the frequency distributions. The mixed model results confirmed our results from the repeated-measures ANOVA. There were no main effect or interactions with retrieval group other than with regards to valence. This interaction with valence replicated the interaction from the ANOVA. None of the other encoding measures showed an effect on frequency (see Table 1).

Although objectively and subjectively rated scene characteristics had few effects on the frequency with which the scenes were subsequently retrieved, an inspection of the frequencies clearly suggested that certain scenes appeared to be remembered more frequently than other scenes, for example a scene with puppies was recalled 29 times whereas a scene with skydivers was recalled only twice (see Table 2). It also appeared that the rank order for the retrieval frequencies of the scenes was quite similar for involuntary and voluntary memories, suggesting similar effects of scene content on the two types of retrieval. In order to examine this more carefully, we ran a spearman’s rho analysis on the frequency of recall of each scene comparing involuntary and voluntary retrieval. The correlation was quite high, r_s (36) = .70, $p < .001$, indicating that certain

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scenes were more frequently retrieved than others, but notably this was unaffected by retrieval condition; highly frequent scenes in the voluntary group were largely the same scenes in the involuntary group (see Table 2).

Predicting Retrieval Characteristics

A key purpose of the present study was to examine if characteristics of the memories recorded at retrieval could be predicted by measures recorded during encoding and furthermore, if this would interact with retrieval strategy, involuntary versus voluntary. Therefore, for the following analyses, we included only the 40 participants, who had retrieved at least one valid memory (involuntary n = 19; voluntary n = 21), which gave us a total of 328 memories included in the analyses. To conduct these analyses, we used mixed model analyses with a fixed slope.

Each predictor variable (encoding ratings of intensity, self-relatedness, and story, and the IAPS valence; see Table 3 for correlations) was paired with each variable measured at retrieval (intensity, vividness, specificity, valence, and reaction time). Pleasantness, which was also recorded during encoding, was not included in these analyses due to its high correlation with the IAPS valence, r = .71. The same reasoning led us to leave out the encoding measure of bodily reaction as it was highly correlated with the encoding measure of intensity, r = .76.

We conducted twenty separate mixed model analyses. (Note that this relatively high number of analyses works against our hypothesis of not finding interaction effects). Table 1 displays the F-values and significant predictors for each dependent variable. Overall, the two retrieval groups’ encoding measures similarly predicted retrieval measures. Out of twenty possible, we identified only three interactions with retrieval type: an interaction between encoding intensity and retrieval type for recall intensity and vividness, and an interaction between encoding valence and retrieval type for recall valence (see Figures 2a, 2b, & 5d). These three interactions were significant at the p <.05 level. They might reflect the fact that we had fewer observations in the

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involuntary group compared with the voluntary group and thus a noisier pattern in the former than the latter, yielding interactions that might be absent in larger samples. At any rate, these interactions are hard to interpret and do not show a systematic pattern of retrieval related differences.

All other significant effects were main effects of the predictor variables, with no further interactions with retrieval. Intensity at encoding significantly predicted all retrieval measures, aside from reaction time (see Figures 2a-d). How well one could relate to the scene (self-relatedness) was only a significant predictor of the valence ratings at recall (see Figure 3a) and had no predictive power with the other retrieval variables (see Figures 3b-d). How well the scene told a story was a strong predictor for multiple retrieval variables (see Figures 4a-c), but not the subjective rating of valence at recall (see Figure 4d). The IAPS valence was also a strong predictor for all retrieval variables, aside from reaction time (see Figures 5a-d). Finally, only retrieval condition significantly predicted reaction time within each mixed model analyses. As previously reported, this was in the expected direction of involuntary memories being retrieved faster than voluntary memories. There were some correlations between the subjective ratings at encoding and the IAPS valence (see correlations in Table 3). However, when the analyses were conducted controlling for valence, similar results were attained.

Summary

The results from the present study largely replicate findings from previous studies (e.g., Berntsen, Staugaard & Sørensen, 2013; Staugaard & Berntsen, 2014), but expand on these findings by examining a broader emotional spectrum as well as the relation between encoding factors, retrieval frequencies, and retrieval qualities. Consistent with Staugaard and Berntsen (2014; in their Studies 1 and 2, using short retention intervals), neutral memories were recalled more frequently compared with emotional (negative and positive) memories for both voluntary and involuntary memories. Predicting frequency of recall for the two types of memories using a mixed model

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analytic strategy reproduced these findings. In addition, notable effects of scene content (independent of IAPS ratings) were observed on the frequency with which the scenes were remembered. It is unclear exactly which aspect of the content these effects reflected, but, importantly, they followed the same pattern for both types of retrieval.

In addition, we demonstrated that the relationship between encoding factors and retrieval qualities was similar for voluntary and involuntary retrieval. Overall, measures taken at encoding were found to predict measures at retrieval, irrelevant of retrieval method. The emotional intensity and valence of the stimuli were strong predictors for emotion, vividness, and specificity at retrieval. The narrative of the stimuli was also a relatively strong predictor, whereas self-reference had little predictive value. A few interactions with retrieval method did occur, which might reflect fewer observations in the involuntary retrieval group, resulting in a slightly noisier pattern, compared with the voluntary condition, or random effects of multiple testing. These interaction effects were significant only at the $p < .05$ level, and should be interpreted with caution. Generally, the same overall pattern was found in both retrieval conditions.

