Improving pedestrians' spatial learning during landmark-based navigation with auditory emotional cues and narrative

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Abstract

Even if we are not aware, our emotions can influence and interplay with our navigation and use of mobile navigation aids. A given map display can make us feel good by reminding us of pleasant past experiences, or it can make us feel frustrated because we are not able to understand the information provided. Navigation aids could also make a given landmark emotionally charged, and thus more salient and memorable for a navigator, for example, by using an auditory narrative containing emotional cues. By storytelling, it would also be possible to provide details about a given landmark and connect proximal landmarks to each other. But how do navigational instructions in the form of emotional storytelling affect spatial memory and map use? Results from a preliminary study indicated that a video presentation viewed from a first person perspective is looked at more often than an abstract map, and this evidence becomes even stronger when instructions are emotionally laden. We discuss results in the context of place meaning and how emotions' role in navigation should be further assessed, in particular to increase spatial learning from navigation aids.

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1 Introduction

Human emotions affect cognition, such as memory, attention, and decision-making, on a daily basis [16]. Our mood and affect influence spatial navigation in familiar and unfamiliar places [4], and can also modify the way we perceive maps [12]. Not only do emotions modulate the way how we extract and recall spatial information from the environment, but also how we make informed spatial decisions [3]. For example, anxiety can decrease attentional focus on navigation-relevant spatial information, and more stressed or fearful states may narrow attention to local visual details [11]. On the other hand, a more positive emotional state, such as happiness, may induce wayfinders to process information at a more holistic level [9]. Human emotions during navigation can also be evoked by external stimuli (auditory, visual, tactile, or olfactory). For example, we might have a negative association with a busy intersection, or feel happy when we pass a favourite restaurant. This may have a positive impact on the memorability of that landmark, and thus enhance spatial learning [2]. Emotionally laden landmarks, especially those with a positive association, are more likely to be recalled compared to neutral cues [13, 14].

Despite the influence of emotions on wayfinding, their role in map-assisted wayfinding and pedestrians' associated spatial learning has not yet been systematically evaluated. To date, cartographic research in GIScience on the role of human emotions on map perception and spatial memory during navigation is scarce. Research shows that map aesthetics affect emotions [5, 6, 10], and there is a clear interplay between maps, physical spaces, and emotions [8]. At the current research stage, it is possible that the directions provided by GPS-enabled navigation assistance devices could be improved and made more memorable if directions were emotionally laden rather than emotionally neutral. Using specially designed navigation aids that increase navigators' engagement can promote attentional focus, spatial memory, and contribute to a more positive navigation experience overall [15].

Hence, the purpose of this experiment was to determine whether: (1) emotion-inducing auditory cues would increase participants' physiological arousal and, at the same time, improve the memorability of navigation-relevant landmarks compared to neutral cues, and whether (2) participants' emotional states affect map use behaviour. To answer these questions, we created different emotionally laden auditory navigation instructions similar to [7], but with emotional cues instead of personal preferences. The narrative contained in the instructions is connected with a military reconnaissance scenario and task presented to the participants during the learning phase. We hypothesised that: (1) navigation instructions containing emotional cues will help participants to easily remember navigation-relevant landmarks compared to participants presented with similar information that is emotionally neutral, and that (2) changes in participants' physiological arousal will predict changes in the way they process visual information, and this, in turn, will predict spatial learning. Two competing hypotheses have been deduced: (2a) the group with emotional stimuli will show a more effective map use behaviour (i.e., less eye fixations and switches between map and 1st person perspective) compared to the control group, and this, in turn, will be associated with improved spatial learning; (2b) emotions affect spatial memory independently from visual attention, even if visual scanning behaviour is relatively similar between groups.

2 Methods

Utilising a between-subject design, we developed an outdoor user study to record participants' emotional responses to ten modified auditory navigation instructions (emotional versus neutral instructions) and their eye movements during an approximately 7-minute learning phase, and to test participants' spatial learning after completing an outdoor navigation task.

During the learning phase, participants were first presented with the reconnaissance scenario and experimental task, and then watched a video of a navigation route through the Swiss town of Le Noirmont, Switzerland. The route, unfamiliar to them, was about 1 km long and featured ten landmarks. During this phase, participants could choose to look at a video of the navigation route (recorded with a GoPro HD camera) or at a Swiss national 1:2,500 scale topographic map of the same route, where the participant's current location was highlighted (Figure 1). After each of the ten route segments, the video stopped and the auditory instruction was played. After each instruction, the participants started the video again to learn the next route segment by pressing the “Enter” button on the keyboard.

