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RESEARCH REPORT

Turn left where you felt unhappy: how affect influences landmark-based wayfinding

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Abstract The present work investigated the impact of affect in landmark-based wayfinding. We assumed that affect-laden landmarks improve wayfinding performance and have an impact on later landmark recognition. To investigate our hypotheses, we ran two experiments in a virtual maze. In Experiment 1, we investigated how affect-laden landmarks influence wayfinding and recognition in comparison with neutral landmarks. The aim of Experiment 2 was to focus on the affective valence of a landmark. The memory tasks of both experiments were repeated after 1 week in order to assess memory consolidation. Results showed that the best wayfinding and recognition performance occurs when negatively laden landmarks were used. In comparison with neutral and positively laden landmarks, recognition performance hardly decreased over time for the negatively laden landmarks. Our results not only support findings in the field of emotion research but also expand the concept of semantic landmark salience with respect to emotional responses.

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Introduction

Wayfinding is a task we engage in throughout our day. It is concerned with how we find our way in complex environments, plan routes to distant locations and finally return to our starting point. The ability to imagine and reason about changes in objects and their spatial layout is indispensable for successful mastery of our daily life (Wolbers and Hegarty 2010). In order to avoid getting lost, navigationally relevant information such as landmarks needs to be stored in long-term memory and made available later on in working memory. A landmark can be seen as an object or structure marking a location that may be used as a point of reference. In fact, everything that "stands out" from a scene can serve as a landmark (e.g., Caduff and Timpf 2008).

Wayfinding is a complex process and each element within this process is subject to influence from strong responses outside of the actual act of wayfinding. One such response is an emotional response: affect. In fact, emotions have an influence on several factors required in wayfinding such as decision making (Damasio 1996), attention (Montello 2009) and working memory (Gray 2001). However, to the best of our knowledge there are no studies that specifically addressed the influence of emotional responses in the context of everyday navigation.

The present work is therefore geared toward combining two different research fields: wayfinding and emotion. First, we will review the role of affect on navigationally relevant factors. Second, we will try to embed its role in a theoretical framework in the field of spatial cognition: landmark salience. Based on that, we will describe our central assumption that affect influences perceptual and cognitive factors and that in turn leads to changes in the way we perceive spatial information and act as agents in our environment.

Emotion research and potential links to navigation

The literature on emotion research reveals various definitions of emotions and emotion-related concepts. In this study we will use the following distinction between mood, emotion and affect. According to Ekman (1994), moods can be distinguished from emotions especially in their duration. Moods tend to be much more long-lasting (Ekman 1994) and less context bound than emotions (Watson and Tellegen 1985). Emotions tend to be briefer (Ekman 1994), more context-sensitive and have a specific cause (Ekman 1992; Schwarz 1990). At the heart of these emotions are basic neurophysiological responses called affect. It is "what makes any event "hot" (i.e., emotional)" (Russell 2003, p. 148). Affect can be described as a neurophysiological consciously accessible state that consists of both hedonic and arousal values (core affect; Russell 2003). Both values occur concurrently on different levels and should not be seen as opposing concepts. The arousal values depict states from sleepy to activated but are not subject of this study. For readability purposes, from hereinafter, the term "affect" describes the hedonic values from Russell's core affect that depict states from pleasure to displeasure.

As previously mentioned, there are several factors and theories that allow us to draw a link between emotion (including affect at its core) and wayfinding performance. According to the somatic marker hypothesis (Damasio 1996), there is a connection between emotion and cognition in practical decision making. 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 support (or impair) the process of thought. If wayfinding consists of decisions in the sense of a choice between alternatives (such as directions), the somatic marker hypothesis implies that stimuli such as landmarks are marked with visceral and non-visceral perceptions as well.

Dual-process theories distinguish between two kinds of thinking: one rapid autonomous process and one distinctive higher-order reasoning process, often referred to as System 1 and System 2 (e.g., Evans and Stanovich 2013). Reasoning and decision making, which are associated with System 2, are generally slow, deliberate and well considered, while emotions are coupled with System 1 and constitute the basis for making fast and automatic decisions (Epstein 1994; Evans and Stanovich 2013).