Discussion

The present study utilized a unique experimental design to examine the qualities of voluntary and involuntary memories of emotional stimuli as a function of factors measured at encoding. The reaction time data showed involuntary memories were retrieved about twice as fast as voluntary memories, suggesting that we were able to successfully induce involuntary memories in the laboratory (also see Berntsen, Staugaard, & Sørensen, 2013; Schlagman & Kvavilashvili, 2008; Staugaard & Berntsen, 2014). Within the involuntary group, we were confident we measured involuntary *explicit* memory, - as opposed to implicit or unconscious memory - as participants spontaneously re-experienced a previous event (a scene from encoding), without an intention to retrieve that information (Schacter, 1987; Schacter, Bowers, & Booker, 1989) and answered

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questions about their conscious experience of each reported memory (e.g., its vividness) as evident by their subjective ratings of their memories at retrieval. Additionally, using measures from encoding, we were able to prospectively predict the frequencies of recall and qualities of the memories for both involuntary and voluntary recall of the same emotional stimuli. This allowed us to examine the competing views in the memory literature about whether encoding factors affect involuntary and voluntary memories differently (Brewin, 2014) or similarly (Berntsen 2009; 2010).

Frequency of recall was associated with the valence of the encoded scenes, with neutral scenes being retrieved more frequently than negative and positive scenes, consistent with Staugaard and Berntsen (2014; Studies 1 and 2). The dominance of neutral scenes was consistent across involuntary and voluntary recall. Effects of scene content were found, with some scenes being recalled considerably more frequently than others, but this effect was largely similar for both types of recall (see Table 2).

Turning to the qualities of the memories at retrieval, intensity and the objective rating of valence at encoding were the most consistent predictors. The more intense a scene was rated at encoding, the more intense, vivid and specific the memory for this scene was rated at recall, consistent with previous research (e.g., Matlin & Stang, 1978; Talarico, LaBar, & Rubin, 2004; Waters & Leeper, 1936). In addition, intensity at encoding was associated with negative valence during retrieval. Compared with neutral and positive scenes, negative scenes were rated higher on intensity, vividness, and specificity at the time of retrieval (see Figures 5a-c and Table 1).

The narrative of the scenes was also a consistent predictor of the qualities of the memories. The more a scene was rated as telling a story during encoding, the more intense, vivid, and specific the memory at recall. This finding follows research in other areas, which shows narrative improves memory for information (i.e., Pichert & Anderson, 1977; Poulsen, Kintsch, Kintsch, & Premack, 1979; Rumelhart, 1977; Thorndyke, 1977; see Craik, 1979 for review). However, most of these studies examined the memory for a story given to participants instead of participants' rating the degree of narrative, as done in the present study. This is the first study, to our knowledge, to examine how perceived narrative qualities of emotional stimuli affect subsequent involuntary and voluntary recall.

The present study found little predictive effects of the rating of self-relatedness at encoding (also see Higgins & Bargh, 1987; Klein & Nelson, 2014). We only found an effect with regards to the subjective rating of valence at retrieval, reflecting that the more a scene was rated as being self-relatable, the more positive the memory was rated at recall. This could simply be due to the content of the presented IAPS scenes where positive scenes depicted holidays and sporting events, and the negative scenes were more gruesome. Future studies may want to use alternative picture databases (for further discussion see Dan-Glauser & Scherer, 2011; Marchewka, et al., 2014).

Importantly, the effects of encoding ratings were largely irrelevant of retrieval condition. The only consistent differences found between the involuntary and voluntary retrieval conditions were reaction time (involuntary faster than voluntary) and the number of memories (voluntary > involuntary). When interactions with retrieval did occur, they were small, unsystematic, and appeared to reflect fewer responses (thus a noisier pattern) in the involuntary group. This finding is consistent with the theory of involuntary memory being a basic form of remembering (Berntsen, 1998; 2009; 2010; Mace, 2007; Rubin, Boals, & Berntsen, 2008) and the view that factors present at encoding affect voluntary and involuntary memory similarly (Berntsen, 2009; Ferree & Cahill, 2009; Hall & Berntsen, 2008; Krans, et al., 2013; Rubin & Berntsen, 2009). The present study thus finds support for the view that voluntary and involuntary memory are of the same memory system and only differ in how they are retrieved (Berntsen, 2009, 2010; Hall & Berntsen, 2008). This is inconsistent with the view that involuntary and voluntary memory are of two separate memory systems and should have different access to encoded information (Brewin, Dalgleish, & Joseph,

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1996; Brewin & Holmes, 2003; Ehlers & Clark, 2000; Horowitz, 1986, van der Kolk & Fisler, 1995; see Brewin, 2014 for review).

Limitation

As noted, age and gender were not recorded due to clerical error, which precludes any control for potential effects of gender. Moreover, given the fact that the participants in the present study were drawn from a population dominated by young women (i.e., psychology students at Aarhus University) more research is needed to examine whether the findings generalize to other and more diverse populations.

