The effect of emotions and emotionally laden landmarks on wayfinding

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Abstract

Emotions have an influence on attention, decision making, and memory (all factors required for wayfinding). It is assumed that both an emotional state and emotionally laden landmarks have an impact on wayfinding and on later recollection of the path. We performed two experiments to investigate our hypotheses. First, in both experiments participants had to study a route in a virtual environment including landmarks. Then they passed a recognition and wayfinding task, which was repeated after one week. The mood was measured using the PANAS scale. In the first experiment the emotionally laden landmarks were used as a between-subject factor in order to investigate the effect of mood in wayfinding. The aim of the second experiment was to examine the effect of emotionallly laden landmarks (within-subject factor) without affecting the emotional state. Results show that emotions have no significant effect on correct recognition, wayfinding and response times (Experiment 1). For Experiment 2 the results show that the best wayfinding performance occurs when negatively laden landmarks were used. Recognition performance was similar, however, hardly decreased over time for the negative stimuli. These findings are discussed within the current research literature.

Keywords: landmark; emotions; mood; wayfinding

Introduction

Spatial cognition is indispensable for successful mastery of our daily life and yet it seems to be almost always unconscious. Well-known paths become automated with time and require less working memory capacities, enabling us to pay more attention to other things. When it comes to taking new directions our undivided attention, as well as greater working memory capacities are necessary to avoid getting lost (Montello, 2009). Navigationally relevant information needs to be stored and becomes available later on. Landmarks serve as anchors in our mental representation of the physical environment and are used in the communication of route directions (e.g., Raubal & Winter, 2002). A landmark is an object or structure that marks a locality and is used as a point of reference. Everything that "stands out" from a scene can be a landmark (e.g., Caduff & Timpf, 2008).

Landmark salience

Landmarks should be salient. This means that an object needs to be conspicuous and pops out in comparison to other surrounding objects (Caduff & Timpf, 2008). The salience of objects is determined by structural, visual and cognitive (semantic) qualities (e.g., Caduff & Timpf, 2008). Objects are called structurally salient, "if their location is cognitively or linguistically easy to conceptualize in route directions" (Klippel & Winter, 2005; p. 1) or if they have a prominent spatial location (Raubal & Winter, 2002). Visual salience includes all visual features of an object such as size, color, shape, texture or contrast (Caduff & Timpf, 2008). Cognitively salient landmarks contain a high idiosyncratic relevance. So the personality of the observer should be taken into account because cognitive salience mainly depends on cultural, personal and historical influences.

Emotion and navigation

For successful wayfinding, landmarks have to be stored in memory. It is of particular interest which physical and psychological factors affect human wayfinding. So, how does an object become a landmark? According to the somatic marker hypothesis (Damasio, 1996), there is a connection between emotion and cognition in practical decision making and beyond that emotions are biologically indispensable to decisions. So each stimulus is "marked" with certain visceral and non-visceral perceptions. They can be both positive and negative (Damasio, 1996). These perceptions are partly responsible for our decision making and complement the thinking process.

Montello (2009) distinguishes between long-term psychological factors, which are character traits of people and tend to be persistent over time and short-term psychological factors like illness, fatigue or anxiety. These short-term psychological factors have in common that they reduce the attention of the observer (Montello, 2009). However, in contrast to the other psychological factors which Montello (2009) described, anxiety is deemed to be a basic emotion (Ekmann, 1999). Emotions play an important role in our lives. If we are happy, we perceive our environment in a different way than when we are sad or angry. Individuals in a positive mood tend to perceive their environment more globally, thus their information processing is less focused and details are blended out. Negative mood promotes a local focus and more detailed attention (Gasper & Clore, 2002). According to the feeling-as-information-theory (Schwarz & Clore, 1996) people attend to their feelings as a source of information and the use of feelings as a source of information follows the same principles as the use of any other information. Hence a positive feeling indicates that an object or situation is good for us. A negative feeling on the other hand signals us to be careful and attentive. Immediately after learning, emotional words are remembered worse than neutral words, but neutral words are recalled better after a time interval of a week (Parkin, Lewinsohn, & Folkard, 1982) or a month (Bradley & Baddeley, 1990). Gray (2001) demonstrated that negative emotional states impair the verbal working memory, but at the same time improve the spatial working memory. For positive emotional states the exact opposite can be observed. It may therefore be assumed that a negative emotional state might lead to improved navigation performance.