According to the feeling-as-information theory (Schwarz and Clore 1996), people attend to their feelings as a source of information and this 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 (i.e., resembling an emotional alarm bell). In particular, the latter could imply that an attentional shift or focusedness could lead to an effective processing of stimulus information.

The role of emotions in perception should not be underestimated. If we are happy, we perceive our environment in a different way than when we are sad or angry. Gasper and Clore (2002) found that 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 and Clore 2002). Gray (2001) demonstrated that negative emotional states impair verbal working memory, but at the same time improve spatial working memory. For positive emotional states, the exact opposite can be observed (Gray 2001). Immediately after learning, emotional words (positive and negative) are remembered worse than neutral words, but they are recalled better after a time interval of a week (Parkin et al. 1982) or a month (Bradley and Baddeley 1990). It may therefore be assumed that both positively and negatively (affect-) laden landmarks might lead to improved navigation performance in comparison with neutral landmarks (which are normally used in controlled experiments in the laboratory).

Landmark salience with respect to emotions

Landmarks serve as anchors in our mental representation of the physical environment; they are essential in the communication of route directions and become more useful when they are salient (e.g., Raubal and Winter 2002). This means that an object needs to be conspicuous and to *stand out* in comparison with other surrounding objects (Caduff and Timpf 2008) with respect to different sensory modalities (Hamburger and Röser 2014; Karimpur and Hamburger 2016). The salience of objects is determined by structural, visual and cognitive (semantic) qualities (e.g., Caduff and Timpf 2008):

- Objects are called structurally salient if they have a prominent spatial location (Raubal and Winter 2002), such as being located at decision points (Janzen and van Turennout 2004).

- Visual salience includes all visual features of an object such as size, color, shape or texture (e.g., Caduff and Timpf 2008).
- Cognitively salient landmarks (also defined as semantic salience) contain a high idiosyncratic relevance. Since cognitive salience mainly depends on cultural, personal and historical influences, the personality of the observer needs be taken into account as well (e.g., Caduff and Timpf 2008).

As previously stated, the influence of emotion on a perceptual level can explain why visual salience could be affected. The more interesting part lies in semantic salience. Although personal influences and the personality of an observer cannot be considered separately from emotions, in this concept of semantic landmark salience, emotions were not explicitly mentioned thus far. However, the idiosyncratic relevance implicitly indicates that there is more to semantic salience than just semantics in the sense of meaning. Let us assume that a statue on the corner stands out from its environment structurally and visually and therefore serves as a landmark; then, this statue is even more useful if it happens to be your favorite statue (semantic landmark salience) because it was the place where you had your first kiss. It means something to you. Can we stop there? We believe that the answer is no. The fact that it means something is most likely accompanied by an emotional response which we call affect. In this scenario, for example, we could say that the affect underlying this event is hedonic positive and mildly arousing.

We see that emotion has several points where it could potentially influence cognitive processes. More importantly, there seems to be a place in the theoretical framework of human landmark-based wayfinding where we can integrate the influence of affect in it: semantic landmark salience. The ability to link it to a specific event with a specific landmark may facilitate wayfinding during times when one's cognitive state is overloaded and may therefore speed up the everyday process of wayfinding as well.

Goal of the study

The goal of the present paper is to extend the concept of semantic landmark salience with respect to emotions by exploring how one's affect influences three performance measures:

1. Correct wayfinding—because this is a core element of landmark-based wayfinding
2. Correct recognition—because the successful association between a stimulus and a route direction requires the correct recognition of a stimulus, and lastly,
3. Response times—because response times allow us to draw conclusions about processing depth/speed.

We try to do so by using landmarks which are more likely to evoke affective reactions and therefore call them hereinafter affect-laden landmarks. Primarily, we want to answer the following three questions: (1) Do affect-laden landmarks in general improve wayfinding performance and related measures? (2) What kind of affective valence has a greater impact on wayfinding performance? (3) And what kind of affective valence has a greater influence on memory consolidation and, therefore, a better long-term memory of the path?

To investigate our research questions, we performed two experiments. In Experiment 1, we investigated how affect-laden landmarks influenced wayfinding performance compared to neutral landmarks. Based on the presented literature, we believed that affect-laden landmarks were superior compared to neutral landmarks, which are mainly used in wayfinding research (e.g., Hamburger and Röser 2014; Raubal and Winter 2002).

