Learning a Map Under Positive Emotions: How Self-Reported Arousal and Individual Differences Relate to Route and Survey Knowledge

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Abstract

Digital map learning is a common everyday activity requiring the encoding of landmarks and their spatial relations, and may be related to individual differences. The present study investigated how individual positive emotional states differing in arousal (high vs. low) relate to route and survey knowledge after spatial learning from maps. A total of 156 participants (ongoing data collection) completed an online within-subject procedure including emotionally induced scenarios, map study, and recall tasks assessing route (landmark order) and survey (landmark location task) knowledge. Results showed no direct effect of arousal condition on performance; however, individual increases in arousal predicted lower route knowledge accuracy, while survey knowledge was unaffected. Importantly, trait positive affect positively predicted both route and survey performance. Age negatively predicted both, gender differences emerged only for survey knowledge, whereas spatial anxiety impaired route knowledge. These findings suggest a selective role of arousal in route processing and highlight the importance of considering individual differences in spatial learning from maps.

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1 Introduction

Reading maps to acquire environmental information is a common experience that requires processing and memorizing details about landmarks and their spatial relations. Spatial learning from maps is related to a variety of individual and contextual factors. One under-explored individual factor is the learner's emotional state, which may affect the ability to form accurate spatial mental representations. Consider, for example, reading a map to find the route to a hospital while feeling rushed and stressed, versus reading a map as a relaxed tourist exploring an unfamiliar city. Both situations involve spatial learning from a map, yet they occur under markedly different emotional conditions.

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Emotions can be conceptualized along two primary dimensions: valence (i.e., the positivity or negativity of an emotion) and arousal (i.e., the intensity of emotional activation), ranging from negative–low arousal states (e.g., sadness) to negative–high arousal states (e.g., anxiety), and from positive–low arousal states (e.g., calmness) to positive–high arousal states (e.g., excitement). Previous research has shown that emotional states, defined along these dimensions [5, 20], are associated with memory and cognitive processing [1, 10, 21]. A growing body of research suggests that emotional factors are closely linked also to spatial memory and the formation of spatial mental representations, particularly following navigation in real or virtual environments. Overall, negative emotional states, especially those characterized by high arousal such as stress, tend to impair spatial processing. For instance, time pressure reduces the accuracy of cognitive maps (e.g., [8, 24, 23, 25]), while stress increases reliance on familiar routes rather than novel shortcuts, leading to longer travel distances and increased task completion times (e.g., [4]). More broadly, negative valence combined with high arousal has been associated with reduced spatial flexibility and distorted spatial judgments (e.g., [3, 6]). In contrast, positive emotional states, particularly at low levels of arousal, are generally associated with improved spatial recall (e.g., [16, 18, 19, 17]. Additionally, arousal itself, independently of valence, can relate to spatial representations by affecting perceived distances and the relationships between landmarks (e.g., [7, 11]). However, to our knowledge, no study to date has specifically investigated the role of emotions in spatial learning from a map and recall of both route and survey knowledge. Route knowledge refers to a sequential, egocentric representation of the environment, based on the ordered series of actions and landmarks encountered along a path. In contrast, survey knowledge reflects an allocentric, map-like representation that encodes the spatial relationships between locations. Understanding how emotional states relate to these distinct forms of spatial knowledge may provide important insights into the mechanisms underlying spatial learning from a map and this represents the research gap addressed by the present study.

Therefore, the present study aims to investigate the role of emotions in the recall of route and survey information following spatial learning from a map under different emotional conditions. Specifically, we focus on the effect of arousal levels (high vs. low) on spatial recall while keeping valence positive, given that positive emotions appear to be the most favourable condition for spatial memory.

In addition, individual differences, such as age, gender, trait levels of positive and negative affect, and spatial anxiety, were considered as potential factors related both to the recall of spatial information learned from a map and to emotional experience. Importantly, the study adopted a within-participant design.

2 Method

Participants and procedure

The study involved 156 participants (103 women and 53 men; data collection is ongoing), aged between 18 and 70 years (M = 37.13, SD = 16.03). Participants were recruited through word of mouth by the experimenters.

