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Emotional state and local versus global spatial memory

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ABSTRACT

The present work investigated the effects of participant emotional state on global versus local memory for map-based information. Participants were placed into one of four emotion induction groups, crossing high and low arousal with positive and negative valence, or a control group. They then studied a university campus map and completed two memory tests, free recall and spatial statement verification. Converging evidence from these two tasks demonstrated that arousal amplifies symbolic distance effects and leads to a globally-focused spatial mental representation, partially at the expense of local knowledge. These results were found for both positively- and negatively-valenced affective states. The present study is the first investigation of emotional effects on spatial memory, and has implications for theories of emotion and spatial cognition.

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1. Introduction

Consider visiting a university campus and studying a large map situated near the entrance, perhaps in an effort to find the department of psychology. The map likely depicts a large amount of information, your acquisition of which is guided by your goals, intentions, and study time (cf., Brunyé & Taylor, in press). In addition to these influences, other factors such as your levels of happiness and arousal may also determine how you gather and organize map-based information in memory. The present work examines this possibility by placing participants into positive and negative affective states, crossed with high and low arousal, and testing whether these emotional states influence people's ability to gather and use information from a common spatial information source: campus maps.

The potential interactions among emotion and memory in the domain of spatial cognition remain relatively unexplored; if affective valence and arousal lead to differential processing and representation of spatial information, such findings have large theoretical and practical implications. There are several circumstances under which emotional state could play a large role in a person's ability to perform complex spatial tasks. Some examples might be a Soldier planning a mission in a remote and degraded environment, a paramedic attempting to navigate to the site of an emergency, or a young college graduate racing excitedly to a first job interview in a new city. In these and similar cases the emotional states evoked by an individual's tasks and circumstances may affect how well they are able to learn and think about environments and subsequently perform complex spatial tasks. The present work assesses this possibility, and is motivated by research in two primary areas. First, we review research suggesting that emotional state can have wide-ranging influences on attention and memory for verbal and non-verbal information, motivating our application of this work to spatial cognition. Second, we review research suggesting both the malleability of spatial memory, and the potential utility of using the symbolic distance effect to assess memory organization.

1.1. Emotional state and memory

Emotional state can be divided into two orthogonal and bipolar continuums: valence (positive versus negative) and arousal (high versus low) (Revelle & Loftus, 1992). Inducing particular valence and arousal states can influence how people process and store information. One particular construct that has received wide attention is the levels-of-focus hypothesis, which predicts that positive and negative affective cues induce relational and item-specific processing, respectively (Clore et al., 2001). For instance, a happy mood during study in the Deese, Roediger, and McDermott (DRM) false memory paradigm increases associative semantic activation and causes individuals to produce more false memories relative to when they are in a relatively negative mood (Storbeck & Clore, 2005). Similarly, Gasper and Clore (2002) found that partic-

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ipants in an induced positive mood state were more likely to base object similarity judgments on global features and those in a negative mood state were more likely to base their judgments on local features. A negatively-valenced affective state is thus generally associated with a focus on local item-specific information whereas happiness tends to increase focus on global associative information (see also Basso, Schefft, Ris, & Dember, 1996; Fredrickson, 1998, 2001; Gasper, 2004; Wadlinger & Isaacowitz, 2006).

There are two primary approaches for investigating arousal influences on attention and memory. First, research can assess attentional focus and memory biases for arousing versus neutral stimuli. Much of this work finds that arousal-inducing elements of a scene produce a narrowing of attention and reduced memory for details (Easterbrook, 1959; Loftus, 1979; Loftus & Burns, 1982; Loftus, Loftus, & Messo, 1987; Siegel & Loftus, 1978). For instance, when participants view an arousing scene of a bank robbery they tend to remember fewer overall details than those viewing a relatively neutral version of the robbery (Loftus & Burns, 1982); memory for specific visual details directly within the arousing area of a scene, however, tends to be heightened (Christianson & Loftus, 1991; Kensinger, Garoff-Eaton, & Schacter, 2006; Kensinger & Schacter, in press).

A second approach, and the one used in the present work, is to place participants into high or low arousal states and investigate memory for neutral stimuli. Work in this area suggests that induced emotional arousal states can lead to global processing biases. For instance, high arousal increases associative semantic memory during word list learning, leading to high rates of false recall and recognition relative to low arousal states (Corson & Verrier, 2007). Further, post-traumatic stress disorder (PTSD) patients characterized by the presence of heightened basal arousal levels show global processing advantages and local disadvantages in visual attention paradigms, relative to controls (Vasterling, Duke, Tomlin, Lowery, & Kaplan, 2004). Finally, soccer players experiencing high arousal states demonstrate global visual attention biases and increased fluidity in switching from local to global tasks (Pesce, Tessitore, Casella, Pirritano, & Capranica, 2007).