Conclusion

The present study examined involuntary and voluntary recall of emotional stimuli and how encoding factors predicted the qualities of memories. We replicated and extended previous studies that utilized a similar experimental paradigm (Berntsen, Staugaard, & Sørensen, 2013; Staugaard & Berntsen, 2014), with our findings that involuntary memories were retrieved more quickly than voluntary memories, and voluntary memories were more frequent. Scene valence and content affected the frequency with which memories were recalled. These effects were independent of retrieval strategy. Intensity, negative valence, and the degree to which a scene was perceived to tell a story at encoding were the most consistent predictors of retrieval qualities, again irrelevant of retrieval method. Some theories assume that involuntary and voluntary memories of a traumatic or highly negative event are either unrelated or inversely related to one another (e.g., Brewin, 2014; Ehlers & Clark, 2000). However, the present findings add to the accumulating evidence that both involuntary and voluntary memory are basic forms of remembering (Berntsen, 1998) that react similarly to most encoding factors, suggesting that they operate on the same underlying system, albeit through different retrieval routes.

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Footnote

[1]Due to experimental error, age and gender were not recorded.

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Tables/Figures

Table 1

Mixed Model Results of Encoding Variables Predicting Retrieval Measures

	Measures at Retrieval					
	Intensity	Vividness	Specificity	Valence	Reaction Time	Frequency+
	F	*F*	*F*	*F*	*F*	*F*
Predictor Variables						
Encoding Intensity						
Retrieval	.82	.68	2.96	.01	33.35**	2.96
Intensity	52.57**	13.84**	4.40*	35.45**	2.18	1.22
Retrieval x Intensity	3.14*	2.69*	1.29	.89	1.15	1.42
Encoding Self						
Retrieval	.44	3.20	.24	2.34	14.81**	1.14
Self	1.79	.27	1.12	10.06**	.76	1.10
Retrieval x Self	1.37	1.75	2.17	1.11	1.14	1.35
Encoding Story						
Retrieval	.29	1.04	2.45	.88	24.43**	3.24
Story	17.67**	8.47**	2.93*	1.51	.85	.78
Retrieval x Story	1.01	2.39	1.12	1.67	.44	.71
IAPS Valence						
Retrieval	.42	1.13	1.96	.00	22.66**	2.89
IAPS Valence	54.36**	11.86**	6.01*	87.38**	.90	15.55**
Retrieval x IAPS Valence	.48	.67	.84	4.49*	.43	3.11*

Note. N = 328. + N = 1800. * = significant at .05 level. ** = significant at .001 level. Predictor Variables: Retrieval = voluntary or involuntary. Encoding = questions asked during encoding of scene-sound pairings and the IAPS rating of valence.

Notice: This is the author's version of a work that was accepted for publication in *Psychology of Consciousness: Theory, Research, and Practice.* A definitive version was subsequently published in *Psychology of Consciousness: Theory, Research, and Practice.* DOI: 10.1037/cns0000190.

Table 2

Recall Frequency of Each IAPS Scene by Group

Scene	Valence	Voluntary	Involuntary	Total
Puppies	Positive	10	19	29
Man drinking wine	Neutral	11	9	20
Traffic	Neutral	7	13	20
Buried child	Negative	11	6	17
Man with fish	Neutral	8	9	17
Starving child	Negative	7	9	16
Men on train	Neutral	6	10	16
Empty pool	Neutral	9	6	15
Hammer	Neutral	11	4	15
Beach	Positive	7	8	15
Policeman	Neutral	6	8	14
Spider	Neutral	4	7	11
Rockets	Neutral	8	2	10
Cliff divers	Positive	4	6	10
Turtle	Neutral	4	5	9
Wind surfer	Positive	5	4	9
KKK	Negative	4	4	8
Seal	Positive	4	4	8
Burned man	Negative	4	3	7
Severed hand	Negative	2	5	7
Man with child	Negative	4	3	7
Skiers	Positive	3	4	7
Duck	Negative	4	2	6
Man on fire	Negative	2	4	6
Child with flies	Negative	4	1	5
Clams	Neutral	3	2	5
Aimed gun	Negative	4	0	4
Bees	Neutral	3	0	3
Couple on beach	Positive	0	3	3
Gymnast	Positive	0	2	2
Rollercoaster	Positive	1	1	2
Skydivers	Positive	2	0	2
Dead animal	Negative	1	0	1
Castle	Positive	0	1	1
Rafting	Positive	1	0	1
Plane Crash	Negative	0	0	0

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Table 3

Pearson's r Correlations of Predictor Variables

Variables	1	2	3
1. Valence	-		
2. Intensity	-.48**	-	
3. Self	.43**	-.06	-
4. Story	-.24**	.44**	.12*

Note. * = significant at .05 level. ** = significant at .01 level. Valence = IAPS rating of valence, coded as: -1 = Negative, 0 = Neutral, and 1 = Positive. Self = how well can you relate the scene to yourself? Story = How well does the scene tell a story?