In Experiment 2, we took a closer look at the distinction between the affective valences and considered the affective valence of a landmark with a more distinct set of stimuli. Here we hypothesized that performance for negative affect-laden landmarks would be best before positive affect-laden and neutral landmarks.

Finally, we assumed that affect-laden landmarks 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. Hence, both experiments were repeated 1 week after (t_2) the first time of testing (t_1).

Preliminary study: validation and selection of affect-laden landmarks

For all experiments, we used affect-laden images as landmarks at decision points, taken from the IAPS Inventory (The International Affective Picture System; Lang et al. 2008). The IAPS Inventory includes a large set of standardized, affect-laden, colored photographs that represent three categories of affective stimuli (negative, neutral and positive) and provides a list with scores of valence and arousal as well. Each picture in the IAPS is rated by a large group of people for the feelings of pleasure and arousal that the picture evokes during viewing. A more detailed description of the IAPS is provided in Bradley and Lang (2007).

The IAPS Inventory mainly refers to the US American context. To ensure that these pictures evoke a similar emotional reaction for our German participants, the valences of the images were validated in a preliminary study. Twenty-four psychology students rated 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 most selective ratings in the pretest were used as landmarks (in the maze) and as distractors (in the recognition phase). We generated stimulus pairs where one of the two pictures with equal emotional valence scores (positive, negative or neutral) in the pretest was assigned to the maze (landmark) while the other one became a distractor in the recognition task. The emotional content of the images is widely diversified: for instance, human experiences, animals, photojournalism from wars and disasters, landscapes, foodstuffs, household objects as well as abstract objects.

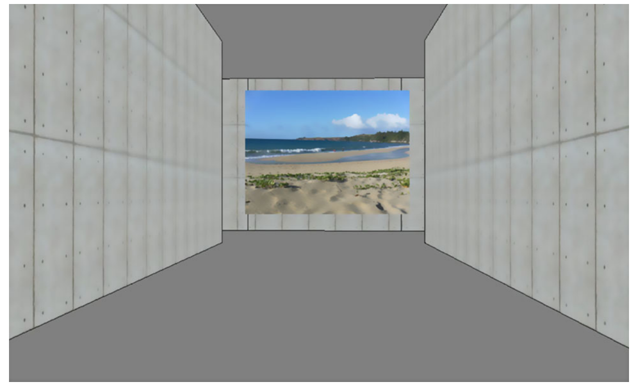

Fig. 1 Virtual maze from the participant's egocentric perspective with a centrally placed exemplary neutral landmark at the T-junction

Experiment 1: affect-laden landmarks

We investigated the influence of affect-laden landmarks on wayfinding compared to neutral landmarks.

Method

Participants

A total of 24 Psychology students from the University of Giessen participated (17 females). They had a mean age of 24 years (SD = 3.82). All participants provided informed written consent. Exclusion criterion was an epilepsy disorder (participant or close relatives) due to presentation in the virtual environment. All had normal or corrected-to-normal visual acuity and received course credits for participation. The use of the landmark material as well as the procedure of the experiments have been approved by the local ethics committee and are in accordance with the latest version (October 2013) of the *Declaration of Helsinki.*

Material

The experiment was performed in the 3-D virtual maze SQUARELAND (e.g., Hamburger and Röser 2014), which was set up with the Freeware-Software Google SketchUp 6.0®. For the current study, the virtual environment consisted of 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 (Fig. 1). To control for landmark position effects (e.g., Röser et al. 2012), landmarks were placed centrally at the decision points. The eye height within the virtual maze was set to 170 cm.

A total of 36 affect-laden images (positive $M = 7.35$, $SD = 0.27$ and negative $M = 2.27$, $SD = 0.23$) as well as 36 neutral pictures ($M = 5.08$, $SD = 0.14$) from the preliminary study were selected. For both conditions, 18 images were used as landmarks while the remaining 18 images of the same affective valence were used as distractors for the recognition phase. The pictures were implemented in two different mazes, an affect-laden maze or a neutral maze (between-subject factor). Thus, both mazes contained 18 images (affect-laden or neutral) positioned at the decision points. In order to avoid direction and sequence effects, we created two mirrored mazes; participants had to turn left and right equally often. Two of these mazes were constructed with landmarks while the remaining two mazes were constructed with the stimuli which were used as distractors in the first two mazes. Thus, a total of four different maze versions allowed for a fully balanced design.

