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Effects of Dissociation and Hyperarousal on Item and Association Memory

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Dual representation theory (DRT) asserts that when an individual experiences an acutely stressful or traumatic event, encoding of memory of individual parts of an event (i.e., items) is enhanced, while connections between parts of an event (i.e., associations) is impaired due to peritraumatic changes in cognitive functioning. The current project sought to refine understanding of DRT by examining the differential effect of dissociation and hyperarousal, two common peritraumatic cognitive reactions, on memory for item and association information. **Method:** Using experimental methods from the cognitive study of memory, two studies evaluated how individual differences in cognitive states (Study 1) and experimentally induced cognitive states (Study 2) affected recognition of items (i.e., images of everyday objects) and associations (i.e., background scene images paired with the objects) on an adapted memory task after a delay of 24 hours. **Results:** The adapted memory task was well-tolerated and performed comparably with similar paradigms. Study 1 results suggested that better item memory was related to greater resting-state dissociation, but unrelated to resting-state arousal; and better association memory was associated with lower resting-state arousal, but unrelated to resting-state dissociation. In Study 2, self-reported cognitive states changed in the predicted directions following experimental manipulations; however, heartrate data suggested no physiological response to the paradigms. These Study 2 analyses of memory performance are interpreted with caution because the sample size was

underpowered to detect studied effects. **Conclusions:** While these results do not provide clear support for DRT, they are discussed in the context of more general memory findings and theories, as well as methodological implications for future studies of DRT.

Acknowledgements

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Introduction

An individual's trajectory of well-being following a traumatic event is strongly related to their memory of that event (Rubin et al., 2008). One suggested predictor of memory for traumatic events is the cognitive reactions that occurred during the event (Layton & Krikorian, 2002; Weston, 2014). The most common and well-studied peritraumatic cognitive reactions include *hyperarousal*, an increase in activation of the physiological systems responsible for an organism's sensory input and motor output (Weston, 2014); and *dissociation*, a decrease in activation of mental processes, which produces disruptions in awareness, self-attribution, or self-control (Cardeña & Carlson, 2011). Beyond identifying that retrospective reports of peritraumatic hyperarousal and dissociation are related to later perceptions of memory for the event (Bedard-Gilligan & Zoellner, 2012; Pfefferbaum & Allen, 1997), experimental psychopathology is only beginning to explore the central question of how hyperaroused and dissociative reactions during a traumatic event may differentially affect memory. To address this gap in the literature, the current dissertation project used a two-study approach to further the understanding of the cognitive mechanisms that contribute to differences in memory for traumatic events. The following introduction reviews literature relevant to both studies. In subsequent sections, Study 1 method, results, and discussion are presented, followed by the method, results, and discussion for Study 2. Finally, the overlaps and implications of the two studies are discussed together.

Memory Function in Non-Traumatic Circumstances

Before focusing on memory function in traumatic circumstances, it is helpful to understand memory function in non-traumatic circumstances. This review focuses on long-term, episodic memory (i.e., conscious recollection of a personal experience from the past), given its relevance to posttraumatic psychopathology, such as involuntary flashbacks or disorganization in voluntary memory, as well as practical applications such as describing an event during psychological therapy. According to the information processing model of long-term memory, memories are initially formed through the process of *encoding*, wherein a mental representation of perceived information is translated to long-term memory. In turn, encoded information can be later remembered through the process of *retrieval*, wherein details are mentally reconstructed using the same neural pathways that were active during the initial perception and encoding (Atkinson & Shiffrin, 1971).

Information comprising a perceived event can be thought of as either *item-level* (i.e., individual parts of the event) or *association-level* (i.e., connections between parts of an event, including semantic connections, as well as temporal and spatial sequencing; Gardiner, 1988; Jacoby, 1991; Yonelinas, 2002). The *binding of item and context* (BIC) model of memory (also called the three-component model; Diana et al., 2007) posits that memories for items and associations are processed through discrete neural pathways (Eichenbaum et al., 2007; Yonelinas, 1994). Evidence suggests that item-level information is processed through the perirhinal cortex (PrC), while association-level information is processed through the posterior parahippocampal cortex (PhC) and

hippocampus (Diana et al., 2007). Although the amygdala has been implicated as an additional mechanism in memory of emotionally arousing material, the PrC and PhC still appear necessary for item and association encoding and retrieval, regardless of the affective content of the encoded information (Kensinger & Schacter, 2006).

Investigations of the BIC model have typically relied on behavioral tasks that allow for item and association memory to be evaluated separately (Ranganath, 2010). Visual paradigms for measuring item versus association performance typically present during encoding a visual stimulus that has both item and association features. At retrieval, recognition memory for the item and association features are assessed separately. Examples of visual stimuli include: line drawings of abstract shapes (item) with varied screen position (association; Slotnick et al., 2003); words (item) with varied screen position (association; Nyberg et al., 1996); words (item) and word-pairs (association; Kamp et al., 2019); words (items) and paired images (association; Goldfarb et al., 2019); line drawings of common objects (item) that varied in size (association; Ranganath et al., 2000); faces (item) with red or blue borders (association; Alves et al., 2019); faces (item) with background scenery images (association; Raganath, 2010); words and pictures (item) with content judgements made at the time of encoding (association; Kensinger & Schacter, 2006).

There is robust and growing evidence for the BIC model, drawing upon behavioral experiments, case studies of neuropsychological patients, neuroimaging studies, and animal models (Diana et al., 2007). The evidence suggests item-level information is processed in discrete neural pathways from association-level information. As a result, it is

possible that the two pathways—and thus the related encoded information—may be differentially affected by psychophysiological reactions that occur during the encoding and/or retrieval processes, such as the cognitive changes that occur during acutely stressful experiences.

Memory Function in Traumatic Circumstances

Memory for traumatic events has long garnered controversy (Bisby et al., 2020; Brewin, 2007). Some researchers suggest that memory processes operate identically under non-traumatic and traumatic circumstances, with arousal during traumatic events enhancing memory for all features of the event (Rubin et al., 2008). Evidence for this perspective comes from comparisons of memory for traumatic versus non-traumatic events that find no difference in the quality (i.e., vividness, fragmentation, disorganization) of involuntary or voluntary episodic memory (Berntsen et al., 2003; Hellawell & Brewin, 2004; Rubin et al., 2016).

In contrast, a second school of thought suggests that not all parts of the memory process are affected equally by the cognitive and physiological reactions during a traumatic event, resulting in enhanced memory for some information and impaired memory for other information (Brewin et al., 2010). Evidence for this perspective comes from comparisons that show diminished quality of memory for traumatic compared with non-traumatic events among populations with clinical levels of psychiatric impairment (e.g., meeting criteria for posttraumatic stress disorder, PTSD; Berntsen et al., 2003; Ehlers et al., 2002; O'Kearney & Perrott, 2006; Rubin et al., 2008; Rubin et al., 2011; van der Kolk et al., 2001). Specifically, for memory of traumatic events, individuals with

clinical PTSD report enhanced involuntary memories of the event that tend to be rich in sensory details (i.e., flashbacks; Hackmann et al., 2004; Michael et al., 2005; Speckens et al., 2007) and diminished voluntary memories that tend to lack contextual details (e.g., fragmented, temporally disorganized, incomplete; Foa et al., 1995; Halligan et al., 2003; Harvey & Bryant, 1999).

Dual Representation Theory

Within the second school of thought regarding trauma memory, a theoretical framework was developed to explain the pattern of enhanced sensory and diminished contextual memory for traumatic events, called dual representation theory (DRT; Brewin et al., 1996; Brewin et al., 2010). Directly building upon the BIC model of episodic memory, DRT posits that peritraumatic reactions differentially affect the neural pathways responsible for encoding item- and association-level information. Because of changes in neural mechanisms at encoding during traumatic stress, DRT suggests an individual will experience stronger item representations and weaker association representations than would be encoded under circumstances that do not involve a traumatic stressor. Stronger item representations are likely to be experienced as more vivid or detailed sensory memories, while weaker association representations are likely to be experienced as chronological or spatial disorganization and disconnection of details within narrative memory of the event. Thus, peritraumatic conditions are thought to result in the pattern of enhanced involuntary sensory and diminished voluntary contextual memory for traumatic events among patients experiencing clinical levels of PTSD.

The original articulation of DRT focused on peritraumatic hyperarousal and affect as the mechanisms by which item memory is enhanced and associative memory is impaired (Brewin, 2001). However, recent work on DRT has begun to examine the role of peritraumatic dissociation as well (Brewin et al., 2013; Brewin & Mersaditabari, 2013). Much of the support for either hyperarousal or dissociation as mechanisms contributing to differences in memory for traumatic events derives from studies finding greater numbers of flashbacks or poorer quality of memory for traumatic events among individuals who retrospectively report greater peritraumatic hyperarousal (Marshall et al., 2006) or dissociation (Engelhard, et al., 2003; Giesbrecht et al., 2010; Halligan, et al., 2003). However, there are limitations to the inferences that can be made from such retrospective studies because posttraumatic self-reports of peritraumatic states may be confounded by psychopathology at the time of reporting (Bryant et al., 2011). Further, because there is no "true" account of the traumatic event which could be used as a benchmark for accuracy, it is unclear whether observed patterns extend beyond secondary memory features (i.e., subjective reflections about the quality of memory, frequency of involuntary recall) to the actual encoding or recall processes (Bedard-Gilligan & Zoellner; 2012). Thus, prospective studies— that draw on induced peritraumatic states in a laboratory setting or individual differences in resting cognitive states— are better positioned to identify causal relationships between peritraumatic reactions and posttraumatic memory. Relatively little research has leveraged laboratory studies to date, which is a focus of the current project.

Hyperarousal and Memory

Investigations of item versus association memory that address arousal have tended to focus on the arousing content of encoded stimuli, rather than the cognitive state of the person during encoding or recall (Bisby & Burgess, 2017; Bisby et al., 2018; Bisby et al., 2016; Madan et al., 2020). However, recent studies have begun to evaluate how natural individual differences in cognitive states relate to performance on memory tasks. For example, Huntjens and colleagues (2015) found that participants who reported higher state anxiety, which shares features of state arousal, displayed inhibited association memory, but not item memory. A second study of state anxiety also found it inhibited episodic memory, though item versus association memory was not examined (Sherrill et al., 2019). Both studies (Huntjens et al., 2015; Sherrill et al., 2019) documented that there are substantive individual differences in state anxiety. While subjective ratings of state arousal have not been examined in relation to memory, there is evidence for individual differences in resting state arousal (Kamp et al., 2019). Taken together, these initial explorations into arousal or related states suggest that examining individual differences in cognitive states could be a useful strategy for understanding how arousal differentially affects item versus association memory.

Arousal has also been studied using experimental methods to induce the cognitive state. By and large, studies of induced arousal and episodic memory (for a review, see Sauro et al. 2003), have not examined the differential effects of arousal on item versus association memory (Bisby and Burgess 2014; Guez et al., 2016; Bolton & Robinson, 2017). However, a few recent studies have examined the intersection of the BIC model

and DRT using experimental methods to manipulate arousal. Two studies used low-grade electric stimulation to induce arousal (Bisby & Burgess 2014; Bolton & Robinson, 2017), and a third study used the trier social stress test, a psychosocial stressor (Guez et al. 2016). These initial studies provide support for DRT, finding arousal impaired associative memory (i.e., photo pairs, Bisby & Burgess, 2014; word-drawing pairs, Guez et al., 2016), but did not affect item memory (i.e., for naturalistic photos, Bisby & Burgess, 2014; line drawings, Guez et al., 2016; and faces, Bolton & Robinson, 2017). Bolton and Robinson (2017) found associative memory was not affected by the arousal manipulation. The authors attributed the difference in findings to differences in the encoding-recognition delay intervals. The null finding occurred with a 5-minute delay (Bolton & Robinson, 2017), while the findings that support DRT occurred with a delay of 24-hours that better approximates episodic memory (Bisby & Burgess 2014; Guez et al. 2016). Note that there are critiques of the external validity of experimentally-induced arousal (Lick & Unger, 1977; Wagstaff et al., 2003). However, because using these methods makes it possible to isolate the effects of cognitive state, the experimental approach presents a unique tool for exploring DRT, despite the limitations.

Dissociation and Memory

While a large body of retrospective research links higher peritraumatic dissociation with impaired posttraumatic memory for the traumatic event (see Bedard-Gilligan & Zoellner, 2012 for review), only a handful of studies have experimentally examined the effects of dissociation on memory. Pregnant people who reported greater peritraumatic dissociation during pregnancy loss later reported more fragmented memories of the loss

(Engelhard et al., 2003), though the authors did not evaluate the content or accuracy of memories, as is almost always precluded when studying recall of real-life stressful or traumatic events. A study that experimentally manipulated dissociation before encoding tasks found participants in the dissociation condition were able to recall fewer details on a story memory task than controls and had worse numeric working memory than controls, though dissociation condition was unrelated to spatial working memory (Brewin et al., 2013a). In contrast, in one of the first studies of item and association memory that assessed individual differences in state dissociation, Huntjens and colleagues (2015) found that self-reported state dissociation was unrelated to item or association memory performance. Despite the null findings, the study documented substantive individual differences in state dissociation (i.e., pre-task ratings on a state dissociation measure, M = 3.54 out of 5 , SD = 4.64; post-task ratings, M = 4.04 out of 5, SD = 4.58) that can be evaluated in settings where it is difficult to experimentally manipulate dissociation (Huntjens et al., 2015).

To manipulate dissociation, researchers have used two methods: gazing at one's own reflection in low-lighting (i.e., mirror gaze; Brewin et al., 2013; Brewin & Mersaditabari, 2013) or hypnosis-induced immobility (i.e., somatoform hypnosis; Hagenaars et al., 2008). Another approach, hypnosis-induced psychological distance (i.e., psychological hypnosis; Holmes et al., 2006) has been used when investigating analogue intrusive thoughts, but it has not been used to examine quality of memory. The outcome of the three studies that examined effects of induced dissociation on memory has been memory for complex information that draws upon both item and associative information together,

without parsing memory for the two forms of information apart. Specifically, outcomes have included story recall (Brewin et al., 2013), complex figure drawing (Rey-Osterrith Figure Test; Brewin & Mersaditabari, 2013), and recall of an analogue trauma film (Hagenaars et al., 2008). Two of the three studies found no relationship between dissociation and memory (Brewin et al., 2013; Hagenaars et al., 2008). The authors of the third study (Brewin & Mersaditabari, 2013) argued that it provided support for DRT, given that participants in the dissociation condition displayed impaired memory for the complex figure, however the memory measure did not permit separate analyses of item and associative memory.

Taken together, past investigations of peritraumatic cognitive states indicate that both hyperarousal and dissociation can affect memory. However, the differential effects of these two peritraumatic reactions on different features of memory (i.e., item and association memory) have yet to be explored because hyperarousal and dissociation have not been evaluated in a single study using comparable outcome measures. Better understanding the specific effects of hyperarousal and dissociation on memory has the potential to support researchers and clinicians addressing the mechanisms that contribute to posttraumatic psychopathology.

Current Project

This project sought to refine the understanding of DRT by exploring the relationship between analogue peritraumatic cognitive states and memory for information encoded while in those cognitive states. Specifically, the current project investigated how hyperarousal and dissociation at the time of encoding related to subsequent recognition of

item-level and association-level visual information. If, as DRT suggests, the discrete effects of peritraumatic cognitive states on item and association memory formation contribute to the trajectory of posttraumatic psychopathology, it is critical to understand how those cognitive states relate to item and association memory. In its original form, this project comprised a single study that focused on the effects of experimentally-induced arousal and dissociation, intended to approximate peritraumatic reactions, on affect-neutral visual recognition of item-level (i.e., images of objects) and association-level (i.e., scene-object pairs) information. However, given restricted in-person data collection in 2020-2021 due to COVID-19, adjustments were made so that data relevant to the study aims could be collected while also adhering to public health guidelines. Thus, an online-only Study 1 was added, which focused on testing associations between naturally-occurring individual differences in cognitive states and memory. Study 2 used the originally planned method to examine experimentally induced cognitive states as predictors of memory. Given COVID-19 constraints, the sample size in Study 2 was substantially under-powered to detect relevant effects and is best understood as a methodological pilot study.