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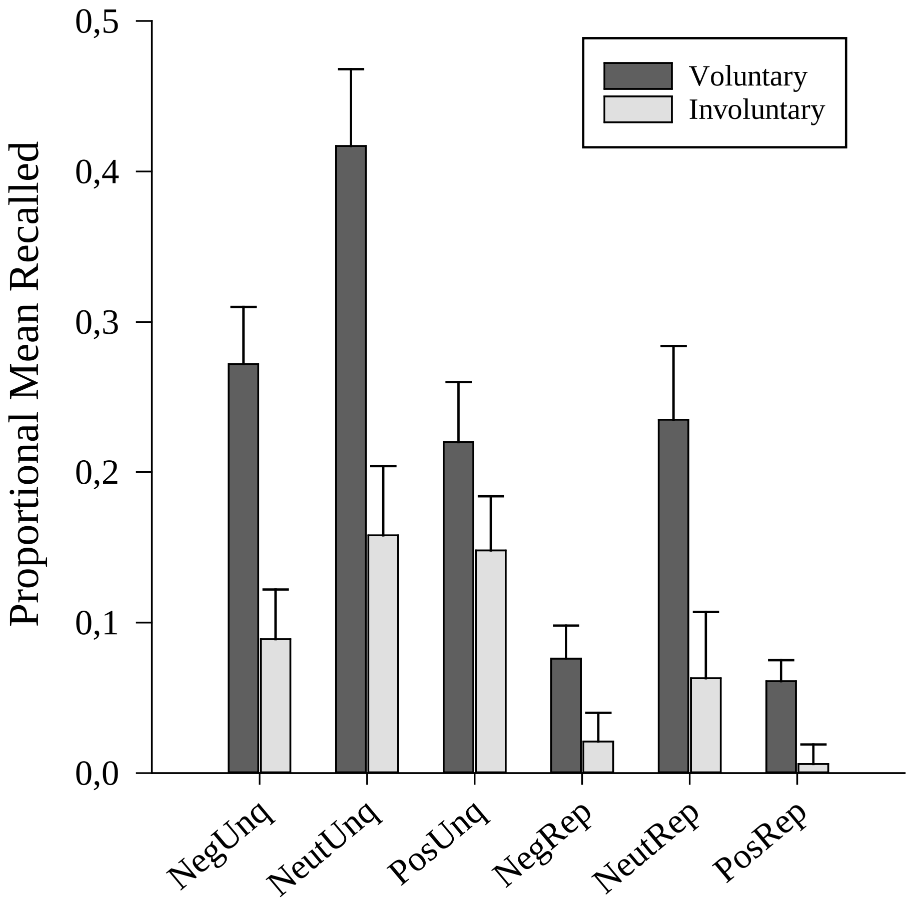

Figure 1a. Proportion of memories recalled in each retrieval group for each trial type. Unq (Unique) and Rep (Repeated) refer to the sound condition. Neg (Negative), Neut (Neutral), and Pos (Positive) refer to the valence of the scene recalled.

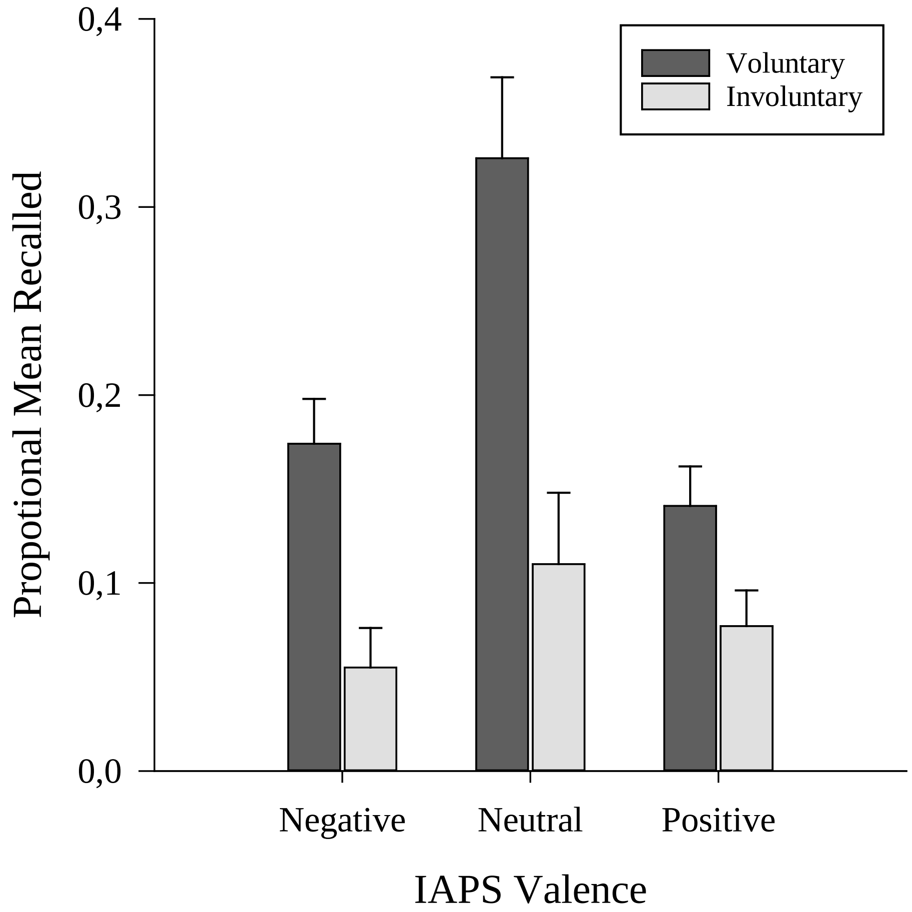

Figure 1b. Valence x Group interaction. Proportion of memories for each type of valence retrieved by each retrieval condition.