Positive and negative affect was measured with the German version (Krohne et al. 1996) of the PANAS scale (Positive And Negative Affect Schedule; Watson et al. 1988). For presentation and data recording, SuperLab 4.0 Stimulus Presentation Software (Cedrus Corporation©) was used.

Procedure

The group assignment was pseudo-randomized (2 conditions and 12 participants per condition: affect-laden and neutral). In single sessions, participants saw a video lasting 4 min and 33 s showing the walk through the maze once. It was presented on a 230 × 170 cm projection screen with a distance of 100 cm. The simulated walking speed was 1.5 m/s. In the learning phase, participants were instructed to learn the route and landmarks they saw in the video.

After the learning phase a recognition phase followed. The stimulus material was presented in random order and 36 images were to be judged (18 landmarks and 18 distractors). A fixation cross was presented for 1500 ms (ms) between successive pictures. Participants were instructed to indicate whether they had seen the pictures in the previous learning phase or not via the according key presses on a response pad (RB-530 Cedrus Corporation©).

After the recognition phase, the instruction for the wayfinding phase appeared. Participants saw the video of the maze again, but this time the video stopped at the decision points where landmarks were presented. Here, participants were instructed to make a directional 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 got lost in the virtual environment.

The same recognition and the same wayfinding phase (t_1) were repeated after 1 week (t_2). Figure 2 shows a schematic presentation of the experimental phases.

To ensure that mood did not change during the experiment, participants filled in the German PANAS version before and after the experiment.

Results

In both the recognition and the wayfinding task, performance was assessed as percentage of correct decisions. Additionally, response times for both tasks were measured. The data were analyzed with an analysis of variance (ANOVA). The factor landmark type (affect-laden and neutral) served as a between-subject factor, while the within-subject factor was the time of testing [immediate (t_1) and 1 week (t_2)].

PANAS

In order to control for mood changes, we used the PANAS. Neither the positive affect [$t(23) = -0.535$; $p = .454$] nor the negative affect [$t(23) = 0.782$; $p = .658$] had changed after testing compared to before testing. Thus, any effect on wayfinding and recognition performance would be a result of the affect-laden landmarks and not of participants' mood changes.

Recognition

Figure 3 depicts participants' performance in the recognition task. Participants performed significantly better when affect-laden landmarks ($M = .91$, $SEM = .02$; post hoc differentiation: positive $M = .88$, $SEM = .04$; negative $M = .95$, $SEM = .02$) were used compared to neutral landmarks ($M = .75$, $SEM = .14$), $F(1, 15) = 6.802$, $p = .020$, $\eta_p^2 = .312$. No significant effect of time of testing and no significant interaction effect of the factors time of testing × landmark type were obtained (both $p > .2$).