They completed the questionnaires and tasks online via Qualtrics in approximately 25 minutes. After reading and providing informed consent, participants reported their emotional valence and arousal using the digital Affective Slider (AS; [2]) before reading and imagining themselves in a described scenario. They were subsequently presented with a positively valenced situation. Two situations were created, and their presentation was randomized across participants. Each situation was designed to elicit a different level of arousal. In the high-arousal condition (e.g., excitement, enjoyment), the scenario involved being in an unfamiliar city in which participants aimed to memorize a route from a map in order to reach a restaurant to meet old friends. In the low-arousal condition (e.g., calmness, relaxation), the scenario involved being in an unfamiliar city in which participants aimed to memorize a route from a map in order to reach a park to relax. After reading the scenario, participants again reported their emotional valence and arousal using the Affective Slider (therefore, post–pre difference scores were calculated for both self-reported valence and arousal). Participants were then presented with a fictitious city map. Two ad hoc schematic urban maps (960 × 720 pixels) were used as experimental stimuli. Each map depicted a comparable network of city streets and a predefined route marked by a red dashed line. The maps were designed using a simplified cartographic style inspired by common web-based mapping services. Each map contained 14 landmarks distributed along the route. Landmarks were represented by pinpoint symbols and identified through verbal labels. The selection and placement of landmarks were validated in a pilot study to ensure comparable levels of recognizability across maps. Following a filler task, two spatial information recall tasks were administered in random order: landmark order task (route knowledge) and landmark location task (survey knowledge). In the Landmark order task participants were asked to recall the landmarks in the correct order along the path (one point was awarded for each landmark recalled in its correct position). In the Landmark location task participants were asked to identify the correct positions of landmarks on the map by choosing among distractor options (one point was awarded for each landmark location correctly identified). Participants then completed another filler task before rating their valence and arousal again, both before and after reading the second description of situation. Then, after a filler task, participants learned the second city map and completed the Landmark order task and Landmark location task. Then, as control participants were asked to recall the two situations presented and their self-reported level of immersion in each, defined as how much they were able to empathize with the described situation. Finally, participants reported their trait positive and negative affect (PANAS; [22]), spatial anxiety (Spatial Anxiety Scale, SAS; [9], adapted from [12]) and their demographic information (e.g., age, gender).

3 Results (collected sample)

First, we verified that the scenarios effectively increased positive emotional states by comparing post- and pre-scenario ratings. For valence, increases in positive valence were observed in both conditions (high-arousal condition: M = 9.68, SD = 19.15; low-arousal condition: M = 5.01, SD = 18.56), with a greater increase in the high-arousal condition (p = .030, d = 0.25). Arousal also increased in the high-arousal condition (M = 7.41, SD = 16.47) and in the low-arousal condition (M = 2.13, SD = 19.61), with a greater increase in the high-arousal condition (p = .010, d = 0.29), indicating that the manipulation of arousal was effective. Furthermore, the two conditions did not differ in reported immersion (high-arousal: M = 2.78, SD = 1.03; low-arousal: M = 2.65, SD = 1.01; p = .268).

Then, we ran linear models on the currently collected sample, using accuracy on the Landmark Order Task (route knowledge) and the Landmark location task (survey knowledge) as dependent variables. Predictors included type of situation (high vs. low arousal), change in state valence (post–pre), change in state arousal (post–pre), gender, age, trait positive affect, trait negative affect, spatial anxiety, and perceived immersion.

Concerning the Landmark Order Task (route knowledge), no effect of high vs. low arousal condition was observed. However, change in arousal (post–pre) emerged as a significant negative predictor ($\beta = -.13$, $p = .020$), indicating that greater increases in arousal were associated with lower route knowledge task performance. Trait positive affect (PANAS-PA) was positively associated with performance ($\beta = .19$, $p = .001$), suggesting that higher levels of positive trait affect predicted better route knowledge. In addition, performance decreased with age ($\beta = -.13$, $p = .026$). No interaction emerged between emotional condition and age, indicating that this relationship did not vary as a function of age. No gender differences were observed. Finally, spatial anxiety was negatively associated with route knowledge ($\beta = -.13$, $p = .027$), indicating that higher spatial anxiety was linked to poorer route knowledge after spatial learning from a map.

Concerning the Landmark location task (survey knowledge), no effect of high vs. low arousal condition was observed, nor was any effect of change in arousal (post–pre). Trait positive affect (PANAS-PA) was positively associated with performance ($\beta = .13$, $p = .028$), indicating that higher levels of positive affect predicted better survey knowledge. Age was negatively associated with performance ($\beta = -.12$, $p = .035$). Gender also emerged as a significant predictor ($\beta = -.50$, $p < .001$), indicating that women showed lower performance than men. However, no interaction emerged between emotional condition and both age and gender.