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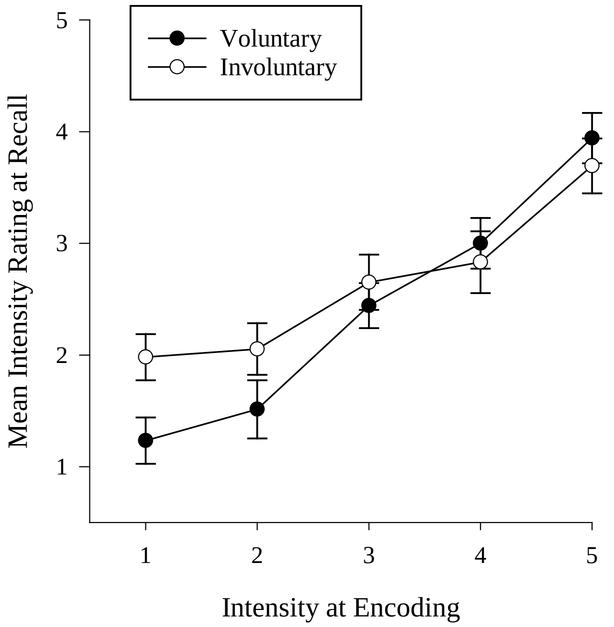
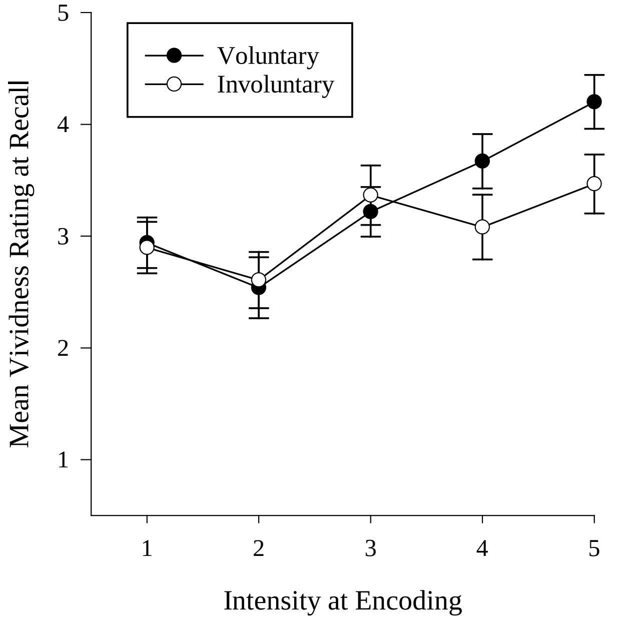
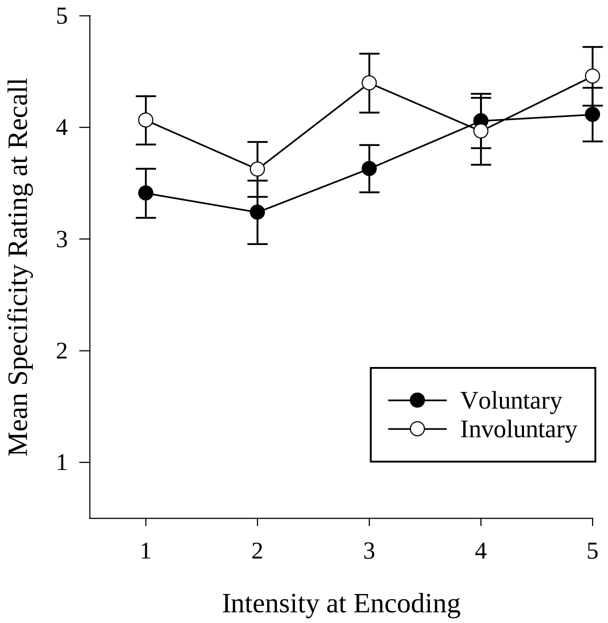


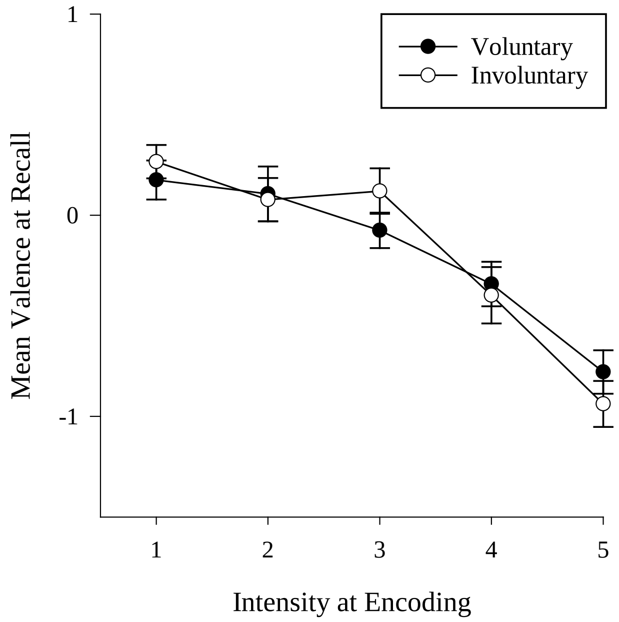
2a. Rating of intensity at encoding predicting intensity at recall.



2b. Rating of intensity at encoding predicting vividness at recall.



2c. Rating of intensity at encoding predicting specificity at recall.



2d. Rating of intensity at encoding predicting valence rating at recall.