The effect of emotions on wayfinding can be considered from two different viewpoints: on the one hand landmarks or the path can trigger mood, such as happiness or sadness, which may have an impact on wayfinding. On the other hand the landmark itself can be emotionally laden, such as a cemetery. With our experiments we try to extend the concept of salience by the aspect of emotions.

Experiments

The main aim of the present study is to explore how emotions may influence the recognition of landmarks and correct wayfinding (*performance*), decision times for the recognition of landmarks as well as directional decisions (*response time*). Based on the literature review, we assumed that both a positive and a negative mood would affect wayfinding. Furthermore, we also assumed that both positive and negative mood during wayfinding should have an influence on memory consolidation. Based on Ebbinghaus` forgetting curve (see Ebbinghaus, 1885), information mainly gets lost from memory after four to six days when there is no attempt to retain it. This is why we repeatedly investigated one week after the experiment (t1) at t2. To investigate the hypotheses we performed two experiments. In Experiment 1 we investigated the effect of an emotional state (positive, negative, neutral) on wayfinding. In Experiment 2 we investigated the effect of emotionally laden landmarks on wayfinding without affecting the emotional state of participants.

Methods

Participants

In each experiment a total of 24 students participated. Experiment 1: Seventeen females and seven males with a mean age of 24 years (*SD* = 3.8). Experment 2: Twenty-two females and two males with a mean age of 23 years (*SD* = 2.9). All participants provided informed written consent. Exclusion criterion was an epilepsy disorder (participant or close relatives). All had normal or corrected-to-normal visual acuity and received course credits for participation.

Material

The experiments were performed in the virtual environment SQUARELAND which was set up with the Freeware-Software Google SketchUp 6.0® by Google® (Hamburger & Knauff, 2011). For the current study SQUARELAND was made up from an 8×8 block maze with a total of 18 T-junctions. Participants could therefore only choose between two directions, right or left turn. The outer structure consisted of concrete walls to generate a neutral maze (figure 1). To control for landmark position effects (e.g., Röser, Hamburger, Krumnack, & Knauff, 2012), landmarks were placed centrally at the decision points. The eye-height within the virtual maze was set to 170 cm.

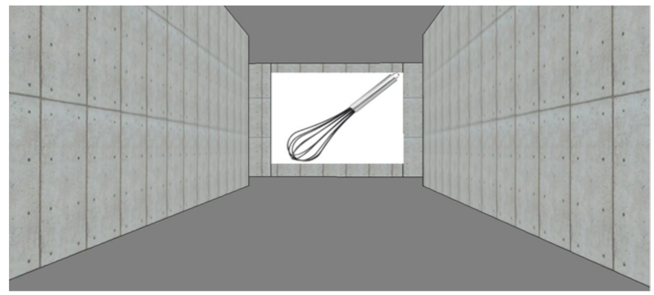

Figure 1: The virtual maze from the participant's egocentric perspective with a centrally placed neutral landmark at the T-junction.

To investigate the effect of emotions on wayfinding, we used emotionally laden images as landmarks, most of them were taken from the IAPS Inventory (The International Affective Picture System; Lang, Bradley, & Cuthbert, 2008). The IAPS Inventory mainly refers to the U.S. American context. To ensure that these pictures generate emotional arousal for our German participants, the valences of the images were tested in a preliminary study. Twenty-four psychology students rated in a total of 162 positive, negative and neutral images in a group session using a likert scale from 1 (very negative) to 9 (very positive). Pictures with the highest ratings in the pretest were used as landmarks (in the maze) and as distractors (in the recognition phase; examples given in figure 2).

Experiment 1 - Mood

The 36 most positive (*M* = 7.35, *SD* = 0.27), most negative (*M* = 2.27, *SD* = 0.23) and most neutral (*M* = 5.08, *SD* = 0.14) pictures were chosen. Per condition 18 pictures were used as landmarks while the remaining 18 images of the same mood condition were used as distractors for the recognition phase. The pictures were implemented in three different mazes divided into positive, negative and neutral mazes (between-subject factor). So in each case 18 emotional images (positiv, negativ, neutral) were positioned at the decision points. This allowed for a distinction between the different moods. Positive and negative affect were measured with the PANAS scale (Positive And Negative Affect Schedule; Watson, Clark, & Tellegen, 1988; Krohne, Egloff, Kohlmann, & Tausch, 1996).