Study 1 Overview

Examining how individual differences in cognitive states relate to memory is useful given individual differences in reactions to traumatic events. In a sample of college students, Study 1 examined whether naturally occurring individual differences in self-reported arousal and dissociation would predict performance on a visual memory task that assessed recognition of both item-level (i.e., images of objects) and association-level

(i.e., scene-object pairs) information. Specifically, participants were asked to self-report arousal and dissociation over the course of the task's encoding phase, as well as before the recognition test 24 hours later. This approach was designed to assess whether hyperarousal versus dissociation differentially affect item and association memory, as would be predicted by DRT. Aims and hypotheses for Study 1 included:

Aim 1.1

Examine how individual differences in cognitive states during an encoding task relate to accuracy of recognition of item versus association level information.

Hypothesis 1.1A

Participants who self-report greater increases in *arousal* over the course of the encoding task will have *more accurate recognition of item-level* information.

Hypothesis 1.1B

Participants who self-report greater increases in *dissociation* over the course of the encoding task will have *less accurate recognition of item-level* information.

Hypothesis 1.1C

Participants who self-report greater increases in *arousal* over the course of the encoding task will have *less accurate recognition of association-level* information.

Hypothesis 1.1D

Participants who self-report greater increases in *dissociation* over the course of the encoding task will have *less accurate recognition of association-level* information.

Aim 1.2

Examine how individual differences in cognitive states before a recognition memory task relate to accuracy of recognition of item versus association level information.

Hypothesis 1.2A

Participants who self-report higher levels of *arousal* at the start of the recognition task will have *more accurate recognition of item-level* information, when controlling for arousal and dissociation at encoding.

Hypothesis 1.2B

Participants who self-report higher levels of *arousal* at the start of the recognition task will have *less accurate recognition of association-level* information, when controlling for arousal and dissociation at encoding.

Hypothesis 1.2C

Participants who self-report higher levels of *dissociation* at the start of the recognition task will have *less accurate recognition of item-level* information, when controlling for arousal and dissociation at encoding.

Hypothesis 1.2D

Participants who self-report higher levels of *dissociation* at the start of the recognition task will have *less accurate recognition of association-level* information, when controlling for arousal and dissociation at encoding.

Study 2 Overview

Isolating the effects of arousal and dissociation on memory using experimentally manipulations can offer insight into dynamics that are difficult or unethical to study

during and after actual traumatic events. Study 2 piloted a procedure designed to test whether experimentally inducing arousal or dissociation prior to encoding predicts performance on the same visual memory task used in Study 1, in a sample of college students. Specifically, using a mixed within-between subjects design, all participants responded to the first half of the encoding task in their unmanipulated baseline state, and then were randomized to either an electric stimulation-induced hyperarousal or hypnosis-induced dissociation condition for the second half of the encoding task. This approach was designed to assess whether hyperarousal versus dissociation differentially affect item and association memory, as would be predicted by DRT. Aims and hypotheses for Study 2 included:

Aim 2.1

Examine the validity of the current cognitive state induction methods.

Hypothesis 2.1A

When comparing baseline to post-induction self-reported states, participants in the dissociation condition will report an increase in dissociation and hypnotic depth; and a decrease in anxiety and arousal.

Hypothesis 2.1B

When comparing baseline to post-induction self-reported states, participants in the arousal condition will report a decrease in dissociation and hypnotic depth; and an increase in anxiety and arousal.

Hypothesis 2.1A

When comparing the experimental groups after condition induction, the dissociation group will report higher levels of dissociation and hypnotic depth and lower levels of arousal, and anxiety than participants in the arousal condition.

Hypothesis 2.1A

The heart rate of participants in the dissociation condition will be slower after induction than at baseline.

Hypothesis 2.1A

The heart rate of participants in the arousal condition will be faster after induction than at baseline.

Aim 2.2

Examine how item and association memory are affected by dissociation and arousal.

Hypothesis 2.2A

There will be a 3-way interaction between time (i.e., before vs. after cognitive state induction; within-subjects factor), memory type (i.e., item vs. association trials; within-subjects factor), and condition (i.e., arousal vs. dissociation; between-subjects factor). That is, the interaction between time and condition will depend on memory type. Specifically, when asked to recognize item-level trials, participants in the arousal condition will be more accurate for trials encoded *after* experimental induction, while participants in the dissociation condition will be more accurate for trials encoded *before* experimental induction. When asked to recognize association-level trials, participants in both conditions will be more accurate for trials encoded *before* experimental induction.

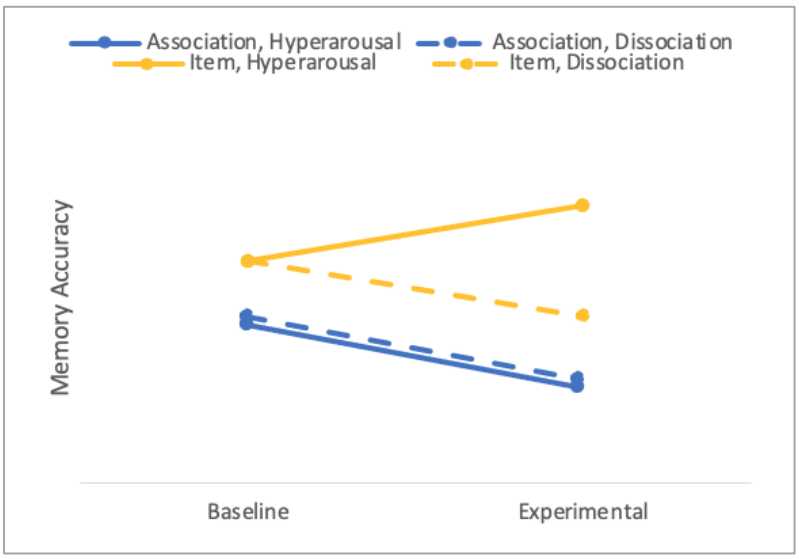


Figure 1. Visualization of Study 2 Hypothesis 2.2A

Study 1

Study 1 Method

Procedures were approved by the University of Denver (DU) Institutional Review Board before recruitment began.

Study 1 Participants

Participants were adults (18 and older) recruited from the DU human subjects pool (HSP), who receive course credit for participation. A total of 152 participants responded to both sessions of study activities. Five participants were excluded from subsequent analyses based on poor behavior task performance (i.e., $n = 1$ failed to pass attention checks; $n = 4$ displayed false alarm rates greater than three standard deviations above the mean, indicating high likelihood of guessing). The remaining 147 participants ranged in age from 18-27 ($M = 19.13$ years, $SD = 1.54$). As is typical of university human subject pools, a majority of the sample were first-year students ($n = 93$, 63%; $n = 33$ 2nd-year students, 22%; $n = 11$ 3rd-year students, 8%; $n = 10$ 4th-year students, 7%). Participants were primarily women (73%, $n = 107$), with the remainder comprising men (25%, $n = 37$) and trans-gender or gender non-binary identifying participants (2%, n = 3). Participants identified their racial/ethnic identities as: 86% white ($n = 126$), 14% Asian or Pacific Islander ($n = 21$), 11% Latinx ($n = 16$), 5% Black ($n = 8$), 1% Native American ($n = 2$), 1% Arab ($n = 2$); selection of more than one category was permitted, resulting in a total greater than 100%. Most of the sample identified their sexual orientation as

heterosexual/straight (76%, *n* =111), 4% lesbian/gay (*n* = 6); 16% bisexual/pansexual (*n* = 23), 3% asexual (*n* = 5), 2% queer (*n* = 3), 1% questioning (*n* = 2). Nearly three quarters of the sample reported experiencing at least one potentially traumatic event before the age of 18 (73%, *n* = 107), and a third reported experiencing interpersonal violence perpetrated by a close person, such as a parent or romantic partner before the age of 18 (33%, *n* = 49).

Study 1 Design

A quasi-experimental design was used to examine the effect of individual differences in cognitive states (i.e., dissociation, arousal, anxiety) at the time of encoding and recognition on memory recognition accuracy.

Study 1 Procedure

Participation involved two one-hour study visits, with encoding at Time 1 and recognition at Time 2, 24 hours later. All activities were conducted online via the internet, with participants choosing the location and time at which to begin the Time 1 session. At Time 1, participants reviewed written informed consent information and responded to a 5-question "consent quiz" designed to check understanding of consent information (DePrince & Chu, 2008). An example consent quiz question is, "Do you have to complete every question?" (correct answer: No). If participants answered one or more questions incorrectly on the first attempt, feedback on the relevant question(s) was provided and the question(s) readministered. All participants who began the first study session successfully passed the consent quiz (i.e., provided correct answers to 100% of questions) after a second administration of the consent quiz. Participants then *provided*

implied consent by selecting a survey button indicating "I agree to participate" or "I decline to participate."

See Figure 2.A for visual representation of activities during the Time 1 session of Study 1. After consenting, participants were asked to respond to questions in an online survey, including demographic information and baseline self-reports of trait dissociation, history of traumatic experiences, and current affect. Also at baseline, the first administration of repeated current-state measures were presented: state arousal, state dissociation, hypnotic depth, state anxiety, and affect. Next, participants reviewed instructions for the encoding task. After each quarter of the baseline encoding trials, participants were asked to respond to current-state measures.

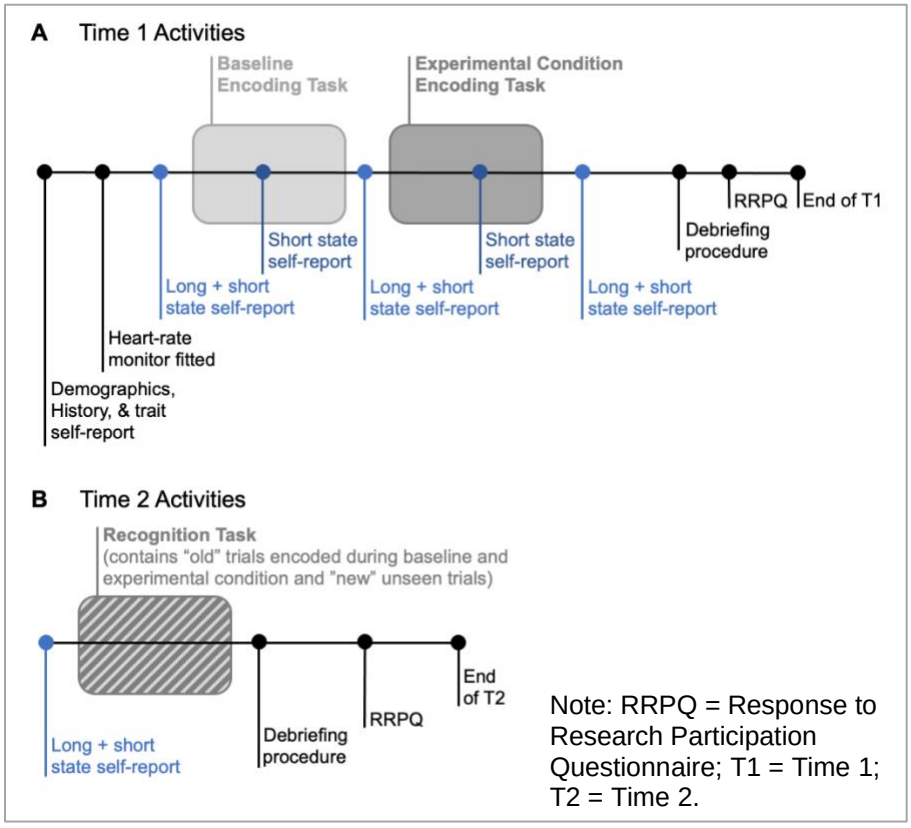


Figure 2. Visual Representation of Study Activities for Time 1 and Time 2 Sessions

In the encoding task, participants viewed everyday objects (item-level information) with associated images of landscape scenes in the background (association-level information). Stimuli did not repeat during either encoding phase; each stimulus image was seen only one time. Participants were asked to make a judgement response (i.e., "Does the object "fit" with the background scene?") about each trial, to facilitate attention to task and obscure the mnemonic nature of the task. Accuracy of fit/no-fit decisions were first determined by the researcher, and then compared against average ratings by participants, and corrected if major discrepancies were identified. Following these activities, participants were asked to provide open-ended text responses to questions about the deception (i.e., not disclosing the mnemonic nature of the task).

Next, participants were asked to respond to the Reactions to Research Participation Questionnaire (RRPQ; Newman & Kaloupek, 1996; Newman et al., 2001). To ensure participants who may have had negative experiences with the current study were supported, those who responded "Agree" or "Strongly Agree" on the either of the flagged questions (i.e., "The research raised emotional issues for me that I had not expected" or "I experienced intense emotions during the research session") were asked whether they would like a referral to Pioneers CARE, a university-wide support resource. In Study 1, 30 participants were flagged, and 6 participants indicated they would like a referral. Participants were then thanked for their time and compensated with course credit for Time 1.

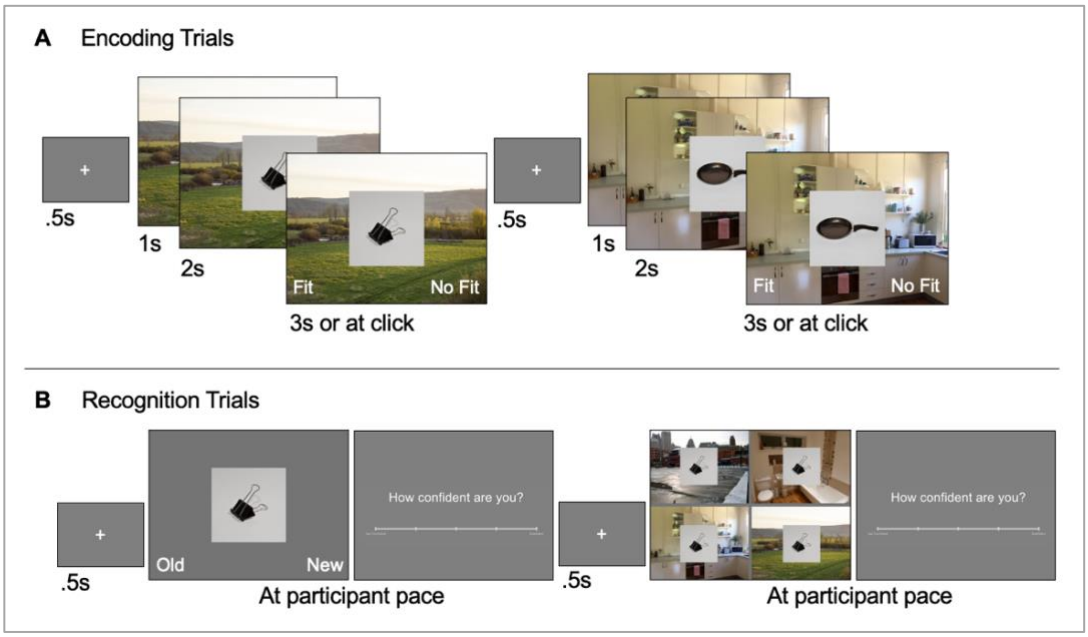
Twenty hours after the start of their Time 1 session, participants received an email reminder of the Time 2 session with a link to begin the Qualtrics survey. Participants

were given a 10-hour window (20-30 hours after starting the Time 1 session) to begin the Time 2 session, which comprised the recognition test and study debriefing. See Figure 2.B for visual representation of Time 2 activities. *At the start of the Time 2 session, participants were reminded of consent information on the first page of the Qualtrics survey and indicated "I agree to participate" or "I decline to participate." Next,* participants who re-affirmed consent were asked to respond to state self-report measures (i.e., state arousal, state dissociation, hypnotic depth, state anxiety, and affect) a final time. Next, participants reviewed instructions for how to perform the recognition task. Following these activities, the same debriefing questions and RRPQ were asked. As in Time 1, any participants who indicated "Agree" or "Strongly Agree" to the flagged RRPQ questions were asked whether they would like a referral to the university-wide support resource. Finally, participants received written debriefing information and a resources handout (i.e., phone numbers and websites for mental health services). Finally, participants were thanked and provided additional course credit for participation in the Time 2 session.