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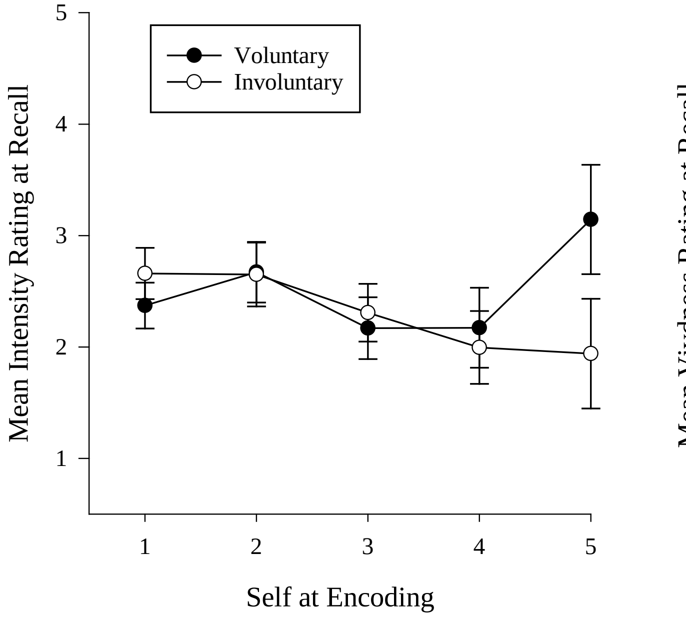
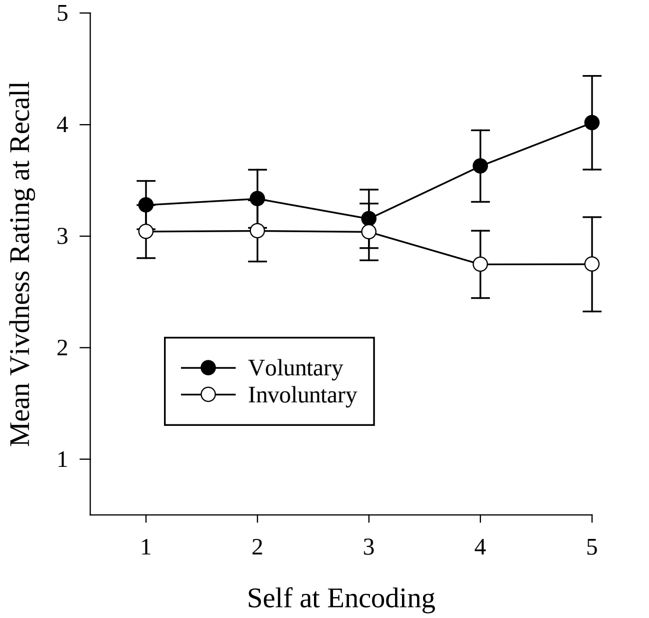
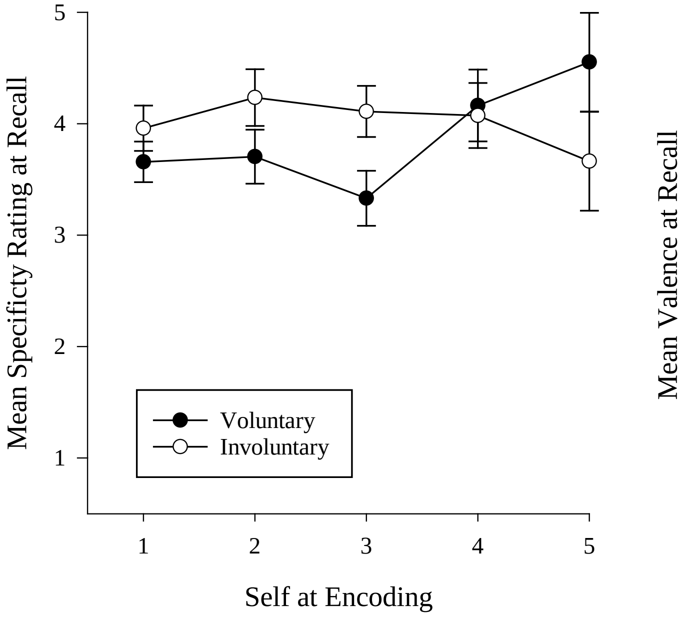


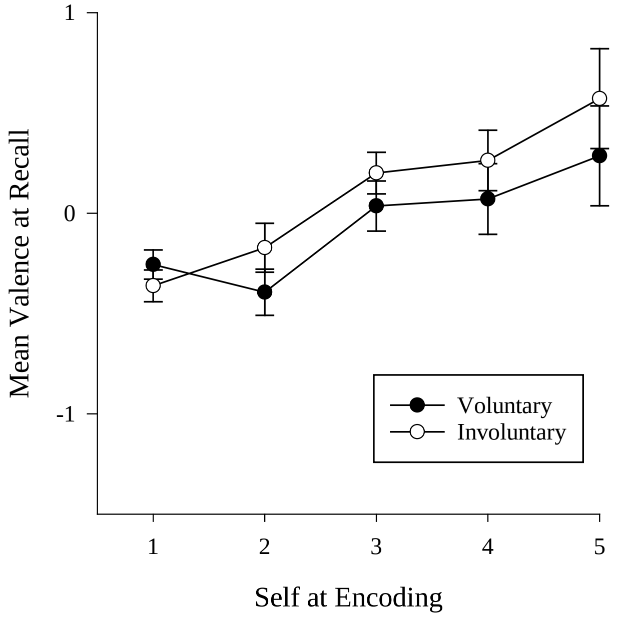
3a. Rating of self-relatedness at encoding predicting intensity rating at recall.