4 Discussion and Conclusion

Overall, the results suggest that emotional factors play a selective role in spatial learning from maps. The manipulation of arousal did not directly affect performance in either task, but individual increases in arousal (post–pre) were associated with poorer route knowledge, in line with evidence that higher arousal can interfere with sequential spatial processing (e.g., [3]). No such effect emerged for survey knowledge. This pattern may be due to the nature of spatial learning from maps, in which survey information is directly supported by the visual format of the map, providing an explicit representation of spatial relationships. As a result, survey knowledge may be less sensitive to fluctuations in arousal and more strongly related to other factors (e.g., visuospatial working memory, [13]). Importantly, trait positive affect was positively associated with performance in both tasks, consistent with theories linking positive affect to enhanced memory [10], and extending this evidence to spatial memory from a map. The negative association between age and performance across tasks is consistent with previous evidence of age-related decline in spatial knowledge after learning spatial information from a map (e.g., [14, 26]). Similarly, gender differences emerged only for survey knowledge, with women showing lower accuracy, in line with prior findings (e.g., [15]), and extending this pattern to spatial recall from maps. Therefore, age and gender have been confirmed as factors to consider when investigating environmental learning. Finally, spatial anxiety was negatively associated with route knowledge, suggesting a specific impact of spatial anxiety on sequential spatial knowledge [12]. Although the present study provides valuable insights, its main limitation is the lack of psychophysiological measures, which could not be collected in the context of an online study. Future research should address this limitation by incorporating objective physiological indices of emotional responses. We also note that the present study is part of a broader research project. An additional study is currently investigating the role of arousal in negatively valenced emotional states (e.g., sadness vs. anxiety) to provide a more comprehensive understanding of the relationship between emotion and spatial learning from maps.

To conclude, emotions elicited in users while they are learning a map may impact their subsequent recall of spatial (route) information. A deeper investigation into the intriguing association between emotion and spatial knowledge after learning a map is therefore important, in order to understand the impact of user-specific factors.

References

1 F. Gregory Ashby. A neuropsychological theory of positive affect and its influence on cognition. *Psychological Review*, 106(3):529–550, 1999. `doi:10.1037/0033-295x.106.3.529`.

2 Alberto Betella and Paul F. M. J. Verschure. The affective slider: A digital self-assessment scale for the measurement of human emotions. *PLOS ONE*, 11(2):e0148037, February 2016. `doi:10.1371/journal.pone.0148037`.

3 Christophe Blaison and Ursula Hess. Affective judgment in spatial context: How places derive affective meaning from the surroundings. *Journal of Environmental Psychology*, 47:53–65, September 2016. `doi:10.1016/j.jenvp.2016.05.005`.

4 Alexander P. Boone, Tom Bullock, Mary H. MacLean, Tyler Santander, Jamie Raymer, Alexander Stuber, Liann Jimmons, Gold N. Okafor, Scott T. Grafton, Michael B. Miller, Barry Giesbrecht, and Mary Hegarty. Resilience of navigation strategy and efficiency to the impact of acute stress. *Spatial Cognition & Computation*, 24(3):195–226, July 2024. `doi:10.1080/13875868.2024.2321920`.

5 Margaret M. Bradley, Mark K. Greenwald, Margaret C. Petry, and Peter J. Lang. Remembering pictures: Pleasure and arousal in memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 18(2):379–390, 1992. `doi:10.1037/0278-7393.18.2.379`.

6 Thackery I. Brown, Stephanie A. Gagnon, and Anthony D. Wagner. Stress disrupts human hippocampal-prefrontal function during prospective spatial navigation and hinders flexible behavior. *Current Biology*, 30(10):1821–1833.e8, May 2020. `doi:10.1016/j.cub.2020.03.006`.

7 Tad T. Brunyé, Caroline R. Mahoney, Jason S. Augustyn, and Holly A. Taylor. Emotional state and local versus global spatial memory. *Acta Psychologica*, 130(2):138–146, February 2009. `doi:10.1016/j.actpsy.2008.11.002`.

8 Sascha Credé, Tyler Thrash, Christoph Hölscher, and Sara Irina Fabrikant. The acquisition of survey knowledge for local and global landmark configurations under time pressure. *Spatial Cognition & Computation*, 19(3):190–219, July 2019. `doi:10.1080/13875868.2019.1569016`.