Study 1 Encoding Task

Drawing upon tasks used by Bisby and Burgess (2014) and Hannula and Ranganath (2009), trials included images of everyday objects associated with background scenes (see Figure 3). After reviewing task instructions in Qualtrics survey, participants clicked a link that launched the encoding task, which fully covered the participant's screen, regardless of the screen size. As in the existing paradigms, background scenes were landscapes without any people or obvious objects. In a modification of the existing

paradigms, everyday objects, rather than faces (Hannula & Raganath, 2009) or emotional scenes (Bisby & Burgess, 2014) were used to reduce the likelihood that stimulus details produced an affective response, as may have happened with the image and face stimuli used in previous studies.



Note: (A) Illustration of encoding trial events. (B) Illustration of a single recognition test trial.

Figure 3. Experimental Paradigm

Stimulus timing and presentation was based on Bisby and Burgess' (2014) paradigm. See Figure 3 for sample trials. For each trial, participants were presented with a unique background scene for a 3-second period, after which an everyday object appeared in the center of the screen in combination with, but not completely covering, the background scene for 3 additional seconds. Participants were instructed to attend to both the background and object. To increase attention and obscure the mnemonic purpose of the

task, while both images were on the screen, participants were asked to make a judgement about whether the object could belong in the background scene. After the scene-object pair had been presented for 3 seconds, the words “No Fit” and “Fit” appeared on the lower left and right of the screen, respectively. Participants were asked to indicate their judgement by clicking on their response choice. For each trial, the X and Y screen coordinates of the mouse click was recorded in normalized units (i.e., center screen is located at (0, 0), with a range from -1 to +1 on both axes). Participants were instructed that judgment responses should be made within the 3 additional seconds the object-scene combination is on the screen, or the response for that trial would not be recorded. The response time of Fit/No Fit judgements was recorded to evaluate participant attention to task. The time between Fit/No Fit options being presented and the participant’s click (i.e., reaction time) was recorded for each trial. Each trial was followed by a fixed-duration inter-trial interval (ITI; 500 ms). In contrast to other paradigms that sequentially present associated objects, the simultaneous presentation of images provided a more ecologically valid association formed by the imagined scene. Participants viewed 4 blocks of 28 trials, for a total of 112 trials per condition. The encoding task took an average of 22 minutes. Trials were presented in randomized order within blocks. The encoding task was built using PsychoPy Builder 3.0 (release version 2020.2.5; Pierce et al., 2019), and hosted using the accompanying Pavlovia online hosting software.

Study 1 Memory Recognition Task

Following the Bisby & Burgess (2014) paradigm, participants were asked to respond to an old/new recognition task. After reviewing task instructions in Qualtrics survey,

participants clicked a link that launched the recognition task, which fully covered the participant's screen, regardless of the screen size. This task involved viewing 224 total trials (112 "old" objects viewed during the encoding task and 112 "new" objects not previously viewed). Old trials from the four encoding blocks were interspersed in randomized order with new objects throughout the recognition trials. During item-level recognition trials (see Figure 3.A), objects were presented on white backgrounds (i.e., without association scene) and participants clicked the on-screen text "old" for previously seen objects (located on the lower, left of screen) and a "new" button for novel objects (located on the lower, right of screen. The X and Y screen coordinates of the mouse click was recorded for each item trial. The time between old/new options being presented and the participant's click (i.e., reaction time) was recorded for each trial. After each item trial, participants rated their confidence on the previous trial from 1 (not at all confident) to 5 (very confident) by clicking a response slider.

Regardless of participant response, all objects (i.e., both old and new) were proceeded by an association-level trial for the same object. While there was no correct response for new association trials, participants viewed association trials for both old and new items, so no feedback was provided on item-level recognition accuracy. In association-level trials, participants were shown the immediately preceding object repeated on the four possible background scenes. Participants indicated which object-scene pair was previously seen during the Time 1 session by clicking on the object-scene pair they thought was correct (see Figure 3.B). The X and Y screen coordinates of the mouse click

was recorded for each trial.[1] As with the item-level trials, after each association trial, participants rated their response confidence from 1 (not at all confident) to 5 (very confident) by clicking an on-screen response slider.

Measures

Perceived State Arousal

The arousal item from the Self-Assessment Manikin (SAM) measure (Bradley & Lang, 1994) was used to evaluate perceived arousal at baseline, during each encoding task block, and after encoding task completion. The item consists of a visual array of five humanoid figures with expressions on a gradient from excited and wide-eyed to relaxed and sleepy. Participants were asked to indicate which of the figures best represents their current state. The measure is brief and can quickly assess state-arousal. As such, it is widely used to repeatedly measure arousal responses to experimental manipulations of biological states (Feldner et al., 2003). The SAM was scored from 0 (least aroused manikin image) to 4 (most aroused manikin image). Per Google Scholar in February 2020, the original SAM publication has been cited 6,825 times. The SAM has been shown to good test-retest reliability and construct validity (Betella & Verschure, 2016; Bynion & Feldner, 2018).

Perceived State Anxiety

Given the limitations of a single-item measure of arousal, a measure of anxiety was also used as a proxy indicator of arousal. A four-item mini subscale of state anxiety from

[1] Due to a software programming error, reaction time was not recorded for association trials during the recognition task.

the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch & Lushene, 1979) was used. The STAI mini state subscale items are: “I feel calm” (reverse scored), “I feel tense,” “I feel at-ease” (reverse scored) and “I feel over-excited.” Participants are asked to rate how much each statement describes their present feelings, with four response options 1), not at all; 2, somewhat; 3) moderately so; 4) very much so). This abbreviated subscale allows for briefer assessment of subjective state anxiety than does the full 20-item measure and has been used as a repeated measure of manipulated anxiety (Rossi & Pourtois, 2012). Item response scores are averaged to yield a mean trait anxiety score ranging from 1-4, with higher scores indicating higher state anxiety. The STAI had demonstrated high internal reliability (Cronbach’s α = .89; Barnes, Harp, & Jung, 2002) and convergent validity with the Depression Anxiety Stress Scale anxiety subscale (Lovibond & Lovibond, 1995).

Perceived State Dissociation

The Peritraumatic Dissociative Experiences Questionnaire (PDEQ; Marmar et al., 1997) was used to assess state dissociation at baseline, during each encoding task block, and after encoding task completion. The PDEQ is a 10-item self-report measure on which participants indicate the degree to which each item describes their current state using a 5-point scale from (1, not at all true; 2, slightly true; 3, somewhat true; 4, very true; 5, extremely true). Items tap experiences of depersonalization, derealization, amnesia, out of body experiences, altered time perception, and body image. An example item is “I feel as if I am losing track of what is going on.” Item scores are averaged to yield a mean score ranging from 1-5, with higher scores indicating more current state dissociation. The

PDEQ has demonstrated concurrent validity with measures of posttraumatic symptomology (Marmar et al., 1997).

Hypnotic Depth

The "hypnotic depth" item from the Stanford Hypnotic Susceptibility Scale (Weitzenhoffer & Hilgard, 1962) was used as a supplementary measure of dissociation. It assesses the degree to which the participant perceives themselves to be hypnotized. Participants were asked to indicate their self-rating on a scale from 0 (wide awake) to 10 (very deeply hypnotized). The measure has been widely used to evaluate the efficacy of hypnotic inductions (Holmes et al., 2006). The scale has demonstrated convergent validity with measures of hypnotic susceptibility (Kekecs et al., 2021).

Potential Covariate: Demographics

Participants were asked to provide information about their age, gender, ethnicity, and level of education.

Potential Covariate: Trait Dissociation

The Dissociative Experiences Scale, Second Edition (DES-II; Carlson & Putnam, 1993) was used to assess self-reported trait dissociation, the tendency to experience symptoms of dissociation in everyday life. The DES-II is a 28-item self-report measure on which participants indicate what percentage (0%-100%) of the time they experience each item, with no specified time frame. Items capture dissociative experiences, including disturbances in memory, identity, awareness, and cognition. An example item is, "Some people have the experience of driving a car and suddenly realizing that they don't remember what has happened during all or part of the trip." Item response scores are

averaged to yield a mean trait dissociation score ranging from 0-100, with higher scores indicating greater likelihood of trait dissociation. The DES-II discriminates clinical and nonclinical samples and demonstrates good construct and criterion validity (Carlson & Putnam, 1993).

Potential Covariate: History of Trauma Exposure

The Trauma History Questionnaire (THQ; Hooper et al., 2011) was used to assess self-reported exposure to potentially traumatic events. The measure comprises 24 events that participants may have experienced during their life, including crime, natural disasters, sexual and physical assault. An example item is, "Has anyone ever attempted to rob you or actually robbed you (i.e., stolen your personal belongings)?" Participants respond "yes" or "no." For each endorsed event, participants were asked to describe how many times the event occurred, as well as their approximate age(s) at the time of the event(s).

Potential Covariate: Affect

The Positive and Negative Affect Scale, Short Form (PANAS-SF; Mackinnon et al., 1999) was used to assess current affective state at baseline, after the encoding task in the baseline condition, and after the encoding task in the experimental condition. The PANAS-SF is a 20-item self-report measure that measures degree of current positive or negative affect on a 5-point Likert scale (1, very slightly; 2, a little; 3, moderately; 4, Quite a bit; 5, Extremely). Items include 10 adjectives that measure positive feelings such as joy or pleasure, and 10 adjectives that measure negative feelings, such as anxiety or sadness. The PANAS-SF is scored by summing responses within the two subscales, with

higher scores indicating greater positive and negative affect, respectively. In a sample of healthy young adults, the measure has demonstrated high internal reliability within the two subscales (positive affect scale Cronbach's $\alpha = .89$; negative affect scale Cronbach's $\alpha = .95$), and to have convergent validity with measures of anxiety and depression (Crawford & Henry, 2004).

Encoding-Recognition Interval

The time of day was recorded at the start of the first encoding trial and at the start of the recognition task. This measurement was used to calculate the delay, in hours, between encoding and cognition.

Awareness of Deception

During both Time 1 and Time 2 study visits, a debriefing questionnaire was administered after study activities. Participants were asked about their experience with the research, including perception of the mnemonic nature of the tasks, subjective experience of the experimental condition, and general experience with the study activities.

Response to Research Participation

The Response to Research Participation Questionnaire (RRPQ; Newman & Kaloupek, 2001) was used to assess participant reactions to study activities. Responses this measure were checked throughout the data collection process to determine whether participants perceived the benefits of participation to outweigh the costs. For this reason, the RRPQ was included at both Time 1 and Time 2. The RRPQ is a 23-item measure on which participants indicate agreement with statements about their experience during the

research session on a 5-point scale from 1 (strongly disagree) to 5 (strongly agree). Items tap five factors, including (1) Participation (e.g., "I like the idea I contributed to science"); (2) Personal Benefits (e.g., "I gained insight into my experiences through research participation"); (3) Emotional Reactions (e.g., "The research raised emotional issues for me that I had not expected"); (4) Perceived Drawbacks (e.g., "The study procedures took too long"); and (5) Global Evaluation ("I was treated with respect and dignity"). The RRPQ has displayed good internal reliability in a sample with college-aged participants (Newman et al., 2001).

Memory Performance Scoring

Performance on the recognition tasks was scored based on Atkinson and Juola's (1973, 1974) application of signal detection theory to recognition memory. In the interest of interpretability, raw rather than normed scores were used, and a liberal decision criterion (c) based on response choice (i.e., old vs. new for items; selection of correct object-scene pair for associations) rather than confidence level[2] was used. Thus, item-level recognition memory performance was represented by a corrected hit rate (CHR), the proportion of old items correctly identified as old (hits) was corrected for guessing by subtracting the proportion of new items incorrectly identified as old (false alarms). Association-level recognition performance was derived from old trials only and calculated as the proportion of correct association responses.

[2] The more conservative measure of memory discrimination, d', was also explored. By using a Z-score transformed hit rate and false alarm rate, d' accounts for bias in responses (Macmillan & Creelman, 1990). However, the results of hypothesis tests that used memory performance as outcomes were similar when using corrected hit rate versus d'. Because the un-transformed corrected hit rate is easier to interpret, only results of analyses using corrected hit rate are presented in this manuscript.

Data Analysis

All analyses were conducted using IBM SPSS 25 software. Descriptive statistics, including normality and bivariate correlations, of all variables were assessed for the necessity of transformations and inclusion of covariates in central analyses. Scores were approximately normal; thus, analyses were run using the original data. An independent-sample *t*-test compared item and association recognition based on whether participants reported awareness of the mnemonic purpose of the study before the deception was revealed to participants. As an indicator of fatigue, the relationship between reaction time at encoding and recognition accuracy was examined using bivariate correlations.

Differences in reaction time during the encoding task based on subsequent recognition accuracy was examined for both item and association trials using paired-samples *t*-tests. Item and association recognition performance was compared to chance (i.e., 0 and .25, respectively) using one-sample *t*-tests. Differences in confidence ratings during the recognition task based on recognition accuracy was examined for both item and association trials using paired-samples *t*-tests. The bivariate correlation between item and association recognition performance was analyzed as an indicator of the validity of the task. Separate regressions of item and association recognition on encoding-recognition time interval were conducted to determine whether the time delay should be included as a covariate in subsequent hypothesis tests. Paired-samples *t*-tests comparing confidence based on subsequent memory performance were conducted for item and association trials.

Changes in self-reported cognitive states before versus after the encoding task were compared using individual paired-samples *t*-tests. Before repeated measures were conducted, variance inflation factor (VIF) estimates for the independent variables were examined for multicollinearity. Independent variables with VIFs smaller than 10 were considered acceptable to include. Recognition accuracy was analyzed using separate regressions of item and association recognition on cognitive states before and after encoding. Two additional regressions of item and association recognition on cognitive states before recognition were conducted, controlling for pre-post encoding change scores for each of the four cognitive states. A pre-post encoding change score for cognitive states was used instead of including individual pre- and post- encoding ratings separately due to collinearity issues with including three sets of repeated measures. Confidence intervals (95%) are reported.

At both Time 1 and Time 2, the RRPQ was analyzed to determine participants' top three reasons for participating and perceived costs and benefits. One-sample *t*-tests compared RRPQ subscale means to a neutral rating.

Study 1 Results

Awareness of Deception

Based on the debriefing questionnaire, only 2% (n = 3) of participants reported thinking the study might be related to memory. An independent-samples *t*-test indicated item recognition was no different for those aware of the deception (M = .50, SD = .07) compared to those unaware of the deception (M = .46, SD = .21), $t(145) = -.27$, $p = .79$. Similarly, association recognition was no different for those aware of the deception (M =

.42, *SD* = .07) compared to those unaware of the deception (*M* = .38, *SD* = .12), *t*(145) = -.52, *p* = .60.

Behavioral Task Performance.

Encoding Task

On average, participants' fit/no fit judgements during the encoding task were 82% accurate (SD = 11%). Overall average reaction times (RTs) for encoding trials are reported in Table 1, as well as reaction times by subsequent performance on the recognition task.

Table 1.
Mean Reaction Times (ms) for Fit/No-Fit Judgements During the Encoding Task, Categorized by Later Memory Performance

Memory Type and Accuracy	*M R*eaction Time in ms (*SD*)
All trials	576 (183)
Item, correct recognition	581 (180)
Item, incorrect recognition	563 (196)
Association, correct recognition	594 (196)
Association, incorrect recognition	562 (183)

A paired-samples *t*-test indicated that participants' RTs during the encoding task were significantly slower for item trials that were later correctly identified as "old," when compared to item trials that were later incorrectly identified as "new," *t*(145) = 2.44, p = .02. Similarly, a paired-samples *t*-test indicated that participants' RTs at encoding were significantly slower for association trials that were later correctly identified as "old," when compared to association trials that were later incorrectly identified as "new," *t*(145) = 4.45, p < .001.