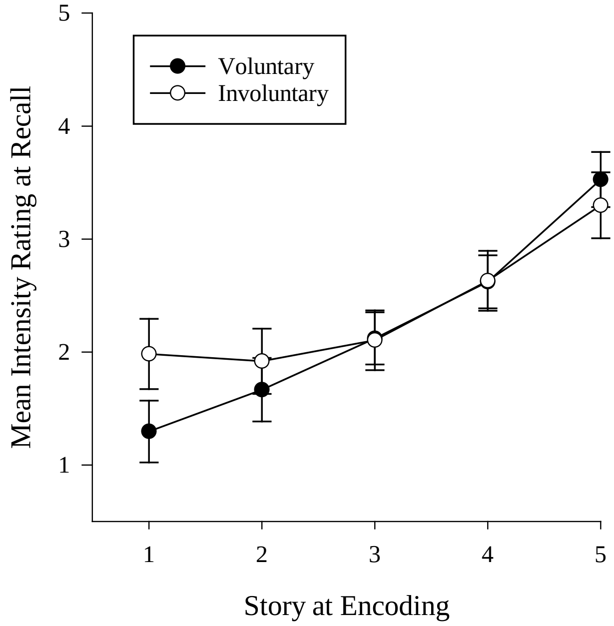
3b. Rating of self-relatedness at encoding predicting vividness rating at recall.



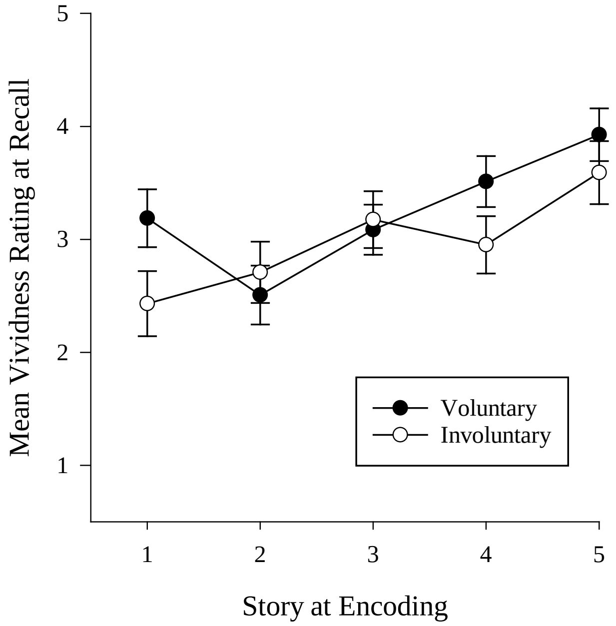
3c. Rating of self-relatedness at encoding predicting specificity rating at recall.



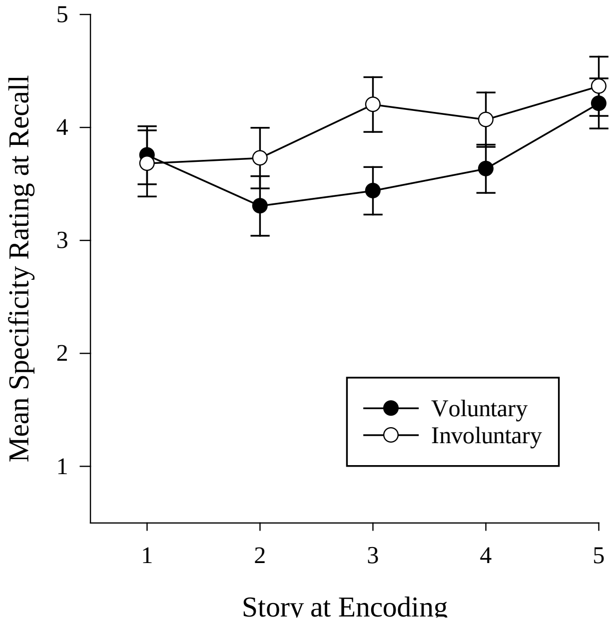
3d. Rating of self-relatedness at encoding predicting valence rating at recall.



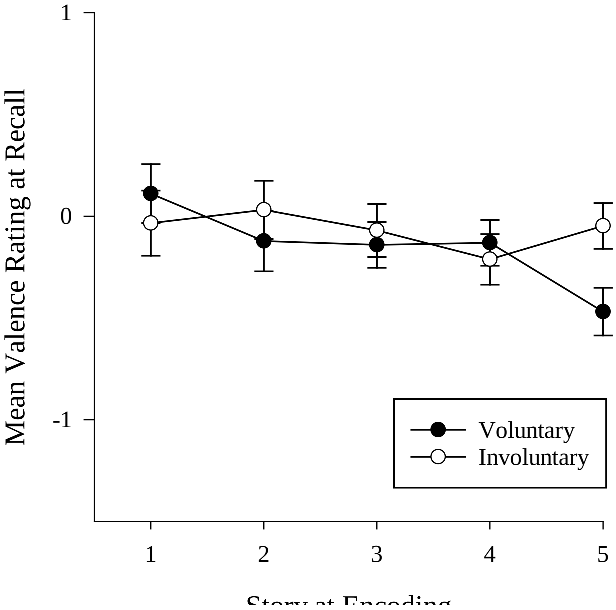
4a. Rating of story at encoding predicting intensity at recall.