Experiment 2 – Emotional landmarks

The effect of emotionally laden landmarks on human wayfinding was investigated while participants were introduced to all three types of emotional material (positive, negative, neutral). The 12 most positive (*M* = 7.63, *SD* =

0.04), most negative (M = 1.74, SD = 0.05), and most neutral (M = 5.01, SD = 0.04) pictures were chosen. Six pictures per mood condition were used as landmarks and the remaining six images were used as distractors for the recognition phase. A total of 18 emotional images (six positiv, six negativ, six neutral) were positioned at the decision points (within-subject factor). We created two mirrored mazes to avoid direction- and sequence-effects. So participants turned left and right equally often. These mazes were constructed with landmarks (maze 1.1 and maze 2.1) and with distractors (maze 1.2. and maze 2.2.). Thus, a total of four different maze versions allowed for a fully balanced design.

To ensure that mood does not change during the experiment, participants filled in the German PANAS version before and after the experiment. For presentation and data recording SuperLab 4.0 Stimulus Presentation Software (Cedrus Corporation©) was used.

Figure 2: The most positive (M = 8.12, SD = 0.26), most neutral (M = 5.0, SD = 0.14) and most negative (M = 1.38, SD = 0.12) image (from left to right) of the preliminary study.

Procedure

The group assignment was random. In single sessions the participants saw a video lasting 4 minutes and 33 seconds showing the maze once. It was presented on a 230×170 meter projection screen from an egocentric perspective, the simulated walking speed was 1.5 m/s. In the first phase participants were asked to learn the path (with landmarks).

After the learning phase a recognition phase followed. Participants were instructed to distinguish between landmarks and distractors via the according key presses on a response pad (RB-530 Cedrus Corporation©). Between successive pictures a fixation cross was shown for 1500 milliseconds (figure 3).

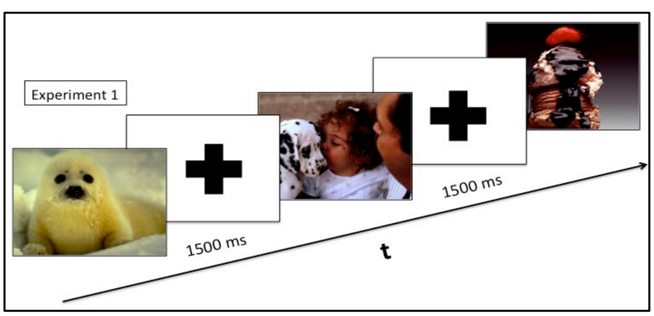

Figure 3: Schematic presentation of three trials in the recognition phase of Experiment 1. Participants had to decide whether the picture has been a landmark in the learning phase or not.

During the wayfinding phase the participants saw the video of the maze again, but this time the video stopped at the decision points were landmarks were presented. Here, participants were instructed to make a direction decision by pressing the right or left button on the response pad (RB-530 Cedrus Corporation©). If participants chose the wrong direction, the video continued in the correct direction to avoid that participants get lost in the virtual environment (implicit feedback). The recognition and wayfinding phase were repeated after one week (t2).

Results

Performance (recognition of landmarks and correct wayfinding) and response time (decision times for the recognition of landmarks as well as directional decisions) in the recognition and wayfinding phase were analyzed with an analysis of variance (ANOVA).

Experiment 1

The mood condition (positive, negative, neutral) served as the between-subject factor, while the within-subject factor was the time of measurement (t1 and t2).

Recognition

Performance

Results show that the negative emotional state influenced participants' performance in the recognition phase (table 1).

Table 1: Results for participants' performance in the recognition phase of Experiment 1. The mean percentage of correctly recognized landmarks and distractors for each mood condition at t1 and t2 are shown.

N=24	**Mood condition**		
Time of measurement	Positive	Negative	Neutral
T1 total	94% (SD = 4.09)	96% (SD = 3.17)	79% (SD = 7.17)
T1 landmarks	93% (SD = 5.74)	96% (SD = 4.65)	77% (SD = 12.87)
T1 distractors	95% (SD = 5.46)	96% (SD = 4.65)	81% (SD = 3.04)
T2 total	84% (SD = 13.34)	93% (SD = 7.50)	70% (SD = 5.46)
T2 landmarks	89% (SD = 9.30)	98% (SD = 3.05)	72% (SD = 11.62)
T2 distractors	80% (SD = 19.77)	88% (SD = 12.67)	69% (SD = 10.34)

However, the ANOVA showed that the mood condition had no significant effect on the ability to remember landmarks and distractors ($F(2,16)$ = 1.459, p = .266) and that there is no significant interaction between the mood and the time of measurement ($F(2,16)$ = .778, p = .478) in the recognition phase. Participants were able to recognize landmarks and distractors at t1 better than at t2 ($F(1,16)$ = 8.814, p = .010).