Recognition Task

The average item hit rate in the sample was .63 (*SD* = .18) corrected for guessing by subtracting the average false alarm rate of .16 (*SD* = .12), yielding a corrected item hit rate of .48 (*SD* = .21). The proportion of correct trials for association items was .39 (*SD* = .13). One-sample *t*-tests indicated that performance on recognition trials was significantly greater than the chance value of 0 for item accuracy, $t(144) = 27.51$, $p < .001$, and the chance value of .25 for association accuracy, $t(144) = 13.09$, $p < .001$. A comparison of difference-from-chance scores for item hit rate (not corrected) and association hit rate revealed that there was no significant difference in item memory difference-from-chance (*M* = .13, *SD* = .18) compared with association memory difference from chance (*M* = .14, *SD* = .13), $t(144) = -.46$, $p = .65$. The correlation between performance on the two memory tests was strong and significant ($r = .71$, $p < .001$). The number of hours between encoding and recognition tasks (*M* = 24.54, *SD* = 4.18, range = 2.34-49.88) did not significantly correlate with performance on item, $r(144) = -.07$, $p = .40$, or association recognition trials, $r(144) = -.16$, $p = .05$.

Average confidence ratings for recognition trials are reported in Table 2, as well as confidence ratings by subsequent performance on the recognition trial. Paired-samples t-tests comparing confidence for correctly versus incorrectly recognized trials indicated participants had greater confidence on correctly recognized trials, for both item-level information, $t(145) = 3.89$, $p < .001$, and association-level information, $t(145) = 12.15$, $p < .001$.

Table 2.
Mean Confidence Ratings for Recognition Trials Categorized by Item Versus Association and Memory Performance

	Confidence Rating	
Memory Type and Accuracy	*M*	*SD*
All item trials	3.83	.61
All old item trials	3.81	.61
All new item trials	3.84	.64
Item, correct recognition	3.83	.71
Item, incorrect recognition	3.59	.68
All association trials	3.61	.70
All old association trials	3.59	.65
All new association trials	3.65	.80
Association, correct recognition	3.80	.62
Association, incorrect recognition	3.41	.72

Relationship Between Encoding Reaction Time and Recognition Accuracy

Bivariate correlations between mean reaction time during the encoding task (T1) and mean recognition accuracy (T2) were examined. With respect to item-level trials, reaction time during encoding did not significantly correlate with recognition accuracy, $r(144) = .12$, $p = .14$. Similarly, recognition accuracy for association-level trials did not correlate with reaction time during encoding, $r(144) = .07$, $p = .38$.

Self-Reported Cognitive States

Descriptive characteristics of the four measures of cognitive state, assessed before (pre-encoding) and after (post-encoding) the encoding task, are presented in Table 3. Internal reliability was also calculated for multi-item measures. Repeated measures of cognitive states were examined for change over time (i.e., before and after encoding). Significant changes were observed for hypnotic depth, $t(137) = -5.00$, $p < .001$, and state arousal, $t(144) = 5.25$, $p < .001$; near-significant change was observed for state anxiety,

$t(145) = 1.92$, $p = .06$; no significant change was observed in state dissociation, $t(146) = 1.11$, $p = .27$. Bivariate correlations between cognitive state measures were also examined (Table 4).

Table 3.
Descriptive Statistics for Cognitive State Measures

	N	*M* (possible range)	*SD*	*α*
State dissociation (pre)[a]	146	.48 (0-4)	.57	.85
State dissociation (post)[a]	146	.44 (0-4)	.62	.89
Hypnotic depth (pre)[b]	145	1.27 (0-10)	1.43	-
Hypnotic depth (post)[b]	137	2.03(0-10)	1.88	-
State arousal (pre)[c]	144	2.48 (0-4)	.76	-
State arousal (post)[c]	138	2.15 (0-4)	.79	-
State anxiety (pre)[d]	146	.95 (0-3)	.59	.71
State anxiety (post)[d]	146	.87 (0-3)	.59	.73
Trait dissociation[e]	146	16.86 (0-100)	12.02	.93
Trait negative affect[f]	146	2.51 (0-4)	.62	.58
Trait positive affect[g]	146	1.72 (0-4)	.55	.74

*p <.05; **p<.01; [a]standardized beta significance = .06

[a]Peritraumatic dissociation experiences questionnaire mean; [b]Stanford hypnotic susceptibility hypnotic depth rating; [c]Self-assessment manikin arousal rating; [d]State subscale of the state-trait anxiety inventory short version, mean; [e]Dissociative experiences scale; [f]PANAS-short negative sub-scale; [g]PANAS-short positive sub-scale.

Table 4.
Bivariate Correlations Between Cognitive State Measures

	2	3	4	5	6	7	8	9	10	11
1. State dissociation (pre)	.70**	.37**	.28*	.03	.17*	.42**	.30**	.51**	.33**	-.18*
2. State dissociation (post)		.26**	.54**	-.05	-.06	.28**	.20*	.47**	.26**	-.10
3. Hypnotic depth (pre)			.53**	-.17*	-.06	.28**	.22**	.19*	.07	.01
4. Hypnotic depth (post)				-.10	-.23**	.16	.08	.28**	.10	.09
5. State arousal (pre)					.50**	.01	-.04	.07	.03	.07
6. State arousal (post)						.05	.05	.03	-.08	.05
7. State anxiety (pre)							.65**	.41**	.51**	-.13
8. State anxiety (post)								.27**	.37**	-.10
9. Trait dissociation									.41**	-.09
10. PANAS negative										-.17*
11. PANAS positive										

*p <.05; **p<.01

[a]Peritraumatic dissociation experiences questionnaire mean; [b]Stanford hypnotic susceptibility hypnotic depth rating; [c]Self-assessment manikin arousal rating; [d]State subscale of the state-trait anxiety inventory short version, mean; [e]Dissociative experiences scale; [f]PANAS-short negative sub-scale; [g]PANAS-short positive sub-scale.

Relationship Between Cognitive States During Encoding and Recognition Memory

To evaluate Hypotheses 1.1A-D, two regressions tested how pre- and post-encoding cognitive states related to (1) item-level recognition task performance and (2) association-level recognition task performance. The omnibus regression of item-level memory on pre- and post-task cognitive states was significant, $F(8, 125) = 3.10$, $p = .003$, $r^2 = .16$. Individual coefficient estimates are presented in Table 5. The omnibus regression of association-level memory on pre-and post-task cognitive states was not significant, $F(8, 125) = 1.89$, $p = .07$, $r^2 = .11$. However, given that the item-level omnibus test was significant, individual coefficient estimates for the association-level regression are also presented in Table 5.

Table 5.
Regression Models with Pre- and Post-Encoding Cognitive States Predicting Item and Association Recognition Performance

Variable	*B*	*SE B*	*β*	*p*	95% CI LL	95% CI UL
Outcome: Item Trial Recognition[a]						
Pre-encoding measures						
State dissociation[b]	-.09	.05	-.24[b]	.06	-.17	.00
Hypnotic depth[c]	.00	.01	.03	.79	-.03	.03
State arousal[d]	-.03	.03	-.11	.27	-.08	.02
State anxiety[e]	-.08	.04	-.23*	.04	-.15	.00
Post-encoding measures						
State dissociation[b]	.12	.04	.38***	.00	.04	.21
Hypnotic depth[c]	-.03	.01	-.25*	.04	-.05	.00
State arousal[d]	-.03	.03	-.13	.18	-.08	.02
State anxiety[e]	.05	.04	.15	.17	-.02	.12
Outcome: Association Trial Recognition[f]						
Pre-encoding measures						
State dissociation[b]	-.03	.03	-.12	.37	-.08	.03
Hypnotic depth[c]	-.01	.01	-.07	.50	-.02	.01
State arousal[d]	-.03	.02	-.21*	.03	-.07	.00
State anxiety[e]	-.03	.02	-.16	.17	-.08	.01
Post-encoding measures						
State dissociation[b]	.04	.03	.21	.11	-.01	.10
Hypnotic depth[c]	-.01	.01	-.10	.40	-.02	.01
State arousal[d]	-.01	.02	-.03	.74	-.04	.03
State anxiety[e]	.02	.02	.11	.31	-.02	.07

*p <.05; **p<.01; **p<.001

Note. Total *N* = 145. CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

[a]Corrected hit rate: proportion correct minus proportion false alarm; [b]Peritraumatic dissociation experiences questionnaire mean; [c]Stanford hypnotic susceptibility hypnotic depth rating; [d]Self-assessment manikin arousal rating; [e]State subscale of the state-trait anxiety inventory short version, mean; [f]Proportion correct out of "old" association recognition trials.

Relationship Between Cognitive States at Recognition and Memory Performance

To evaluate Hypotheses 1.2A-D, two regressions tested how a pre-post encoding cognitive states change score[3] and pre-recognition cognitive state ratings related to (1) item-level recognition task performance and (2) association-level recognition task performance. The omnibus test predicting item-level memory was not significant, $F(8, 114) = 1.89$, $p = .07$, $r^2 = .11$. The omnibus test predicting association-level memory was also not significant, $F(8, 114) = .66$, $p = .71$, $r^2 = .05$. Individual coefficient estimates for the item and association regressions are presented in Table 6.

[3] A pre-post encoding change score for cognitive states was used instead of including individual pre- and post- encoding ratings separately due to collinearity issues with including three sets of repeated measures.

Table 6.
Regression Models with Encoding and Retrieval Cognitive States Predicting Item Memory and Association Memory

					95% CI	
Variable	*B*	*SE B*	*β*	*p*	*LL*	*UL*
Outcome: Item Trial Recognition[a]						
Encoding measures (pre-post task)						
State dissociation change	.10	.05	.22*	.04	.01	.18
Hypnotic depth change	-.02	.05	-.01	.35	-.04	.01
State arousal change	.00	.02	.01	.88	.05	.92
State anxiety change	.04	.04	.10	.31	-.04	.11
Recognition measures (pre-task)						
State dissociation	-.01	.05	-.01	.91	-.11	.10
Hypnotic depth	-.02	.01	-.12	.20	-.04	.01
State arousal	.00	.02	.01	.93	-.04	.04
State anxiety	.02	.03	.05	.66	-.05	.08
Outcome: Association Trial Recognition[f]						
Encoding measures (pre-post task)						
State dissociation change	.04	.03	.15	.16	-.02	.10
Hypnotic depth change	.00	.01	.01	.93	-.02	.02
State arousal change	-.02	.02	-.10	.30	-.05	.01
State anxiety change	.03	.03	.10	.33	-.03	.08
Recognition measures (pre-task)						
State dissociation	.02	.04	.05	.69	-.06	.09
Hypnotic depth	-.01	.01	-.09	.36	-.02	.01
State arousal	-.00	.01	-.02	.89	-.03	.02
State anxiety	.00	.02	.00	.99	-.04	.05

*p <.05; **p<.01

Note. Total *N* = 145. CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

[a]Corrected hit rate: proportion correct minus proportion false alarm; [b]Peritraumatic dissociation experiences questionnaire mean; [c]Stanford hypnotic susceptibility hypnotic depth rating; [d]Self-assessment manikin arousal rating; [e]State subscale of the state-trait anxiety inventory short version, mean; [f]Proportion correct out of "old" association recognition trials.

Response to Research Participation

On the RRPQ at Time 1, the top three reasons for participating in the study were: "I was curious" (*n* =120, 82%), "To help others" (*n* = 84, 58%), and "To help myself" (*n* = 61, 42%). At Time 2, the same explanations were selected as the top reasons for participating in the study were: "I was curious" (*n* =124, 85%), "To help others" (*n* = 78, 53%), "To help myself" (*n* = 57, 39%), and "For course or extra credit" (*n* = 59, 40%).

As depicted in Table 7, one-sample *t*-tests indicated that, during both study visits, the two cost subscales were rated significantly less positively than the neutral point on the scale (i.e., 3 out of 5), and two of the three benefit subscales (i.e., participation and global evaluation) were rated significantly more positively than the neutral point on the scale.

Table 7.
Time 1 and Time 2 RRPQ Subscale Descriptive Statistics and One-Sample t-Tests Comparing Subscale Means to Neutral Score

		Time 1				Time 2			
Measure		*M*	*SD*	α	*t*(152)	*M*	*SD*	α	*t*(152)
RRPQ Scales, Positive	Participation	3.86	.58	.58	17.86***	3.77	.66	.67	13.90***
	Personal Benefits	2.89	.74	.76	-1.74	2.69	.78	.78	-4.69***
	Global Evaluation	4.16	.47	.72	29.54***	4.01	.64	.80	19.03***
RRPQ Scales, Negative	Emotional Reactions	2.09	.92	.86	-11.77***	1.89	.86	.88	-15.67***
	Perceived Drawbacks	2.28	.57	.68	-15.28***	2.63	.63	.73	-7.03***

Study 1 Discussion

A brief discussion of Study 1 results is presented here with a broader discussion of Studies 1 and 2 appearing in the Overall Discussion section below. With respect to the effects of individual differences in dissociation versus arousal, Study 1 suggested that better item recognition was related to an increase in dissociation over the course of encoding, but unrelated to arousal during encoding or any cognitive states at recognition; and better association recognition was related to a decrease in arousal over the course of encoding, but unrelated to dissociation during encoding or any cognitive states at recognition. The results can be interpreted as supportive of the BIC model. While the BIC model specifically focuses on the neural correlates of memory performance, the behavioral patterns observed in Study 1 indicated that item and association memory were differentially related to levels of dissociation and arousal. Not only does this suggest that item and association memory may be encoded separately, but also that the processes could be related separately to an individual's cognitive state at the time of encoding.

The current study also suggests that the dynamics of DRT do not apply to low levels of dissociation and arousal. Study 1 examined individual differences in resting cognitive states (which were largely closer to zero than scale midpoints), whereas DRT focuses on the high levels of arousal or dissociation that are experienced during acutely stressful or traumatic events. The study of traumatic memory has often focused on the bottom-up feature of the affective content of information to be encoded and retrieved. In contrast, DRT focuses on top-down cognitive effects. If supplemented by future studies of the effects of high levels of dissociation and arousal on memory, the Study 1 findings support

DRT's explanation that differences in memory for traumatic versus non-traumatic events can be attributed to the effects of heightened cognitive states during acute stress.

With respect to dissociation, Study 1 was undertaken from the perspective of spectrum models of dissociation, such as the sociocognitive model (Lynn et al., 2019), which suggest that that even lower levels of dissociation may affect behavioral performance, with increasing levels of dissociation producing dose-dependent impairment of behaviors (Butler, 2006). However, the Study 1 results provide evidence that a threshold model, in which only extreme levels of dissociation produce cognitive deficits, is more appropriate (Kozlowska et al., 2015). Indeed, the Study 1 finding that an increase in dissociation over the course of encoding was related with better item recognition may be reflective of the *benefits* of a non-pathological dissociative cognitive style, which has been associated with improved attention, working memory, and episodic memory (de Ruiter et al., 2006).

The Study 1 arousal findings can be better understood when compared to the few studies that have examined the differential effects of arousal on item versus association memory from a binding of item and context (BIC) perspective. It must be noted that most BIC studies have experimentally manipulated arousal, rather than relied on natural cognitive state variations, as was done in the current Study 1. The Study 1 finding that arousal during encoding was unrelated to item recognition has been observed based on natural variations (Huntjens et al., 2015) and experimentally-manipulated (Goldfarb et al., 2019) arousal; however, in other studies, greater arousal was found to relate to less accurate item recognition (Bisby & Burgess, 2014; Bolton and Robinson, 2017). As in

the current study, arousal has been found to be related to less accurate association recognition (individual differences in arousal: Huntjens et al., 2015; experimentally-manipulated arousal: Bisby & Burgess, 2014), though two studies of experimentally-manipulated arousal found no relationship with association recognition (Bolton & Robinson, 2017; Goldfarb et al., 2019). The arousal-biased competition (ABC; Mather & Sutherland, 2011) model can help to explain how the inclusion of multiple stimuli—as in a task with both item and association features— diffuses the typical effect of arousal to enhance directed attention toward a single stimulus. That is, arousal impairs complex stimulus encoding because it diminishes divided attention and working memory capacity (Mather, et al., 2006; Morelli & Burton, 2009; Mitchell, et al., 2006). While DRT focuses on the neural processes of encoding, the ABC model points to the processes of perception, which occur earlier in the memory process.

Study 2

Study 2 Method

Procedures were approved by the University of Denver (DU) Institutional Review Board before recruitment began.