9 Rossana De Beni, Francesca Pazzaglia, Valérie Gyselinck, and Chiara Meneghetti. *Batteria per la valutazione delle abilità spaziali*. Giunti OS, Firenze, 2014.

10 Barbara L. Fredrickson. The role of positive emotions in positive psychology. *American Psychologist*, 56(3):218–226, July 2001. `doi:10.1037/0003-066x.56.3.218`.

11 Aaron Gardony and Holly A. Taylor. Affective states influence spatial cue utilization during navigation. *Presence: Teleoperators and Virtual Environments*, 20(3):223–240, June 2011. `doi:10.1162/PRES_a_00046`.

12 Carol A. Lawton. Gender differences in way-finding strategies: Relationship to spatial ability and spatial anxiety. *Sex Roles*, 30(11-12):765–779, June 1994. `doi:10.1007/BF01544230`.

13 Veronica Muffato, Chiara Meneghetti, and Rossana De Beni. The role of visuo-spatial abilities in environment learning from maps and navigation over the adult lifespan. *British Journal of Psychology*, 111(1):70–91, February 2020. `doi:10.1111/bjop.12384`.

14 Veronica Muffato, Chiara Meneghetti, Virginia Di Ruocco, and Rossana De Beni. When young and older adults learn a map: The influence of individual visuo-spatial factors. *Learning and Individual Differences*, 53:114–121, January 2017. `doi:10.1016/j.lindif.2016.12.002`.

15 Alina Nazareth, Xun Huang, Daniel Voyer, and Nora S. Newcombe. A meta-analysis of sex differences in human navigation skills. *Psychonomic Bulletin & Review*, 26:1503–1528, 2019. `doi:10.3758/s13423-019-01633-6`.

16 Massimiliano Palmiero and Laura Piccardi. The role of emotional landmarks on topographical memory. *Frontiers in Psychology*, 8:763, May 2017. `doi:10.3389/fpsyg.2017.00763`.

17 Téophile Rasse, Valérie Gyselinck, and Jérôme Guegan. Encountering an emotional landmark on the route for a better spatial memory: What matters, valence or arousal? *Journal of Environmental Psychology*, 91:102145, November 2023. `doi:10.1016/j.jenvp.2023.102145`.

18 F. Ruotolo, M. H. G. Claessen, and I. J. M. Van Der Ham. Putting emotions in routes: the influence of emotionally laden landmarks on spatial memory. *Psychological Research*, 83(5):1083–1095, July 2019. `doi:10.1007/s00426-018-1015-6`.

19 Francesco Ruotolo, Filomena L. Sbordone, and Ineke J. M. Van Der Ham. The relationship between emotionally laden landmarks, spatial abilities, and personality traits: An exploratory study. *Brain Sciences*, 10(6):326, May 2020. doi:10.3390/brainsci10060326.

20 James A. Russell. A circumplex model of affect. *Journal of Personality and Social Psychology*, 39(6):1161–1178, 1980. doi:10.1037/h0077714.

21 Norbert Schwarz. Emotion, cognition, and decision making. *Cognition & Emotion*, 14(4):433–440, July 2000. doi:10.1080/026999300402745.

22 Antonio Terracciano, Robert R. McCrae, and Paul T. Costa. Factorial and construct validity of the italian positive and negative affect schedule (panas). *European Journal of Psychological Assessment*, 19(2):131–141, April 2003. doi:10.1027/1015-5759.19.2.131.

23 Jan Wilkening and Sara Irina Fabrikant. The effect of gender and spatial abilities on map use preferences and performance in road selection tasks. In *Proceedings of the 25th International Cartographic Conference*, Paris, France, 2011. doi:10.5167/uzh-51316.

24 Jan Wilkening and Sara Irina Fabrikant. How do decision time and realism affect map-based decision making? In Max J. Egenhofer, editor, *Spatial Information Theory*, volume 6899 of *Lecture Notes in Computer Science*, pages 1–19. Springer, Berlin, Germany, 2011. doi:10.1007/978-3-642-23196-4_1.

25 Jan Wilkening and Sara Irina Fabrikant. How users interact with a 3d geo-browser under time pressure. *Cartography and Geographic Information Science*, 40(1):40–52, 2013. doi:10.1080/15230406.2013.762140.

26 Naoki Yamamoto and Giuseppe De Girolamo. Differential effects of aging on spatial learning through exploratory navigation and map reading. *Frontiers in Aging Neuroscience*, 4:14, 2012. doi:10.3389/fnagi.2012.00014.