Based on the above work, it is clear that a distinction exists between processing characteristics elicited by (and memory for) an arousal-inducing stimulus itself, versus the effects of an induced arousal state on the processing of neutral stimuli. The former may narrow attention towards and increase memory for the arousal-inducing elements of a scene, whereas the latter appears to induce global processing of otherwise neutral stimuli. Given the seemingly large effects of induced emotional state on the processing and representation of geometric figures (Gasper & Clore, 2002), word lists (Corson & Verrier, 2007; Storbeck & Clore, 2005), and hierarchical number stimuli (i.e., global number figures comprised of many local numbers; Vasterling et al., 2004), we hypothesize that spatial memory for maps might be similarly affected. To our knowledge only one study to date has examined the effect of emotion on spatial memory. In a picture-learning paradigm, Crawford, Margolies, Drake, and Murphy (2006) found that memory for the location of valenced images was biased by valence direction (positive versus negative) such that participants tended to show biases towards representing positive images in higher screen positions relative to negative images. This study provides the first evidence suggesting that valence may carry implications for the representation of spatial information. If so, such a finding holds theoretical importance towards understanding the form and function of spatial memory, and practical implications for the design and development of navigation devices (e.g., Wickens, Vincow, & Yeh, 2005). To assess this possibility we evaluate the extent to which spatial memory might be more or less locally- or globally-biased as a function of participant emotional state.

1.2. Spatial memory

Given the identified effects of emotional state on visual attention and verbal memory, happiness and arousal may prove to play a role in how individuals memorize spatial information. Indeed recent work demonstrates that spatial memory is highly susceptible to various encoding manipulations including instructions, goals, limited study time, individual differences, and dual-task interference (e.g., Brunyé & Taylor,2008a, 2008b; Brunyé & Taylor, in press; Brunyé, Rapp, & Taylor, 2008; Denis, 2008; Noordzij, Van der Lubbe, & Postma2005, 2006; Pazzaglia, De Beni, & Meneghetti, 2007).

Work with maps and spatial descriptions suggests that spatial memory is best characterized as hierarchical, analog, and often incomplete (Denis, 2008; Denis & Kosslyn, 1999; Noordzij & Postma, 2005; Tversky, 2005). Hierarchical organization can be defined by both spatial and non-spatial information types, such as street layout, topography, coordinate axes, landmarks, neighborhoods, building functions, and even racial demographics of area residents (Brunyé, Taylor, & Worboys, 2007; Huttenlocher, Hedges, Corrigan, & Crawford, 2004; Maddox, Rapp, Brion, & Taylor, 2008). The analog organization of spatial memory has been likened to that of mental images, or structural analogues representing original perceptual experiences (Denis & Zimmer, 1992). These characteristics of spatial memory increase performance, with both higher accuracy and faster response times, when participants are tasked to compare distances between landmarks that are relatively far as opposed to close to one another (Denis, 2008; Hirtle & Jonides, 1985; Noordzij & Postma, 2005). This phenomenon is called the *symbolic distance effect* (i.e., Moyer, 1973), and has received much attention in the cognitive psychology literature, particularly with regard to the ongoing debate about the analog versus propositional nature of human memory (Borst, Kosslyn, & Denis, 2006; Pylyshyn, 2002).

In spite of the evidence that human spatial memory is differentially well-suited for proximal versus distal spatial relationship judgments, we also know that comprehensive knowledge of *both* close and far landmark locations is critical for navigation success (Foo, Warren, Duchon, & Tarr, 2005; Loomis, Klatzky, Golledge, & Philbeck, 1999). Considering the importance of accurate local and global spatial representations towards real world navigation, we are interested in the extent to which emotional state might affect local versus global spatial memory biases. If indeed emotional states can induce local and global processing biases in memory, such an effect might modulate the symbolic distance effect.

1.3. The present study

We ask whether changes in participant emotional state might modulate the symbolic distance effect during spatial statement verification. To do so, we crossed valence (positive or negative) and arousal (high or low) and assessed their influences on spatial memory. Participants learned a map of a large-scale environment while in one of four emotional states (or a control group) and then completed two memory tests. The first test was verbal and involved free recall, allowing us to assess the completeness and organization of verbal memory following emotional state induction. The second test was spatial and involved the verification of spatial statements, allowing us to assess performance on fine-grained local (i.e., knowledge of proximal landmark interrelationships) or holistic global (i.e., knowledge of distal relationships) spatial knowledge using both accuracy and response times.

The present procedure for assessing the symbolic distance effect is quite different from traditional procedures. Specifically, earlier