Response time

Table 2 shows the differences between the mood categories. It seems as if emotions affect participants' response time in the recognition phase. The ANOVA revealed that the response time at t1 was significantly shorter than at t2 ($F(1,16)$ = 6.78, p = .021). But there was no significant difference between the mood conditions (*F(2,16)* = .596, *p* = .564). Furthermore, there is no significant interaction between mood and time of measurement (*F(2,16)* = .778, *p* = .478).

Table 2: Results for participants' response time in the recognition phase of Experiment 1. Mean response times in milliseconds for each mood condition at t1 and t2 are given.

N=24	Mood condition		
Response time	Positive	Negative	Neutral
T1 total	1293 ms (*SD* = 395.19)	1169 ms (*SD* = 310.13)	1153 ms (*SD* = 277.63)
T1 landmarks	1349 ms (*SD* = 393.78)	1123 ms (SD = 499.94)	1208 ms (*SD* = 352.58)
T1 distractors	1248 ms (*SD* = 432.90)	1215 ms (*SD* = 292.72)	1097 ms (*SD* = 273.24)
T2 total	1775 ms (*SD* = 913.99)	1646 ms (*SD* = 665.14)	1308 ms ((*SD* = 414.13)
T2 landmarks	1771 ms (*SD* = 1096.07)	1134 ms (*SD* = 329.21)	1324 ms (*SD* = 462.63)
T2 distractors	1777 ms (*SD* = 773.28)	1967 ms (*SD* = 912.35)	1480 ms (*SD* = 513.80)

Wayfinding

Performance

Performance in the positive condition was 85% (*SD* = 9.73) at t1 and 83% (*SD* = 14.91) at t2. The performance in the negative condition was 84% (*SD* = 13.26) at t1 and 71% (*SD* = 15.42) at t2. The performance in the neutral condition at t1 was 81% (*SD* = 11.52) and 80% (*SD* = 12.99) at t2. Even though there is a large difference in the negative condition an ANOVA for mood during the learning phase on correct wayfinding (*F(2,16)* = .440, *p* = .653) remained insignificant (due to absent differences for the other two conditions). Also there were no significant differences between t1 and t2 (*F(1,16)* = 3.719, *p* = .074).

Response time

The descriptive statistics show that the mean response time of participants in the positive condition was 722 ms (*SD* = 348.47) at t1 and 930 ms (*SD* = 731.47) at t2. The response time in the negative condition was 552 ms (*SD* = 199.39) at t1 and 607 ms (*SD* = 257.24) at t2. The response time in the neutral condition was 699 ms (*SD* = 361.07) at t1 and 768 ms (*SD* = 584.58) at t2. An ANOVA revealed no significant differences between the learning phase and the wayfinding phase for the response time (*F(2,16)* = .460, *p* = .640) and there were no significant differences between t1 and t2 (*F(1,16)* = 1.497 *p* = .241). Furthermore, there were no significant interactions between mood conditions and time of measurement (*F(2,16)* = .298, *p* = .747).

PANAS

At both, t1 and t2 the descriptive results of the PANAS questionnaire show differences between the mood conditions (table 3). So emotionally laden landmarks at least had an influence on participants' mood.

Table 3: Results of the PANAS questionnaire at t1 and t2 of Experiment 1. Mean scores of positive affect (PA) and negative affect (NA) before (PRE) and after (POST) testing for each mood condition are shown.

N=24	Mood condition		
Affect	Positive	Negative	Neutral
T1 PA PRE	M = 3.1 (*SD* = 0.89)	M = 3.8 (*SD* = 0.62)	M = 3.3 (*SD* = 0.64)
T1 PA POST	M = 3.4 (*SD* = 0.97)	M = 3.3 (*SD* = 0.88)	M = 3.3 (*SD* = 0.65)
T2 PA PRE	M = 3.0 (*SD* = 0.84)	M = 3.2 (SD = 1.12)	M = 4.1 (*SD* = 0.73)
T2 PA POST	M = 3.3 (*SD* = 1.01)	M = 3.0 (*SD* = 1.30)	M = 3.5 (*SD* = 0.94)
T1 NA PRE	M = 1.8 (*SD* = 0.65)	M = 1.4 (*SD* = 0.33)	M = 1.6 (*SD* = 0.39)
T1 NA POST	M = 1.4 (*SD* = 0.68)	M = 1.7 (*SD* = 0.50)	M = 1.3 (*SD* = 0.33)
T2 NA PRE	M = 1.7 (*SD* = 0.72)	M = 1.3 (*SD* = 0.24)	M = 1.6 (*SD* = 0.92)
T2 NA POST	M = 1.5 (*SD* = 0.87)	M = 1.4 (*SD* = 0.53)	M = 1.3 (*SD* = 0.63)