4b. Rating of story at encoding predicting vividness at recall.



4c. Rating of story at encoding predicting specificity at recall.



4d. Rating of story at encoding predicting valence at recall.

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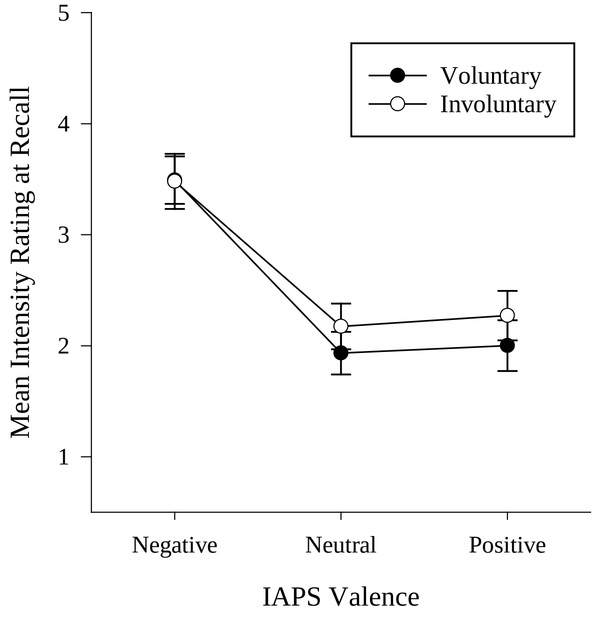
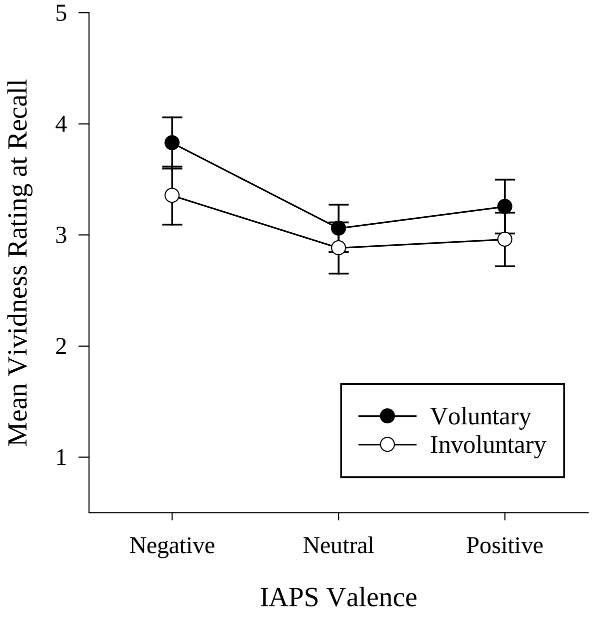
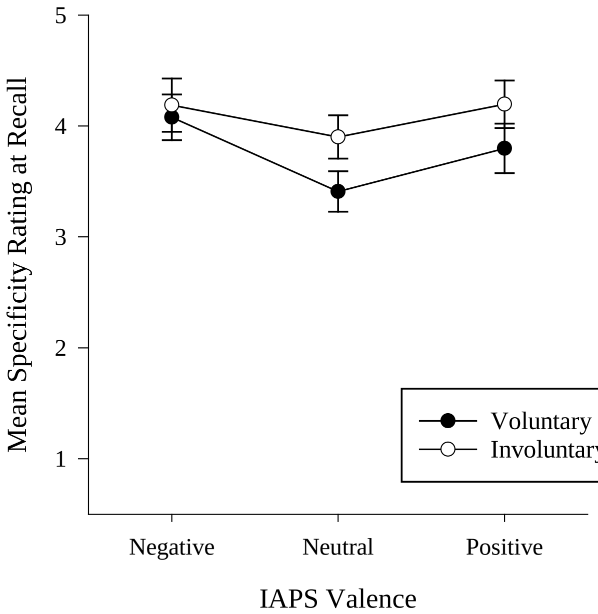


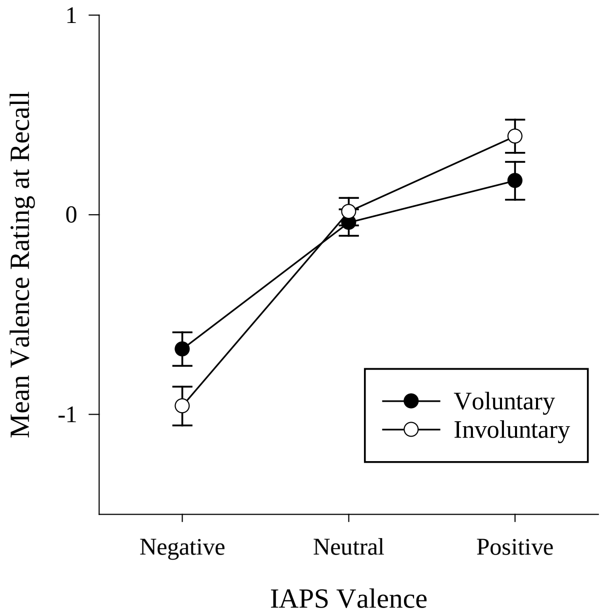
5a. IAPS valence predicting intensity at recall.



5b. IAPS valence predicting vividness at recall.



5c. IAPS valence predicting specificity at recall.



5d. IAPS valence predicting valence rating at recall.