After the participants learned the route, they then navigated the route to the best of their knowledge while walking. If the participant deviated from the route at any time, the experimenter informed them after 1 minute and returned them to the decision point that the wrong turn was made. Following the learning and navigation phases, participants then completed a landmark recognition and sequencing task using 20 printed pictures of landmarks that they may have seen or not seen in the environment during learning. Only ten of the 20 landmarks shown were described while listening to the navigation instructions in the learning phase, while the additional ten landmarks are also found along the route but were not mentioned in the auditory instructions. Participants also drew two sketch maps of the environment; this data was recorded for a separate study.

To present the map and video at 3840x2160 pixel spatial resolution, we utilised an 170W Lenovo ThinkPad P51 laptop. To collect eye-tracking data participants wore non-invasive Pupil Invisible eye glasses (PupilLabs, https://pupil-labs.com/, accessed at 12.06.2021) that tracked participants gaze during the learning phase. In addition, we collected participants' real-time physiological responses during the learning phase with an Empatica E4 wristband (Empatica, https://www.empatica.com/, accessed at 12.06.2021). The instructions were developed by a specialist instructor from the Swiss Armed Forces in an appropriate manner to the military context, i.e. according to a reconnaissance scenario and task, for which the experienced navigators we tested were trained. The emotional instructions have been divided in two randomised blocks, i.e., five instructions containing a negative association and five with positive cues. Examples of a neutral instruction (1), and the equivalent (negative) emotional instruction (2) follow: (1) *"Turn left at the village house. The house is one of the oldest houses in the village"*, and (2) *"Turn left at the village house. In the garden of the house there are four prospective search dogs of a private security service"*.

Twelve members of the Swiss Armed Forces voluntarily participated in this study (12 males). We found this expert group to be particularly appropriate for our pilot test as they work in an emotionally charged context, and use maps and other situational awareness instruments on a daily basis. Their age ranged between 19 and 21 years (M=21). This study was approved by the Ethics Committee of the University of Zurich (application no. 19.6.10). All participants agreed to engage in the study through a written consent form. They also entered this study on an entirely voluntary basis and received no compensation.

Figure 1 Example of the screen display that participants viewed during the learning phase of the experiment. Participants could look at either the video (left) or the map (right, blue dot tracked participants current location).

3 Results and Discussion

3.1 Emotion manipulation check

As an emotion manipulation check, we fit a multilevel linear regression model to the data to test for a difference in physiological arousal (as measured by electrodermal activity; EDA) between the emotional instructions group and the control instructions group. We tested to see if there was a general effect of navigation instructions on EDA, as well as whether this effect differed based on the stage of learning (listening to instructions vs. watching a video). There was a marginally significant increase in EDA when participants listened to the emotional instructions compared to when they viewed the navigation video (($\beta = -1.47, p = .05, 95\%CI = [-2.96, 0.01]$, see Figure 2). For the control instructions group, there was no difference in EDA between the instructions phase and video phase ($\beta = 0.65, p = .46, 95\%CI = [-1.07, 2.38]$).

Figure 2 A small increase in EDA area under the curve (AUC; measurement unit: µS/s) occurs when participants listen to emotional navigation instructions compared to when they are viewing the video, and this increase only occurs for the emotional instructions group, not the control group. Dots represent mean, bars represent bootstrapped +/- 95% confidence intervals.

3.2 The effects of emotional cues on spatial learning

We fit a multilevel logistic regression model to the data to assess whether there was a difference in landmark recognition accuracy dependent on navigational instructions. While the random effect of participant had an SD of 0 due to a small sample size, we still interpreted the results of the model's fixed effect parameter estimate. We found no significant difference in landmark recognition accuracy between the two landmark instruction types ($Odds - ratio = 1.11, p = .69, 95\%CI = [.66, 1.85]$). Further, we found that EDA level during the task did not predict landmark recognition ($Odds - ratio = 1.00, p = .88, 95\%CI = [.95, 1.05]$).