Experiment 2

The mood condition (positive, negative, neutral) and the time of measurement (t1 and t2) served as within-subject factors.

Recognition

Performance

Table 4 shows the differences between mood valences for recognition performance. An ANOVA revealed that participants were able to recognize landmarks and distractors at t1 better than at t2 (*F(1,23)* = 16.789, *p* < .001). However, the mood valences had no significant effect on the ability to remember landmarks and distractors (*F(2,46)* = 0.665, *p* = .517). There is an interaction between mood valence and the time of measurement (*F(2,46)* = 3.625, *p* = .035) for neutral (*t(23)* = 2.635; *p* = .015) and positive stimuli (*t(23)* = 4.047; *p* < .001).

Table 4: Results for participants' performance in the recognition phase of Experiment 2. Mean correct recognition of landmarks and distractors for the mood valences at t1 and t2 are shown.

N=24	Mood valences		
Time of measurement	Positive	Negative	Neutral
T1 total	97% (*SD* = 4.7)	93% (*SD* = 6.6)	94% (*SD* = 6.3)
T1 landmarks	95% (*SD* = 9.2)	86% (*SD* = 12.7)	90% (*SD* = 12.9)
T1 distractors	99% (*SD* = 3.4)	99% (*SD* = 3.4)	99% (*SD* = 4.7)
T2 total	89% (*SD* = 10.6)	92% (*SD* = 9.5)	89% (*SD* = 8.0)
T2 landmarks	89% (*SD* = 17.6)	92% (*SD* = 13.0)	93% (*SD* = 12.9)
T2 distractors	89% (*SD* = 11.7)	93% (*SD* = 12.9)	85% (*SD* = 13.8)

Response time

The response time at t1 was significantly shorter than at t2 (*F(1,23)* = 31.209, *p* < .001) and there was a difference between the mood valences (*F(2,46)* = 7.433, *p* = .002). Positive (*t(23)* = 2.874; *p* = .009) and neutral stimuli (*t(23)* = -3.252; *p* = .004) differed significantly from negative stimuli. For recognition of negative stimuli (*M* = 1224.1 ms, *SEM* = 73.3) more time was needed than for positive (*M* = 1120.5 ms, *SEM* = 49.4) or neutral (*M* = 1125.5, *SEM* = 60.7) stimuli.

Wayfinding

Performance

An ANOVA showed that the emotional valence of a landmark during the learning phase had a significant influence on correct wayfinding ($F(2,46) = 6.688$, $p = .003$). There were significant differences between t1 and t2 ($F(1,23) = 12.236$, $p = .002$). Wayfinding performance with negative landmarks (*M* = 89.2 %, *SD* = 12.6) was significantly better than with positive (*M* = 79.2 %, *SD* = 16.8, $t(23) = 2.839$; $p = .009$) or neutral landmarks (*M* = 77.4 %, *SD* = 16.8, $t(23) = -3.874$; $p = .001$).

Response time

An ANOVA revealed that the emotionally laden landmarks had a significant influence on response time ($F(2,46) = 11.377$, $p = .001$) and that there was a significant difference between t1 and t2 ($F(1,23) = 5.916$, $p = .023$). The response time for neutral stimuli was significantly longer than for positive ($t(23) = -3977$; $p = .001$) or negative ($t(23) = 3.135$; $p = .005$) stimuli.

PANAS

For t1 and t2 the ANOVA showed no mood differences before and after testing as assessed by the PANAS questionnaire ($F(1,23) = 0.031$, $p = .861$). Neither the positive affect ($t(23) = -0.629$; $p = .536$) nor the negative affect ($t(23) = 0.630$; $p = .535$) had changed after testing compared to before testing.