Study 2 Participants

Participants were adults (18 and older) recruited from the DU human subjects pool (HSP) and through announcements to DU courses by email and in person. A total of 42 participants were enrolled and participated in the Part 1 (encoding) visit. Almost all participants (n = 39; 93% retention) returned for Part 2 (recognition) the following day. The remaining 39 participants demonstrated acceptable behavior task performance. Participants ranged in age from 18-29 (M = 20.10 years, SD = 2.26). The largest portion of the sample were first-year undergraduate students (41%, n = 16; 21% second-year students, n = 8; 11% third-year students, n = 4; 15% fourth-year students, n = 6; 13% graduate-level students, n = 5). Participants were primarily women (74%, n = 29), with the remainder identifying as men (26%, n = 10). Participants identified their racial/ethnic identities as: 74% white (n = 29), 18% Asian or Pacific Islander (n = 7), 10% identified with another race/ethnicity, combined for confidentiality (i.e., Black, Native American/Alaska Native, Arab; n = 4); selection of more than one category was permitted, resulting in a total greater than 100%. Most of the sample identified their sexual orientation as heterosexual/straight (85%, n =33); the remaining participants

indicated their sexual orientation was lesbian, gay, bisexual, pansexual, asexual, or queer. Over two thirds of the sample reported experiencing at least one potentially traumatic event before the age of 18 (64%, n = 25)

Design

A two-factor mixed within- and between-subjects design was used to prospectively examine the effect of time (baseline vs. induction), condition (hyperarousal vs. dissociation), and memory type (item vs. association) on recognition accuracy. Participation occurred during two study sessions that occurred approximately 24 hours apart. The Time 1 (encoding) session took approximately 1.5 hours and occurred in person; the Time 2 (recognition) session took approximately 1 hour and occurred remotely via online survey and task.

Procedure

The timeline of study activities is depicted in Figure 3. Time 1 data was collected in person at a university research office. Time 2 data was collected remotely on participants' personal computers at the location of their choosing. Due to COVID-19 social distancing requirements, most Time 1 activities were conducted with the researcher and participant in separate rooms with doors closed using Zoom video conferencing software to communicate. At Time 1, participants received informed consent information verbally and in writing and responded verbally to the same 5-question "consent quiz" described in Study 1 (DePrince & Chu, 2008). All participants were able to successfully answer 100% of consent quiz questions within two administrations of the consent quiz. Next, participants were asked to sign the informed consent form via an online survey.

After consenting, participants were asked to respond to the same online survey described in Study 1 (i.e., demographic questions, baseline self-report measures of trait dissociation and affect, history of traumatic experiences, and the first administration of repeated cognitive state measures). Next, participants were fitted with heart-rate monitoring equipment and asked to do the baseline encoding task. After baseline encoding, participants were randomized to either the hyperarousal or the dissociation experimental condition. Following induction of experimental condition, participants were asked to respond to the second block of the encoding task.

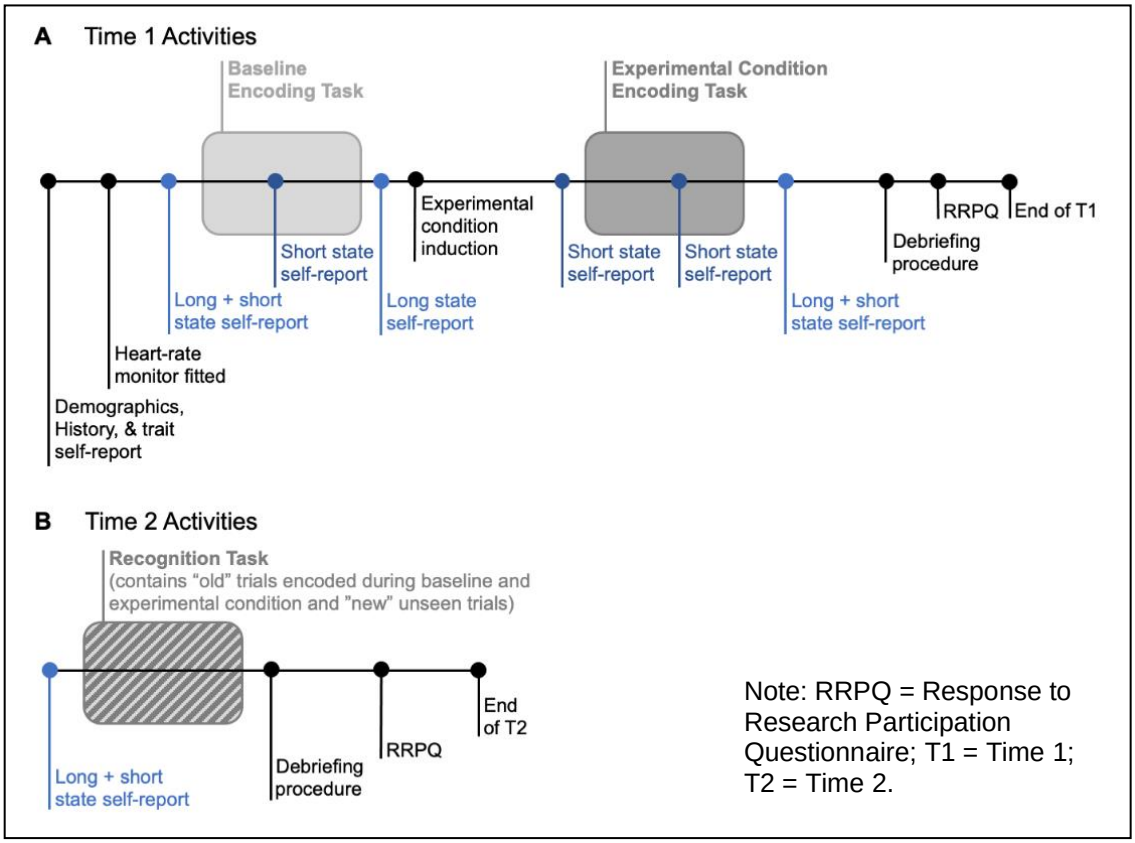


Figure 4. Visual Representation of Study Activities for Time 1 and Time 2 Sessions

To assess effectiveness of experimental induction and to assess changes in cognitive states over time, repeated state measures (i.e., state arousal, state dissociation, hypnotic depth, state anxiety, and affect) were re-administered over the course of the Time 1 visit. A longer battery (i.e., several items tapping state dissociation and state anxiety) was administered at two timepoints: (1) after baseline encoding task, and (2) after experimental condition encoding task. An abbreviated self-report measure, including four items (hypnotic depth, arousal, affect, and dominance), was administered at four timepoints: (1) midway through baseline encoding task, (2) after experimental condition induction before beginning the experimental condition encoding task, (3) midway through the experimental encoding task, and (4) after experimental condition encoding task.

The encoding task was identical to that described in Study 1. After the first half of the encoding task, experimental condition was randomized and induced. For participants in the hyperarousal condition, introduction of hyperarousal involved an electrical stimulation calibration procedure (described below). For participants in the dissociation condition, introduction of dissociation involved listening to a hypnosis script administered by a research assistant. Following these Time 1 study activities, a debriefing survey was used to assess participant awareness of manipulations and experience with the study procedures. Following these Time 1 study activities, participants were asked to respond to the Response to Research Participation Questionnaire (RRPQ; Newman & Kaloupek, 2001). As in Study 1, participants who indicated “Agree” or “Strongly Agree” to the flagged RRPQ questions were asked whether they would like a referral to the university-wide support resource. In Study 2, three participants were flagged and zero

participants indicated they would like a referral. Participants were then thanked for their time and compensated with course credit or $22.50 via Amazon gift certificate that was sent to participants via email. Compensation type was determined based on the method of recruitment.

Procedures for the Time 2 session (which occurred 20-30 hours after Time 1 began) were identical to procedures for the Time 1 session, except participants recruited through community flyers or announcements were compensated with $15.00 via Amazon gift certificate for participation at the end of the Time 2 session.

Experimental Conditions

Baseline Condition

In the baseline condition, participants were instructed to perform the encoding task: making judgements about object-scene pairs on a computer screen. In this condition, participants were told there was no risk of electrical stimulation or use of hypnosis.

Hyperarousal Condition

Hyperarousal was induced using threat of 6ms electrical stimulation, administered according to a standardized procedure (e.g., Robinson et al., 2013) using the BIOPAC STIMSOC system (BIOPAC Systems, Inc.). The stimulations were administered to the participant's wrist of the non-dominant hand via a single lead. To comply with COVID-19 social distancing requirements, participants were given written and verbal instructions for how to attach stimulation leads to their own wrist. The researcher was available to enter the participant's room, but most participants received verbal and visual consultation through Zoom video only. To minimize risk associated with electric stimulation, participants engaged in a stimulation calibration procedure before beginning the

hyperarousal task. Participants were instructed to identify a stimulation voltage that was "highly irritating but not painful," using a staircase procedure (Dunsmoor et al., 2012) that exposed participants to stimulation voltages that increased in approximately 1V increments until the participant indicates the appropriate stimulation level has been reached. All participants experienced at least two stimulations, and no participants experienced more than five stimulations (Dunsmoor et al., 2009). In the current study, participants in the arousal condition calibrated the electrical stimulation to an average level of 55V (*SD* = 15; range = 35-80V).

The application of electrodes and calibration procedure took 5-10 minutes. During the hyperarousal encoding task, stimulations were administered at a four pseudorandom time points during the task (i.e., two stimulations during each of the two blocks). Stimulations were delivered during the inter-trial intervals to ensure that the stimulations did not affect performance directly, though the manual stimulus initiation resulted in variation in timing.

Dissociation Condition

Dissociation was induced using a hypnosis script that has been identified as a safe and reliable way to create psychological distance between the participant and subsequent tasks (Holmes et al., 2006; Oakley et al., 2007). Rather than alternative methods for inducing dissociation (i.e., mirror gaze, Brewin et al., 2013; Brewin & Mersaditabari, 2013; somatoform hypnosis, Hagenaars et al., 2008; sensory deprivation, Leonard et al., 1999), psychological distance hypnosis was selected for this study given that it can be used to durably induce dissociation while also allowing participants to engage with a complex task.

The suggested dissociation script (see Appendix A for full script) begins with instructions for regular breathing, eye closure, muscle relaxation, descent imagery, and identification of a "special place." Next, participants heard instructions that increase psychological distance, including looking at their body from the outside and feeling that surroundings and sensations are unfamiliar or strange. The script took approximately 10 minutes. After the dissociation portion, the script instructs participants to open their eyes, orient to the computer in front of them and respond to the encoding task. Afterward, the script instructed participants to close their eyes, return to normal feelings, and mentally return to the "special place." Finally, the script reversed hypnosis through backwards numerical counting and increased body awareness.

Encoding and Recognition Tasks

The tasks used in Study 2 were identical to those used in Study 1.

Measures

Condition Validity Measures

Self-Reported Cognitive State Measures

As in Study 1, participants were asked to report perceived state arousal (Self-Assessment Manikin; Bradley & Lang, 1994), state dissociation (Peritraumatic Dissociative Experiences Questionnaire; Marmar et al., 1997), and hypnotic depth (Stanford Hypnotic Susceptibility Scale; Weitzenhoffer & Hilgard, 1962).

Physiological Arousal

Objective physiological arousal was assessed using average heart rate at baseline, during each encoding task block, and after the encoding task. Heart rate was taken via a lead-II BIOPAC Systems ECG100C Electrocardiogram (ECG) Amplifier. The sampling

rate was 200 Hz. To comply with COVID-19 social distancing requirements, participants were given written, visual, and verbal instructions for how to attach electrodes to their own torso. The researcher was available to enter the participant's room, but most participants received verbal and visual consultation through Zoom video only. The researcher visually confirmed correct placement of all leads before ECG data collection began. Heart rate was computed using BIOPAC Acqknowledge software to extract beats-per-minute (BPM). Error due to the movement artifacts was manually edited. A mean heart rate for each block of the encoding task was calculated by averaging the BPM for each inter-beat-interval during the relevant block.

Given significant variability in heartrate due to situational factors (e.g., movement, caffeine intake, medication) and that researchers reviewing heartrate data are not medically trained, no heartrate information was shared with participants to reduce the likelihood of false positive information being shared with participants. Heartrate was expected to increase from baseline in the hyperarousal condition (Cloitre, 1998; Perry et al., 1995), and conversely, decrease from baseline in the dissociation condition (Cloitre et al. 2005; Koopman et al., 2004; Marx et al., 2005; Polusny et al., 2004).

Potential Covariate Measures

As in Study 1, participants were asked to report demographic information, trait dissociation[4] (Dissociative Experience Scale, 2nd Edition, DES-II; Carlson & Putnam, 1993), history of trauma exposure (Trauma History Questionnaire, THQ; Hooper et al.,

[4] Note: Trait anxiety was not measured due to researcher error when compiling measures to be included in the online questionnaire and IRB documents.

2011), affect (Positive and Negative Affect Scale, Short Form, PANAS-SF; Mackinnom et al., 1999), research reactions (RRPQ; Newman & Kaloupek, 2001).

Encoding-Recognition Interval

The time of day was recorded at the start of the first encoding trial and at the start of the recognition task. This measurement was used to calculate the delay, in hours.

Data Analysis

All analyses were conducted using IBM SPSS 25 software. Performance on the recognition tasks was scored using the same procedure described in Study 1. Descriptive statistics, including normality and bivariate correlations, for all variables were assessed for the necessity of transformations and inclusion of covariates in central analyses. Scores were approximately normal; thus, analyses were run using the original data. An independent sample *t*-test compared item and association recognition based on whether participants reported awareness of the mnemonic purpose of the study before the deception was revealed to participants.

The validity of the experimental induction paradigms was evaluated using paired-sample *t*-tests to compare within-subject cognitive state ratings from before versus after experimental state induction, separately for the two experimental groups. At teach of the measured time points, differences between the two experimental groups' cognitive states were evaluated using independent-samples *t*-tests. Given that fatigue can influence performance on behavioral tasks, the linear effect of time on indicators of fatigue (i.e., self-reported affect, reaction time, and accuracy of judgements during encoding) was examined using repeated measures ANOVAs. As another indicator of fatigue, the

relationship between reaction time at encoding and recognition accuracy was examined using bivariate correlations.

Participant heart rate was examined using a two-way mixed measures ANOVA, with one between-subjects variable (i.e., experimental condition; dissociation vs. arousal) and one within-subjects condition (time; before vs. after condition induction).

Differences in reaction time during the encoding task based on subsequent recognition accuracy was examined for both item and association trials using paired-samples *t*-tests. Reaction time before versus after experimental induction was also examined separately within the dissociation and hyperarousal groups using paired-sample *t*-tests. An independent-samples *t*-test compared accuracy between the dissociation and hyperarousal groups. Within subjects, a paired-samples *t*-test was used to compare recognition accuracy during baseline versus experimental trials. Item and association recognition performance was compared to chance (i.e., 0 and .25, respectively) using one-sample *t*-tests. Differences in confidence ratings during the recognition task based on recognition accuracy was examined for both item and association trials using paired-samples *t*-tests. The bivariate correlation between item and association recognition performance was examined as an indicator of the validity of the task. Correlations of recognition performance before versus after experimental induction were examined for both item and association trials. Separate regressions of item and association recognition on encoding-recognition time interval were conducted to determine whether the time delay should be included as a covariate in subsequent hypothesis tests. Paired-samples *t*-tests comparing confidence based on subsequent memory performance were conducted for item and association trials.

To evaluate the effects of methodological differences between Study 1 and Study 2, separate independent-samples *t*-tests compared item and association accuracy by delivery format (i.e., online vs. in-person).

Memory performance analyzed using a repeated-measures ANOVA with experimental induction (baseline vs. induction) and memory type (item vs. association) entered as within-participant factors, and condition (hyperarousal vs. dissociation) entered as between-participant factors. Item and association memory performance was analyzed together to determine whether the hyperarousal versus dissociation resulted in differential effects on memory (i.e., interaction effects between experimental condition and accuracy for item and associative memory). Based on the significance of the omnibus ANOVA, we planned to examine within-model main effects (i.e., of experimental induction, memory type, and condition), two-way interactions (i.e., experimental induction x memory type, experimental induction x condition, and memory type x condition), and three-way interaction (i.e., experimental induction x memory type x condition) to determine relative effects of the different components of the experimental manipulation. Effect sizes were calculated for ANOVA using partial eta squared.