3.3 The effects of emotional cues on visual attention and navigation

We fit two multilevel linear regression models to the data to assess whether there was an influence of emotional cues on visual attention during learning (measured by fixation rate and revisits per second). The participants looked at the video more often than the map ($\beta = 20.3, p < .001, 95\%CI = [15.9, 24.7]$) on average regardless of the instruction type, and revisited the video more often than the map ($\beta = 0.3, p = .006, 95\%CI = [0.1, 0.5]$). The emotional instructions did not significantly affect participants fixation rate ($\beta = -0.1, p = .93, 95\%CI = [-0.2, 0.2]$) or revisits per second ($\beta = 0.5, p = .54, 95\%CI = [-1.0, 1.9]$) to the two areas of interest overall. Interestingly, there was a significant interaction such that emotional instructions changed how often participants looked at the video versus the map - individuals who received emotional instructions looked at the map less and the video more than individuals in the control group (see Figure 3; $\beta = -0.29, p = .002, 95\%CI = [-0.5, -0.1]$). However, neither fixation rate to the video ($Odds-ratio = 1.13, p = .81, 95\%CI = [0.4, 3.0]$) nor to the map ($Odds-ratio = 1.09, p = .94, 95\%CI = [0.1, 11.5]$) predicted landmark recognition.

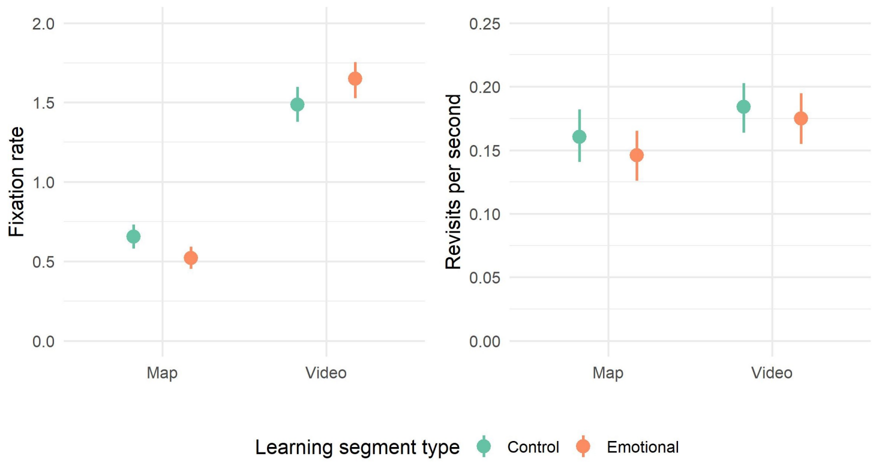

Figure 3 Difference in fixation rate (fixation counts per second) and revisits per second between experimental conditions, split between the map and video areas of interest on the display. Dots represent mean, bars represent bootstrapped +/- 95% confidence intervals.

4 Summary and Outlook

In sum, while emotional cues raised arousal compared to neutral cues, emotions appeared to have a minimal effect on landmark recognition. However, the emotion group looked at the video perspective more often than the map perspective for learning when compared with the control group, suggesting that emotions can change how individuals utilise navigational aids even if there is a minimal effect on landmark recognition. This may indicate that emotional cues independently affect map use behaviour from spatial learning, at least as measured by landmark recognition.

Past research [3] suggests that elements of a visual scene, which are described in the arousal-inducing instructions, prompt participants to focus their attention and, in turn, better remember specific visual details located within the same scene. This may have led participants who heard emotional instructions to look more at the presentation that emphasised the visual properties of a place to gain more detailed information about a feature mentioned in the auditory narrative. Furthermore, emotions elicited by a narrative can produce a sensory and embodied experience related to a specific geographic feature where no particular attachment existed before [1]. The abstract and impersonal space thus becomes a place that evokes emotions and stories.

We hope that future work will further investigate how emotions and motivations might influence spatial learning and navigation, and encourage exploration of unfamiliar environments. In particular, follow-up studies should focus on different levels of spatial learning, and assess how emotions affect parsing of and attention to differing cartographic visual variables and map presentations or perspectives, especially when a video is not present during route learning. In addition, affective and personality traits might affect how individuals utilise navigation aids and this should be further investigated.

In conclusion, our work serves as a first step in establishing that even subtle changes in emotional cues and providing an emotionally laden narrative can influence how individuals utilise navigational aids. In this case, navigators who heard emotional instructions tended to utilise a first-person video perspective more than a map when compared with navigators who heard neutral navigational instructions. Making navigation aids more emotionally laden, relatable, and memorable may help to improve a wide variety of application domains, including military operations, pedestrian navigation, tourism, and gaming.

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