Discussion Experiment 1

Positive and negative emotions do not seem to strongly affect participants' wayfinding performance and response times. The results show no significant interaction between mood condition and time of measurement. This could be due to the very high performance in all three conditions. Nevertheless, the descriptive results show a clear trend. In the recognition phase participants were able to recollect negative landmarks and distractors better at t2 than positive or neutral landmarks and distractors. This supports results of Parkin et al. (1982) and Bradley and Baddeley (1990), which indicate that negative associations are remembered better over time than positive and neutral associations. Yet, the high recognition rates for negative images do not mean that they actually serve as good landmarks. In the wayfinding phase participants in the negative condition showed lower performance than participants in the positive or neutral condition, although negative pictures in the recognition phase were better recollected. If these pictures were integrated as landmarks in the virtual maze and were linked to learning a path then the path is remembered worse. Based on the feeling-as-information-theory a negative mood signals the person to be careful and attentive (Schwarz & Clore, 1996), but the increased attention refers to the negative object (Gasper & Clore, 2002), which in this case is the landmark. So, for the actual wayfinding task not enough attentional resources and working memory capacities seemed to be available, which are essential for successful wayfinding (Montello, 2009). For both, the recognition and the wayfinding phase, the response times in the positive and negative condition were longer than in the neutral condition. The positive and negative images mostly show people during social interactions, whereas in the neutral images individual objects were seen. Therefore, the positive and negative pictures were also more complex than the neutral pictures. This could have led to extended response times. The descriptive results for the PANAS questionnaire demonstrate mood changes over time. Participants in the positive condition showed an increase in positive affect and a decrease in negative affect after testing compared to before testing. Participants in the negative condition showed exactly the opposite. For the neutral condition no mood change was observed.

Discussion Experiment 2

Performance for negative stimuli did not decrease over time. This result also supports the results of Parkin et al. (1982) and Bradley and Baddeley (1990), indicating that negative associations are better remembered over time than positive and neutral associations. Though, the response times for negative images in the recognition phase are conspicuous. Negative landmarks were well recognized but it took participants longer to respond to negative landmarks. Hence, participants might be emotionally involved, as the negative landmarks showed people in violent and traumatic situations or tortured and abused animals. Herbert, Pauli, and Herbert (2011) demonstrated that especially negative information is processed deeper when this negative information has a self-reference. In the wayfinding phase, participants showed significantly higher performance for negative landmarks than for positive or neutral landmarks. When positive, negative and neutral pictures are linked to learning the path (within-subject), then the path is remembered better with negative landmarks. According to Carretie, Mercado, Tapia, and Hinojosa (2001) more and faster attentional resources are provided for negative stimuli. This did not occur for non-negative stimuli even if the same amount of emotional arousal was triggered. Information which is linked to the highly aroused stimuli is remembered better (Bradley, Greenwald, Petry, & Lang, 1992). The direction of turn might be such information. As expected, the evaluation of the PANAS questionnaire showed no mood change over time. It can thus be said that information processing did not change due to mood but because of the emotionality of the landmarks.

General Discussion

In both experiments a decrease in performance for recognition and wayfinding was observed. Participants showed worse performance and required more time to respond at t2 in comparison to t1, which is in line with the forgetting curve (Ebbinghaus, 1885). In Experiment 1, a trend can be observed that negative landmarks were recollected better than positive landmarks and positive landmarks were remembered better than neutral landmarks. But, if these landmarks were integrated in the virtual maze and were linked to path learning, then the path was remembered worse. Experiment 2 revealed that participants show higher wayfinding performance for negative landmarks than for positive landmarks and a higher wayfinding performance for positive landmarks than for neutral landmarks. Furthermore, negative landmarks were recollected better than positive and neutral landmarks since recognition performance did not decrease over time. It therefore seems to play a role whether negative landmarks were presented alone or in a path together with positive and neutral landmarks. A possible explanation for this could be evolutionary benefits. In a negative environment safety becomes a far higher priority and reaching the destination quickly and reliably is key for survival. So, in both experiments the emotionally laden landmarks were remembered better than the neutral landmarks. This might indicate that the emotionally laden landmarks had some idiosyncratic relevance (Caduff & Timpf, 2008). Moreover, our results support the concept of cognitive (Sorrows & Hirtle, 1999) and semantic (Klippel & Winter, 2005) salience. The emotional state of the observer and the emotional valence of the landmarks contribute to a higher wayfinding performance and could be seen as another aspect of cognitive or semantic salience. It might also serve as a basis for a new landmark salience category: emotional landmark salience.

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