At both Time 1 and Time 2, the RRPQ was analyzed to determine participants' top three reasons for participating and perceived costs and benefits. One-sample *t*-tests compared RRPQ subscale means to a neutral rating.

Study 2 Results

Awareness of Deception

No participants reported thinking the study might be related to memory.

Self-Reported Cognitive States and Traits

Descriptive statistics for the six measures of cognitive states, assessed across six points during the Time 1 (encoding) session, are reported in Table 8. Internal reliability is also included for multi-item measures. Table 9 depicts descriptive statistics for the six cognitive state measures at the start of the Time 2 (recognition) session. Descriptive statistics for the three cognitive trait measures, assessed before the start of the encoding task are reported in Table 10.

Table 8.
Descriptive Statistics for Cognitive State Measures in Full Sample During Time 1 Session

	Baseline, Pre Block1				Pre Block 2			Pre Experimental Induction			
	n	*M*	*SD*	*α*	*n*	*M*	*SD*	*n*	*M*	*SD*	*α*
State dissociation[a]	39	1.15	.25	.79	-	-	-	38	1.15	.32	.84
State anxiety[c]	39	1.68	.51	.64	-	-	-	39	1.66	.47	.58
Hypnotic depth[b5]	34	1.76	.82	-	36	1.81	1.00	-	-	-	-
State arousal[d]	39	2.59	.59	-	39	2.56	.55	-	-	-	-
State affect[e]	39	1.95	.51	-	39	2.05	.56	-	-	-	-
State dominance	39	4.18	.76	-	39	4.23	.78	-	-	-	-
	Pre Block 3				Pre Block 4			Post Block 4			
	n	*M*	*SD*		*n*	*M*	*SD*	*n*	*M*	*SD*	*α*
State dissociation[a]	-	-	-		-	-	-	39	1.42	.66	.92
State anxiety[c]	-	-	-		-	-	-	39	1.65	.47	.46
Hypnotic depth[b]	39	3.13	2.44		29	2.83	2.21	28	2.39	1.81	-
State arousal[d]	39	2.46	.82		39	2.51	.82	38	2.55	.89	-
State affect[e]	39	2.08	.74		39	2.05	.60	38	2.00	.67	-
State dominance	39	3.69	1.00		39	3.85	.88	38	3.92	.94	-

[a]Peritraumatic dissociation experiences questionnaire mean; [b]Stanford hypnotic susceptibility hypnotic depth rating; [c]State subscale of the state-trait anxiety inventory short version, mean; [d]Self-assessment manikin arousal rating; [e]Self-assessment manikin affect rating; [f]Self-assessment manikin dominance rating.

[5] Note: The smaller sample size of the Hypnotic Depth measure is a result of the measure being presented first in the section and participants clicking past without providing a valid response.

Table 9.
Descriptive Statistics for Cognitive State Measures in Full Sample During Time 2 Session

State	N	M	SD	α
State dissociation[a]	39	2.09	.22	.81
State anxiety[c]	39	1.71	.57	.62
Hypnotic depth[b]	25	.88	1.45	-
State arousal[d]	39	2.49	.64	-
State affect[e]	39	2.20	.89	-
State dominance	39	4.54	.79	-

Table 10.
Descriptive Statistics for Cognitive Trait Measures

Trait	N	Mean	SD	α
Trait dissociation[a]	39	16.45	10.96	.94
Trait negative affect[b]	39	2.38	.56	.74
Trait positive affect[c]	39	3.69	.39	.44

[a]Dissociative experiences scale; [b]PANAS-S negative sub-scale; [c]PANAS-S positive sub-scale.

Validity of Experimental Induction Paradigms

Self-Reported Cognitive States

Paired-sample *t*-tests comparing self-reported cognitive state ratings from before versus after experimental state induction, within condition groups are presented in Table 11. Between-groups comparisons of cognitive states, using independent-sample *t*-tests, are depicted in Table 12.

Table 11.

Paired-Sample t-Tests Comparing Cognitive States Before Versus. After Experimental Induction by Condition

	Pre-Induction		Post-Induction			95% CI	
Cognitive State	*M*	*SD*	*M*	*SD*	*t*(38)	LL	UL
Dissociation Condition							
State Dissociation[a]	1.24	.43	1.77	.79	-4.66***	-.77	-.29
Hypnotic Depth[b]	2.00	1.08	4.85	2.28	-6.61***	-3.75	-1.95
State Anxiety[c]	1.68	.51	1.41	.37	2.38*	.03	.52
State Arousal[d]	2.55	.60	2.00	.65	2.98**	.16	.94
State Affect[e]	1.95	.51	1.90	.72	.30	-.31	.41
State Dominance[f]	4.20	.83	3.30	1.13	3.45**	.36	1.45
Arousal Condition							
State Dissociation[a]	1.07	.17	1.12	.33	-1.38	-.13	.03
Hypnotic Depth[b]	1.56	.89	1.25	.58	1.58	-.11	.74
State Anxiety[c]	1.66	.44	1.89	.44	-2.02[a]	-.48	.00
State Arousal[d]	2.58	.51	2.95	.71	-2.69*	-.65	-.08
State Affect[e]	2.16	.60	2.26	.73	-1.46	-.26	.05
State Dominance[f]	4.26	.73	4.11	.66	1.00	-.17	.49

*p <.05; **p<.01; ***p<.001; [a]standardized beta significance = .06; CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

[a]Peritraumatic dissociation experiences questionnaire mean; [b]Stanford hypnotic susceptibility hypnotic depth rating; [c]State subscale of the state-trait anxiety inventory short version, mean; [d]Self-assessment manikin arousal rating; [e]Self-assessment manikin affect rating; [f]Self-assessment manikin dominance rating.

Table 12.
Independent-Sample t-Tests Comparing Cognitive States Across Experimental Condition by Timepoint

	Dissociation Condition		Arousal Condition			95% CI	
Cognitive State	*M*	*SD*	*M*	*SD*	*t*(38)	LL	UL
Baseline – Pre Block 1							
State Dissociation[c]	1.18	.29	1.75	.19	.94	-.09	.24
State Anxiety[d]	1.68	.57	1.68	.45	-.06	-.34	.33
Hypnotic Depth[e]	2.00	.96	1.56	.62	1.62	-.12	1.00
State Arousal[f]	2.65	.67	2.53	.51	.64	-.27	.51
State Affect[g]	1.80	.41	2.11	.57	-1.93	-.63	.02
State Dominance[h]	4.10	.79	4.26	.73	-.67	-.66	.33
Pre Block 2 (Short)							
Hypnotic Depth[e]	2.00	1.08	1.56	.89	1.31	-.244	1.12
State Arousal[f]	2.55	.60	2.58	.51	-.16	-.39	.33
State Affect[g]	1.95	.51	2.16	.60	-1.17	-.57	.15
State Dominance[h]	4.20	.83	3.26	.73	-.25	-.57	.35
Pre Exp Induce (Long)							
State Dissociation[c]	1.23	.42	1.07	.17	1.57[b]	-.05	.37
State Anxiety[d]	1.66	.50	1.66	.44	.03	-.30	.31
Pre Block 3 (Short)							
Hypnotic Depth[e]	4.85	2.28	1.32	.58	6.71***[b]	2.44	4.63
State Arousal[f]	2.00	.65	2.95	.71	-4.37***	-1.39	-.51
State Affect[g]	1.90	.72	2.26	.73	-1.56	-.83	.11
State Dominance[h]	3.30	1.13	4.11	.66	-2.70**	-1.41	-.20
Pre Block 4 (Short)							
Hypnotic Depth[e]	4.06	2.27	1.31	.63	2.67*	.43	3.13
State Arousal[f]	2.10	.72	2.95	.71	-3.72**	-1.31	-.39
State Affect[g]	2.05	.61	2.16	.60	-.56	-.50	.28
State Dominance[h]	3.70	.98	4.00	.75	-1.07	-.87	.27
Post Block 4 (Both)							
State Dissociation[c]	1.77	.79	1.12	.33	3.33**[b]	.25	1.05
State Anxiety[d]	1.41	.37	1.89	.44	-3.66**	-.76	-.22
Hypnotic Depth[e]	3.5	1.99	1.29	.47	4.76***[b]	1.70	4.30
State Arousal[f]	2.21	.85	2.89	.81	-2.53**	-1.23	-.14
State Affect[g]	1.94	.66	2.24	.83	-1.14	-.82	.23
State Dominance[h]	3.74	1.15	4.11	.65	-1.21[b]	-.99	.25

	Dissociation Condition		Arousal Condition			95% CI	
Cognitive State	*M*	*SD*	*M*	*SD*	*t*(38)	LL	UL
Pre Encoding							
State Dissociation[c]	1.13	.28	1.06	.15	.92	-.08	.21
State Anxiety[d]	1.91	.56	1.49	.50	2.50*	.08	.77
Hypnotic Depth[e]	.92	1.44	.83	1.53	.15	-1.14	1.13
State Arousal[f]	2.45	.76	2.53	.51	-.36	-.50	.35
State Affect[g]	2.20	.89	2.00	.67	.79	-.31	.71
State Dominance[h]	4.45	.95	4.63	.60	-.71	-.69	.33

*p <.05; **p<.01; ***p<.001; [a]standardized beta significance = .06; [b]equal variances not assumed based on Lavene's test;
Note: CI = confidence interval; *LL* = lower limit; *UL* = upper limit; [c]Peritraumatic dissociation experiences questionnaire mean; [d]State subscale of the state-trait anxiety inventory short version, mean; [e]Stanford hypnotic susceptibility hypnotic depth rating; [f]Self-assessment manikin arousal rating; [g]Self-assessment manikin affect rating; [h]Self-assessment manikin dominance rating.

Fatigue

Self-reported affect over the course of the encoding task (see Table 12 for means) was examined using a repeated-measures ANOVA. The linear main effect of time on affect was not significant, $F(1, 38) = 2.29$, $p = .14$, $\eta_p^2 = .06$. Reaction times were also examined as a function of time, which indicated reaction times did not significantly differ over the course of the encoding task (Block 1 $M = .61$, $SD = .19$; Block 2 $M = .58$, $SD = .20$; Block 3 $M = .63$, $SD = .25$; Block 4 $M = .64$, $SD = .25$), $F(1, 38) = 1.40$, $p = .24$, $\eta_p^2 = .04$.

Fit/No-Fit judgement accuracy was also examined as a function of time, which indicated fit/no-fit judgements were significantly less accurate over the course of the encoding task (Block 1 $M = .88$, $SD = .14$; Block 2 $M = .82$, $SD = .14$; Block 3 $M = .83$, $SD = .14$; Block 4 $M = .75$, $SD = .16$), $F(1, 38) = 58.66$, $p < .001$, $\eta_p^2 = .61$.

Bivariate correlations between mean reaction time during the encoding task (T1) and mean recognition accuracy (T2) were examined. With respect to item-level trials, reaction time during encoding did not significantly correlate with recognition accuracy, $r(38) = -.24$, $p = .14$. Similarly, recognition accuracy for association-level trials did not correlate with reaction time during encoding, $r(38) = -.05$, $p = .77$.

Heart Rate

Descriptive statistics for participant heart rates are depicted in Table 13. A two-way mixed measures ANOVA indicated there was no significant main effect of the between-subjects variable, experimental condition (dissociation vs. arousal), on heart rate, $F(1, 32) = 1.26$, $p = .27$, $\eta_p^2 = .04$. With respect to the within-subjects variable, there was a significant main effect of time (before vs. after condition induction) on heart rate, $F(1, 32) = 4.72$, $p = .04$, $\eta_p^2 = .13$, such that participants' heart rate was significantly faster before condition induction (*M = 77.12, SD = 8.73)* compared to after condition induction (*M = 75.75, SD = 8.80).* The interaction term of the ANOVA indicated there was no significant interaction between condition and time, $F(1, 38) = 1.26$, $p = .27$, $\eta_p^2 = .04$, with heart rate before versus after condition induction across participants in the dissociation and arousal condition groups.

Table 13.
Average Heart Rates During the Baseline and Experimental Blocks of the Encoding Task for Participants in the Dissociation and Arousal Conditions, and in the Full Sample

	Baseline Blocks		Experimental Blocks		Combined	
Condition	*M*	*SD*	*M*	*SD*	*M*	*SD*
Dissociation	75.31	8.45	74.66	9.34	75.33	8.53
Arousal	79.42	8.82	77.13	8.15	79.52	8.14
Full Sample	77.12	8.73	75.75	8.80	77.31	8.51

Behavioral Task Performance

Encoding Task

Across experimental conditions, participants' fit/no fit judgements during the encoding task were 80% accurate (*SD* = 13%). An independent-samples *t*-test indicated there was no significant difference in accuracy between the dissociation (*M* = 82%, *SD* = 8%) and arousal (*M* = 78%, *SD* = 17%) groups, $t(37) = .96$, $p = .34$. Within subjects, a paired-samples *t*-test indicated participants were significantly more accurate during baseline trials (*M* = 85%, *SD* = 13%) than during experimental trials (*M* = 79%, SD = 14%), $t(38) = 6.44$, $p < .001$.

Overall average reaction times (RTs) for encoding trials are reported in Table 14, as well as reaction times by subsequent performance on the recognition task.

Table 14.
Mean Reaction Times (ms) for Fit/No-Fit Judgements at Encoding, Categorized by Later Memory Performance

Memory Type and Accuracy	*M* Reaction Time in ms (*SD*)
All trials	608 (197)
Item, correct recognition	608 (193)
Item, incorrect recognition	615 (232)
Association, correct recognition	614 (195)
Association, incorrect recognition	603 (202)

A paired-samples *t*-test indicated there was no significant difference between participants' RTs during the encoding task for item trials that were later correctly identified as "old," when compared to item trials that were later incorrectly identified as "new," $t(38) = -.48$, $p = .64$. Similarly, a paired-samples *t*-test indicated there was no

significant difference between participants' RTs at encoding for association trials that were later correctly identified as "old," when compared to association trials that were later incorrectly identified as "new," $t(38) = .99$, $p = .33$. A paired-samples *t*-test comparing baseline RTs ($M = 589$ms, $SD = 186$ms) to experimental RTs ($M = 628$ms, $SD = 246$ms) indicated there was no significant difference in RT based on time across both experimental conditions, $t(38) = -1.27$, $p = .21$. Separate paired-sample *t*-tests for each of the experimental conditions indicated there was no significant difference in RT before versus after experimental condition induction in the dissociation condition, $t(38) = -1.21$, $p = .24$; or in the arousal group, $t(18) = -.38$ $p = .70$ (see Table 15 for means and standard deviations).

Table 15.
Mean Reaction Times (ms) for Fit/No-Fit Judgements at Encoding Before versus After Experimental State Induction, for the Two Experimental Condition Groups

	Reaction Time (ms)			
	Baseline Trials		Experimental Trials	
	M	*SD*	*M*	*SD*
Dissociation Condition	604	187	669	290
Arousal Condition	574	189	584	188

Recognition Task

On average, participants from the full sample participated in the recognition task 25.9 hours after the encoding task ($SD = 5.97$ hours, range = 20.02-47.66). An independent sample *t*-test indicated the two experimental groups did not significantly differ in the delay between encoding and recognition, $t(38) = -.71$, $p = .48$ (dissociation group $M = 25.24$, $SD = 3.64$; arousal group $M = 26.61$, $SD = 7.76$).

When evaluating recognition performance of the full sample, the item hit rate was .66 (*SD* = .18) corrected for guessing by subtracting the false alarm rate of .13 (*SD* = .08), yielding a corrected item hit rate of .52 (*SD* = .18). The proportion of correct trials for association items was .40 (*SD* = .13). One-sample *t*-tests indicated that performance on recognition trials was significantly greater than the chance value of 0 for item accuracy, $t(38) = 18.57$, $p < .001$, and the chance value of .25 for association accuracy, $t(38) = 7.30$, $p < .001$. A paired-samples *t*-test comparing difference-from-chance scores for item hit rate (not corrected; *M* = .16, *SD* = .18) and association hit rate (*M* = .15, *SD* = .13) revealed that there was no significant difference in item memory difference-from-chance compared with association memory difference from chance, $t(38) = .30$, $p = .77$.

Before condition induction, the positive correlation between performance on the two memory tests was strong and significant ($r = .47$, $p < .01$). After condition induction, the positive correlation between performance on the two memory tests was strong and significant ($r = .33$, $p < .05$). The positive correlation between performance on item trials over time (before vs. after condition induction) was strong and significant ($r = .81$, $p < .01$). The positive correlation between performance on association trials over time (before vs. after condition induction) was strong and significant ($r = .73$, $p < .01$). The number of hours between encoding and recognition tasks did not significantly correlate with performance on item, $r(39) = -.24$, $p = .14$, or association recognition trials, $r(39) = -.08$, $p = .64$.

Overall average confidence ratings and confidence ratings by performance on the recognition trial are reported in Table 16. Paired-samples *t*-tests comparing confidence

for correctly versus incorrectly recognized trials indicated participants had greater confidence on correctly recognized trials, for both item-level information, $t(38) = 4.51$, $p < .001$, and association-level information, $t(38) = 6.74$, $p < .001$.

Table 16.
Mean Confidence Ratings for Recognition Trials Categorized by Item Versus Association and Memory Performance

Memory Type and Accuracy	*M* Confidence Rating	*SD*
All item trials	4.02	.44
All old item trials	4.00	.46
All new item trials	4.04	.48
Item, correct recognition	4.09	.47
Item, incorrect recognition	3.64	.57
All association trials	3.79	.61
All old association trials	3.68	.60
All new association trials	3.89	.70
Association, correct recognition	3.95	.53
Association, incorrect recognition	3.46	.71

Task Delivery Format

An independent-samples *t*-test indicated that the corrected hit rate for participants in the online-only format (Study 1, $N = 146$, M = .46, SD = .21), was significantly lower than the rate for participants in the in-person format (Study 2, $N = 39$, M = .57, SD = .17), $t(183) = 2.92$, $p = .004$. A second independent-samples *t*-test indicated that the proportion of correct association trials for participants in the online-only format ($N = 146$, M = .38, SD = .12) did not significantly differ from the rate for participants in the in-person format ($N = 39$, M = .42, SD = .14), $t(183) = 1.54$, $p = .13$. Note that, despite the difference in sample size between the two studies, Lavene's Test indicated that equal variances could be assumed for both comparisons above.

Memory Performance Predicted by Condition, Memory Type, and Time

The results of the two-way mixed measures ANOVA indicated there was no significant main effect of the between-subjects variable, experimental condition (dissociation vs. arousal), on recognition accuracy, $F(1, 38) = .002$, $p = .96$, $\eta_p^2 < .001$, with participants in the dissociation condition ($M = .15$) performing like participants in the arousal condition ($M = .15$). With respect to within-subjects variables, there was no significant main effect of memory type (item vs. association) on memory accuracy, $F(1, 38) = .07$, $p = .79$, $\eta_p^2 = .002$. Recognition accuracy was similar across item ($M = .16$) and association trials ($M = .15$). The ANOVA indicated there was a significant main effect of time (before vs. after condition induction), such that participants' recognition was better for items presented before condition induction ($M = .19$) and worse after condition induction ($M = .12$), $F(1, 38) = 25.08$, $p < .001$, $\eta_p^2 = .40$.

The two-way interaction terms of the ANOVA (see Table 17 for means) indicated there was no significant interaction between condition and memory type, $F(1, 38) = .60$, $p = .44$, $\eta_p^2 = .02$, with performance on item trials being comparable to performance on association trials across participants in the dissociation and arousal condition groups. There was also no significant interaction between time and experimental condition; that is, the decrease in performance before versus after condition induction did not differ based on participants' experimental condition, $F(1, 38) = 1.37$, $p = .26$, $\eta_p^2 = .03$. Conversely, there was a significant interaction between memory type and time, $F(1, 38) = 6.24$, $p = .02$, $\eta_p^2 = .14$, such that the rate of decrease in performance over time across

conditions was most extreme for item-level trials. Finally, the ANOVA revealed there was no significant three-way interaction, $F(1, 38) = 2.11$, $p = .16$, $\eta_p^2 = .05$.

Table 17.
Task Performance Across Item and Association Trials in Baseline and Experimental Conditions

	Condition	*n*	*M*	*SD*
Baseline Item Accuracy (corrected for chance)	Dissociation	20	.23	.16
	Hyperarousal	19	.18	.18
	Total	39	.21	.17
Experimental Item Accuracy (corrected for chance)	Dissociation	20	.11	.20
	Hyperarousal	19	.11	.23
	Total	39	.11	.21
Baseline Association Accuracy (corrected for chance)	Dissociation	20	.16	.12
	Hyperarousal	19	.18	.17
	Total	39	.17	.14
Experimental Association Accuracy (corrected for chance)	Dissociation	20	.12	.11
	Hyperarousal	19	.14	.15
	Total	39	.13	.13

Response to Research Participation

On the RRPQ at Time 1, the top three explanations participants selected as their reasons for participating were: "I was curious" (*n* = 36, 92%), "To help others" (*n* = 31, 80%), and "For the money or class credit" (*n* = 19, 49%). At Time 2, the same explanations were selected as top reasons for participating: "I was curious" (*n* =37, 95%), "To help others" (*n* = 32, 82%), "To help myself" (*n* = 57, 39%), and "For course or extra credit" (*n* = 19, 49%). To evaluate the cost-benefit ratio, global evaluation scores were separately compared to the two negative sub-scales using paired-samples *t*-tests. As depicted in Table 18, one-sample *t*-tests indicated that, during both study visits, the two

cost subscales were rated significantly less positively than the neutral point on the scale (i.e., 3 out of 5), and two of the three benefit subscales (i.e., participation and global evaluation) were rated significantly more positively than the neutral point on the scale.

Table 18.
Time 1 and Time 2 RRPQ Subscale Descriptive Statistics and One-Sample t-Tests Comparing Subscale Means to Neutral Score

		Time 1				Time 2			
Measure		*M*	*SD*	*α*	*t*(38)	*M*	*SD*	*α*	*t*(38)
RRPQ Scales,	Participation	4.53	.43	.73	22.04***	4.39	.42	.43	20.65***
Positive	Personal Benefits	3.12	.61	.56	1.24	3.08	.77	.74	.63
	Global Evaluation	4.58	.32	.64	30.93***	4.46	.42	.74	21.94***
RRPQ Scales,	Emotional Reactions	1.63	.66	.78	-13.06***	1.40	.64	.81	-15.75***
Negative	Perceived Drawbacks	1.65	.43	.69	-19.51***	1.96	.54	.73	-12.08***

*p <.05; **p<.01; ***p<.001

When asked about their observations of the experimental manipulation tasks (i.e., electrical stimulation or relaxation script), most participants (n = 13 in the dissociation condition; n = 14 in the arousal condition) shared qualitative descriptions, included in Table 19.

Table 19.
Participant Descriptions of their Subjective Experience of Experimental Manipulations

Condition	Participant Description
Relaxation Script (Dissociation)	After the relaxation I felt like I did the study slower.
	During the relaxation script, I felt as though I was becoming less connected physically and that my body was "melting".
	For the relaxation script, it achieved its goal of making me relaxed and more calm.
	I could only see what was in front of me or what I imagined, everything else was "fuzzy".
	I felt incredibly relaxed during the relaxation script but I don't think I was actually hypnotized. Your voice is so soothing!
	I felt extremely tired like I could just lean forward on the desk and take a nap.
	I zoned out towards the end of the relaxation script and felt less alert than before.
	In the moment it did not feel very out of body but coming out of it felt very weird. I have been hypnotized once and realized it was similar, I might have been resisting some even though I was trying to relax.
	It was hard to stay in the moment of relaxation but nice once I was there
	It was interesting I felt very relaxed.
	Relaxation script was tiring.
	Relaxing.
	The relaxation script was really soothing, I felt dreamy.

Electrical Stimulation (Arousal)	I did feel an increased edge while being stimulated I forgot about the electrical stimulation as I got further along in the experiment. I kind of forgot about the shock until it came back but then it dissipated for a while. I was hyper aware of the electrical stimulation. I would feel drowsy up until the shocks and they would "wake" me up. It felt like that one psychology study where the men are asked to shock the student and see if they continue in obedience (Milgram?). It was fun to see the different levels of electricity and what my forearm did in reaction. It was not as bad as it was in my mind. It was weird to always be waiting for a shock, it kept things from getting boring. It wasn't as bad as I thought it would be. Some shocks felt more pronounced than others. I think at one point I forgot it was attached and then when I was shocked it also startled me so I felt it was more noticeable. The electrical stimulation did not feel irritating if that was the goal, because I feel like it was not done enough times to feel irritated. The electrical stimulation was interesting, I felt like my reactions were somewhat slower. The electrical stimulation was weird because it didn't hurt, but I still flinched every time it happened and it was uncomfortable. My hands are now shaky from it as well.

Study 2 Discussion

A brief discussion of Study 2 results is presented here, followed by a broader discussion of Studies 1 and 2 in the Overall Discussion section. Given the pilot nature or Study 2, the results of Study 2 are most useful as a validity test of the cognitive state induction methods (i.e., Hypotheses 2.1A-E), which will be discussed here; and as an in-person test of the visual item/association memory task used in Study 1, which will be reviewed in the Overall Discussion.

To evaluate the efficacy of the cognitive state induction paradigms, participants' self-reports of cognitive states and heart rate before versus after condition induction (i.e.,

hypnosis vs. electrical stimulation calibration) were evaluated. The validity of the hypnosis script used to induce dissociation was supported by participants in the dissociation condition reporting significant *increases* in measures of dissociation and significant *decreases* in measures of arousal and anxiety after the induction paradigm, relative to baseline. With respect to the arousal induction paradigm, the level of electrical stimulations calibrated by participants in the current study were consistent with levels calibrated in previous studies (e.g., Bisby & Burgess, 2014), meaning the voltages should have been sufficient to increase arousal. The validity of electrical stimulations as an induction of arousal in Study 2 was supported by participants in the arousal condition reporting significant *increases* in state arousal after the induction paradigm, relative to baseline; dissociation was unchanged. While reaction times before versus after the experimental induction did not differ within either of the groups both paradigms were supported by a between-conditions comparison of cognitive states. Though there were no differences between the groups' cognitive states at baseline, after the induction paradigms, participants in the dissociation condition reported *higher* dissociation and *lower* levels of arousal and anxiety than participants in the arousal condition.

Despite indications from self-reports that the induction paradigms affected cognitive states, the heart rate data showed no differences between individuals before versus after the induction paradigms or between the groups. Such a discrepancy between self-report and heart rate has been found before in a study of dissociation, in which self-reported dissociation predicted later intrusive memories independent of heart rate (Holmes et al., 2006). That finding suggests that a clinically-relevant increase in cognitive state could

fail to be detected using physiological measures. Alternatively, the discordant subjective and objective ratings in Study 2 could be attributable to participant bias in self report. Participants were not told that the paradigms were intended to induce arousal or dissociation, though they were made aware of the two condition options during consenting. While the differences could be attributed to social desirability (Van de Mortel, 2008), the current study did not account for the potential contribution of that dynamic.

With the caveat that Study 2 was under-powered,[6] the results will also be interpreted from the perspective of dual representation theory (DRT). It was predicted based on DRT that item memory would be improved relative to baseline for participants in the experimentally-induced arousal group and be impaired relative to baseline for participants in the experimentally-induced dissociation group; and that both cognitive states would impair association memory. Study 2 results did not provide support for this hypothesis. Indeed, seemingly contradictory evidence came from the finding that both experimental groups became significantly less accurate after the cognitive state induction paradigm, an effect that was more pronounced for item-level trials but also present in association-level trials. This finding could suggest that greater levels of both arousal and dissociation during encoding impair the memory process for item-level visual information. Indeed, the Study 2 pattern of arousal impairing item-level memory, but not affecting association memory has been previously observed (Bolton & Robinson, 2017),

[6] An *a priori* power analysis indicated a minimum sample size of 84 would be necessary to achieve an effect size of .2 (as observed in Bisby & Burgess, 2014) at $\alpha = .05$, with 95% power (calculated using G*Power software; Erdfelder et al., 1996).

however other researchers found arousal had no effect on item or association memory (Yonelinas et al., 2011; Kamp et al., 2019). Note that Kamp and colleagues (2019) found that familiarity (i.e., perception that a stimulus has been encountered previously, independent of recall of specific features of the stimulus, operationalized similarly to item memory in the current study) was enhanced by arousal (Evans & Wilding, 2012), while the other study did not (Yonelinas et al., 2011). As will be discussed in detail below, the structure of the task used in the current project precluded familiarity analyses.

Alternative explanations for the decreased recognition accuracy after cognitive state induction across experimental groups observed in Study 2 should be considered. The effects of increasing fatigue, which can affect attention and engagement, over the course of a cognitive task, were examined indirectly using participants' reaction times. While the consistency in reaction times over the course of the study suggests the pre/post induction differences in performance may not be related to fatigue, such an effect cannot be discounted using the data available in the current study. As is discussed further in the Overall Discussion section, a fully within-subjects design could account for potential fatigue effects.

Another explanation for the pre/post induction differences in accuracy is the concept of *proactive interference* (PI; Crowder, 1976; Keppel & Underwood, 1962). PI describes when the process of encoding items presented earlier in a sequential learning task inhibits the encoding of items presented later. However, PI appears to have the strongest effect on short-term or working memory, and the effects do not persist across longer delays, such as those employed in the current study (Kane & Engle, 2000). Analysis of recognition

accuracy based on the serial order of items was outside the scope of Study 2, but it would be useful to explore this potential confound in future studies of dual representation theory.

Study 2 and previous behavioral studies of recognition memory point to dynamics that DRT, a clinically derived framework, has yet to address. For example, DRT suggests cognitive states during encoding rather than retrieval account for differences in retrieval, and DRT fails to explore the role of post-encoding cognitive states altogether. As emerging research on arousal suggests, retrieval accuracy is affected by cognitive states during the post-encoding phase (McCullough & Yonelinas, 2013; Yonelinas et al., 2011) and during retrieval (Goldfarb et al., 2019; McCullough & Yonelinas, 2013).

With respect to the Study 2 dissociation findings, no direct comparisons can be made to existing literature, given that similar studies of the effects of dissociation on item versus association memory have not been conducted to date. The Study 2 finding that item memory was less accurate following dissociation induction is broadly consistent with Brewin and colleague's (2013) finding that experimentally-induced dissociation impaired memory for details on a story memory task, though item and association memory were not assessed separately. Relative to the growing body of arousal-memory research, the interplay between dissociation and memory warrants an increased focus from experimental psychopathology. It will be particularly important to examine the role of timing of dissociation throughout the memory cycle, given clinical findings that persistent posttraumatic, rather than peritraumatic dissociation, is more predictive of acute stress and posttraumatic stress disorders (Panasetis & Bryant, 2003; Briere et al.,

2005). For example, a robust methodological approach could be to replicate the timing of arousal manipulations used by Goldfarb and colleagues (2019) with a dissociation manipulation.

From a methodological perspective, Study 2 can inform the refinement of the condition induction methods used here for future experimental studies of DRT. In the current project, both induction methods were well-tolerated by participants, as indicated in their comments on the debriefing survey. Regarding the dissociation induction method, this study differed from those that have previously employed the guided hypnosis script (Holmes et al., 2006; Oakley et al., 2006) limited their sample to individuals with a high susceptibility to hypnosis. In the current study, participants were not pre-screened for hypnotic susceptibility given the potential to limit the generalizability of findings. However, clinical evidence suggests that peritraumatic dissociation does not occur randomly: a general predisposition to dissociate is predictive of acute dissociative symptoms following a traumatic stressor (Bryant et al., 2001). Future studies of DRT that experimentally manipulate dissociation could consider focusing on high dissociators or using methods that are more likely to induce dissociation regardless of tendency to dissociate, such as through pharmacological means (Lehmann et al., 2021).

With respect to the use of electrical stimulation to induce arousal, the method has long been used to induce anxiety in laboratory settings, but few studies measure arousal in response to electrical stimulations, either with subjective (e.g., self-report) or objective (i.e., physiological) indicators. The current study found the electrical stimulation increased objective but not subjective measures of arousal. Future studies could consider

increasing the frequency of stimulations during the encoding task and including measures of cortisol or galvanic skin response.

Fatigue was a potential confound in Study 2, which could be mitigated by a fully within-subjects design. For example, after recognition during the Time 2 session in the present Study 2 design, a second encoding phase could be added that employs the second encoding state (with order counter-balanced across participants). In turn, the final recognition task would be conducted during an added Time 3 session 24 hours after the Time 2 session. While this design would be more burdensome for participants and would require revealing the mnemonic nature of the study, similar approaches have been successfully implemented (Goldfarb et al., 2019). Such a within-subjects design could also be helpful in addressing the proactive interference concerns raised earlier in this discussion.

Though conclusions regarding the memory outcomes of Study 2 should be tempered by the mixed evidence that the experimental manipulations truly induced arousal and dissociation, discussed above, and the potential confounding effect of fatigue, the Study 2 findings and piloting of specific methods highlight useful future directions.

Overall Discussion

The two studies that comprised this dissertation evaluated how individual differences in cognitive states (Study 1) and experimentally induced cognitive states (Study 2) related to item and association memory for neutral visual information. These methods were employed to refine the understanding of Dual Representation Theory (DRT; Brewin et al., 1996; Brewin et al., 2010), which was the principal goal of this project. DRT suggests that peritraumatic cognitive reactions produce clinical findings of enhanced memory for details of traumatic experiences (i.e., item-level memory) but diminished memory for connections between those details (i.e., association-level memory).

Findings from the current project provided mixed support for DRT. While Study 1 was not designed to directly assess the heightened cognitive states produced during acutely stressful or traumatic events, it provided evidence that the dynamics predicted by DRT are not present at subacute levels of dissociation and arousal. Thus, the Study 1 results are consistent with models that suggest there is something unique about acutely stressful events (i.e., those that precipitate elevated dissociation or arousal) that can affect memory for those events. Similarly, the Study 2 findings suggest that there is something unique about the cognitive states experienced during traumatic events: both dissociation and arousal affected item and association memory to varied extents. However, without replication in a more robust sample, Study 2 should only serve as a proof of concept that

analogue experimental methods can be used to study DRT dynamics in recognition memory.

It should be noted that the self-report measures used to indicate "arousal" included a measure of state anxiety, given that a longer measure of state arousal was not available to supplement the Self-Assessment Manikin (Bradley & Lang, 1994) item that directly assessed state arousal. Both the physiological similarity between state anxiety and arousal (Purvis et al., 20218) and the current-study finding that the two measures displayed convergent validity (i.e., correlated across time points) provided evidence that state anxiety could be interpreted as an indicator of arousal. However, given that trait anxiety was not measured in the current study, we were unable to account for potential individual-specific tendencies toward arousal or anxiety that may have affected reactions to the task.

An Adapted Memory Task

The memory task employed in both Study 1 and Study 2 was adapted from existing tasks to include an affect-neutral content that was representative of more lifelike encoding stimuli. Evidence from both Study 1 and 2 suggests this task performed similarly to existing tasks, though participants were less accurate when completing the task at the location of their choosing in the online-only version. Increased variability and smaller effect sizes in remote, online administrations of behavioral tasks compared to in-person tasks has been observed previously (Anwyl-Irvine et al., 2020). Across delivery formats, the task was well-tolerated by participants, as indicated in their RRPQ self-reports. Very few participants (only 2% of the combined samples) detected the mnemonic

nature of the task at encoding. During the encoding task, participants appeared to be attentive and putting forth reasonable effort, as suggested by the accuracy of their fit/no fit judgements and reaction times. During the recognition task, in the full sample, participants' performance was better than chance for both item and association trials. The finding that item memory performance was superior to association memory performance replicates previous findings (Bisby & Burgess, 2014; Goldfarb et al., 2019). However, it should be noted that the structure of memory tasks appears to influence what information is recalled, such that tasks that emphasize associations result in superior recall for association trials compared to items (Kamp et al., 2019). The in-person and online-only versions of the task appeared to perform similarly, with the exception that online reaction times during encoding were related to subsequent recognition accuracy, while reaction times were unrelated to recognition in the in-person version. The reason for this discrepancy is unclear.

The task could be improved in two important ways. First, in its current iteration, the stimuli were designed to be neutral in content so as to isolate the effects of cognitive state. However, both DRT and BIC, as well as previous findings suggest that the affective content, as well as participants' subjective perception of memoranda is related to subsequent memory (Bisby & Burgess, 2013; Cahill & McGaugh, 1995; Kensinger et al., 2007; Mather, 2007; Rimmele et al., 2011; Sutherland & Mather, 2017). Thus, future iterations of the task used in the current project would benefit from modifications to include negatively and positively valenced trials.

The second major limitation was the method by which confidence in trial responses was assessed. In the current project, participants made old/new judgements, then were asked to rate their confidence from 1 (not at all confident) to 5 (very confident). It is more typical of recognition tasks that include confidence judgements for the scale to be 1 (Certain old), 2 (Relatively sure old), 3 (Guess old), 4 (Guess new), 5 (Relatively sure new), and 6 (Certain new). This subtle difference allows for a comparison of the leading recognition memory models: signal detection theory versus threshold theory. More specifically, the Certain Old – Certain New scale allows for the plotting of receiver-operating characteristic (ROC) curves based on decreasingly conservative confidence bins (Juola et al., 2019). In turn, the area under the curve can be derived from a ROC as a more precise measure of recognition accuracy. Further, familiarity (i.e., the degree to which an event is perceived as having been encountered before, regardless of whether specific details are recalled) and recollection (i.e., recalling specific qualitative information about an encoded event) can be examined separately; Evans & Wilding, 2012). This would be a simple, but impactful, change to the task.

Overall Limitations and Conclusions

The convenience samples of college students used in the present project may limit the generalizability to other populations. However, the accessibility of this population, and the prevalence of traumatic experiences among emerging adults suggested that analyses of DRT in this population was warranted and meaningful. The 24-hour delay between the Time 1 and Time 2 sessions was likely a barrier for some participants, though the relatively high retention rates suggest the procedures were accessible for participants who

chose to enroll. Despite these potential limitations, the proposed research has the potential to contribute to debates on the mechanisms underlying posttraumatic psychopathology and play an important role in shaping trauma psychology theory and clinical approaches in the coming years.

The current project focused on recognition (i.e., prompted by an external cue) rather than recall memory, given that the intrusive memories that characterize posttraumatic psychopathology can often be involuntarily "triggered" by an external cue (Franke et al., 2021). However, the therapeutic processes of exposure and desensitization to trauma-related memories often require voluntary free recall. Indeed, findings suggest that cognitive states may affect recognition differently than recall (DePrince & Freyd, 2001; McCullough & Yonelinas, 2013; Merz, 2017; Yonelinas et al., 2011; Zoladz et al., 2011) and that the neural mechanisms that predict free recall are dissociable from those that predict recognition (Staresina & Davachi, 2006). As research in this field develops, understanding how peritraumatic cognitive states affect free recall may help to inform basic science and have implications for clinical intervention.

The current project and suggested future directions are viewed in light of the broader understanding of memory and trauma. Patterns of psychopathology following traumatic events are intertwined with the quality of an individual's memory of the event (Rubin et al., 2008). Indeed, nearly all theories of PTSD and broader posttraumatic psychopathology address memory (e.g., emotional processing theory, Foa & Kozak, 1986; Foa & Riggs, 1993; social cognitive theories, Horowitz, 1986; Janoff-Bulman, 1983; cognitive model, Ehlers & Clark, 2000; metacognitive model, Wells 2000; Wells &

Sembi, 2004). If peritraumatic cognitive reactions are found to affect memory for item-level and association-level information differently, it could have important implications for research and clinical settings. From the perspective of theory, such findings would suggest that identical neural mechanisms record the *soundtrack* of memories for non-traumatic and traumatic events— but that variations in cognitive states at the time of recording can *adjust the volume* of particular features of the memory. Such a framework would explain "special" characteristics of trauma memories, without the existence of a "special mechanism" (Brewin, 2013). Clinically, identifying patterns of memory that are more characteristic of peritraumatic dissociation versus hyperarousal could be useful, given the link between pre-trauma cognitive tendencies, peritraumatic reactions, and posttraumatic psychopathology (Bryant et al., 2001). For example, a patient who tends to dissociate under stress even in safe situations could learn to focus on both item- and association-level information using attention strategies or mnemonic frameworks. Such an intervention could be useful for learning in a therapeutic setting and in day-to-day situations such as classroom learning.

Taken together, the current project helped to refine DRT by providing evidence that the differential effects of dissociation and arousal predicted by DRT are not present when the cognitive states are not clinically elevated. Several theoretical and methodological future directions were also highlighted. Clinical and cognitive psychology still have much to clarify regarding memory for traumatic experiences. Yet, the current project evinces that experimental approaches can be a helpful tool in the pursuit of understanding, and

eventually ameliorating, the memory-related challenges associated with exposure to traumatic stress.

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Appendix A

Script for Suggested Dissociation Condition

Fixate

Open your eyes. Go ahead and get in a comfortable seated position. Keep your arms where they are, relaxed by your side with your hands on the keyboard. Look at the cross in front of you, which I shall refer to as the target. Please look steadily at the target and while concentrating on the target pay attention to my voice. Focus your mind on what I ask you to think about—keeping your gaze fixed upon the target. If you find your mind wandering at any time, just bring your thoughts back to the target and to my words.

Eye Fatigue at Fixation, Eye Closure, Tiredness, Relaxation, and Counting

Now you may feel you have stared for long enough but continue to look at the target for a little longer. Your eyes will feel tired and will shortly start to close. Breathe gently and easily and as you breathe out and relax more and more your eyes will begin to close all by themselves. Just let this happen and when your eyes have fully closed, please say "yes" so that I know. Breathe in and out and each time you breathe out you will feel more deeply relaxed—deeply relaxed. Feel the muscles of your face letting go... and the relaxation spreading through your facial muscles into your forehead and into the muscles of your scalp. Feel those muscles letting go... and the feelings of relaxation moving through your head... around and behind your eyes and into the muscles of your jaw. And the relaxation continues to move down through your body... to your neck... throat, shoulders. Your shoulders feeling limp, heavy, and relaxed.

Feelings of relaxation extend along your arms... down to your elbows... to your wrists... your hands... yours fingers. Your arms feel heavy. You feel deeply and peacefully relaxed. Your eyelids are becoming heavier and heavier... heavier and heavier. *[IF CLOSED: "Your eyelids closed and heavy." IF NOT CLOSED: "And if they have not already closed, they will soon do so."].* Relaxation moves across your shoulders... into your chest... spreading like a wave through your body... moving down to your waist. Your breathing is easy and regular. Each time you breathe out you go deeper and deeper... feeling more and more relaxed. Waves of relaxation spread from your waist to your hips... to your legs... down to your knees... to your ankles... down to your feet... to your toes. As you become more and more relaxed, your body may feel heavy... or perhaps a little numb. You may begin to have this pleasant feeling of numbness and heaviness in your legs and feet, in your hands and arms, throughout your body... as though you were settling deep into the surface beneath you. Your eyelids feel heavy and tired... *[IF CLOSED: "...remaining tightly closed... heavier and heavier. Your eyelids seem weighted down... pulled down by the weight." IF NOT CLOSED: "...and if they are not closed yet, they will begin to close soon as they feel heavier and heavier... just say 'yes' when they have closed completely. Your eyelids seem weighted down... pulled down by the weight... so heavy... just allow them to close by themselves now... let them close ..." CONTINUE UNTIL subject says, "Yes."].*

You are going to become even more relaxed. It is easier to relax with your eyes closed. So keep them closed now. You feel deeply relaxed... as you continue to listen to

my voice. Just keep your thoughts on what I am saying. Soon I shall begin counting from one to twenty. As I count you will feel yourself going down further... and further into a deep state of relaxation, however, you will be able to do all the things you are asked to do without it disturbing your deep state of relaxation. And you can find that background sounds bother you less and less as time goes by—just letting them slip to the back of your mind. One... two... down, down into a deep state of relaxation... three... four... five... more and more deeply relaxed... six... seven... you are sinking deeper and deeper... eight... nine... ten... half way... eleven... twelve... thirteen... fourteen... deeply relaxed... hearing my voice clearly... fifteen... sixteen... seventeen... eighteen... deeper... deeper... more and more relaxed... nineteen... twenty... deeply relaxed. Just remain in that deeply relaxed state for now.

Relaxed and Passive Imagery

As you relax deeper and deeper... allow a scene—your special place—to come to mind and begin to experience yourself as part of that scene— there in your special place—just letting the scene unfold like in a dream... just allowing the images to shift and change as they will... in ever more pleasant and relaxing ways. There in your special place. [Identify individual special place and set it up using the information from the standard sheet].

If everything is O.K. and you have the feeling of being there in your special place, please let me know by saying “yes.” Just remain in your special place enjoying the imagery.

Please give me the number on your scale now.

I will speak to you again shortly. Stay in your special place.

Dissociation Instructions and Preparation for Computer Activity

Stay as relaxed as you are now with your eyes closed–imagine that you are looking at a television screen–begin to have the experience of the screen in front of you. [*Pause. Participant is asked to signal with a head nod when this has been achieved*]. As you do that begin to have the experience of looking at the screen but of seeing it from a different perspective as though you are viewing it from outside your own body–from a different point of view–looking at the screen and being aware of yourself looking at the screen almost as though you were another person . . . being aware of the screen and being aware of yourself watching it. As you continue to look at the screen, everything around you beginning to seem strange and unreal as though you were somehow another person in a strange place. Begin to have that feeling of being outside yourself and of the screen and surroundings being unfamiliar *[Pause. Participant is asked to signal with a head nod when this has been achieved]*.

Good. Just let those feelings of being outside yourself develop further as you watch the screen–and those feelings of the screen and your surroundings being unfamiliar and unreal becoming stronger and clearer–until they are as strong as they can be for you just now. *[Pause. Participant is asked to signal with a head nod when this has been achieved]*.

In a few moments I will ask you to open your eyes in order to do the computer activity. When you open your eyes continue to have those feelings do the computer activity–being fully aware of the activities on the computer– and continuing to watch what happens as though you are viewing it from outside your own body. . . you will feel strange and unreal as though you were someone else watching what is happening–all the time paying full attention to the activity on the screen while watching it from another perspective . . . Continue to have these feelings for the whole time you do the computer activity until you are given different instructions. Stay as relaxed as you are now, open your eyes and respond to the computer activity.

When the Computer Activity Ends

'Please close your eyes now–returning to normal feelings, experiencing the world from your own perspective–everything feeling as real and normal as it should *[Pause. Participant is asked to signal with a head nod when this has been achieved]*. Return now to your special place.

Leave your special place now and all the imagery associated with it but remain as relaxed and relaxed as you are now—please let me know by saying "yes" when you have done that.

Reversal of Hypnosis

In a moment, I will count back from twenty to one, and as I do just return to alert wide-awake feelings so that you are fully alert and wide awake when I get to one. Keep your eyes closed for now, but as I count your eyes will feel less and less tired and start to

open. Just let this happen, and when your eyes have fully opened please say “yes” so that I know. O.K., just returning to wide-awake, alert feelings now as I count.

Twenty... nineteen... eighteen... returning to wide-awake feelings... seventeen... sixteen... fifteen... more and more alert... fourteen... thirteen... twelve... eleven... ten... half way... nine... eight... seven... back to normal wide-awake feelings... no more heaviness or numb feelings... six... five... four... all the muscles throughout your body back to their normal state of tension and tone... three... two... and one, wide awake, fully alert.

Leave your special place now and all the imagery associated with it but remain as relaxed as you are now—please let me know by saying “yes” when you have done that.

When you are ready, open your eyes and bring your attention back to the room around you.