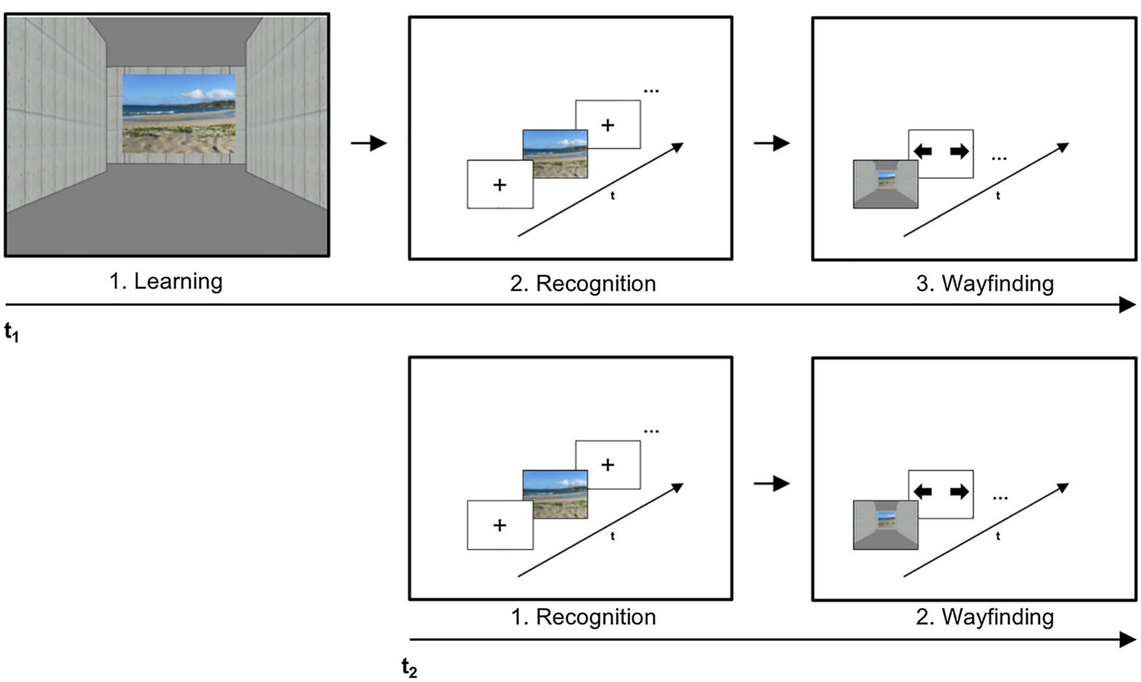

Fig. 2 Schematic presentation of all experimental phases in t_1 and t_2. *Top*: 1. Learning phase: participants saw a video showing the maze once. 2. Recognition phase: participants had to decide whether the picture had been shown as a landmark in the learning phase or not (here: exemplary picture of a beach scene, positive affect). 3. Wayfinding phase: the video stopped at the decision points where landmarks were presented. Participants were instructed to make a direction decision by pressing the right or left button on the response pad. *Bottom*: The recognition and wayfinding phase were repeated after 1 week (t_2)

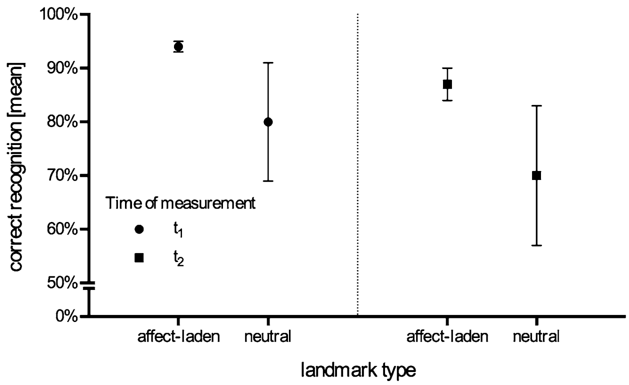

Fig. 3 Results for participants' performance in the recognition phase of Experiment 1. The mean percentage of correctly recognized landmarks and distractors for affect-laden landmarks and neutral landmarks at t_1 and t_2 are shown. The error bars represent the SEM

The analysis of response times reveals that participants were significantly faster in the recognition of landmarks immediately at t_1 ($M = 1207.18$ ms, SEM $= 77.19$) than 1 week after testing at t_2 ($M = 1571.83$ ms, SEM $= 166.02$), $F(1,\ 15) = 4.880$, $p = .043$, $\eta_p^2 = .245$. No significant effects were obtained for the factor landmark type or the time of testing × landmark type interaction (both $p > .2$).

Wayfinding

On a descriptive level, wayfinding performance was better at time of testing t_1 ($M = .83$, SEM $= .11$) than 1 week after at t_2 ($M = .78$, SEM $= .14$). At t_1, participants were slightly better when affect-laden landmarks ($M = .85$, SEM $= .03$; post hoc differentiation: positive $M = .88$, SEM $= .03$; negative $M = .84$, SEM $= .05$) were used compared to neutral ($M = .81$, SEM $= .05$). These differences disappeared in t_2. Results further show that participants were faster at t_1 ($M = 663.96$ ms, SEM $= 74.48$) compared to t_2 ($M = 778.12$ ms, SEM $= 134.69$). Despite these differences, inferential statistics reveal that there were no significant main effects or interactions in the wayfinding task, neither for wayfinding performance nor for response time (all $p > .2$).

Discussion

In the recognition phase, we obtained higher response times at the second time of testing after 1 week (t_2), which is not surprising. At t_1, the benefits from primary effects and availability of information in working memory could explain this effect. Contrary to our expectations, we did not find any differences of response times in landmark categories. However, affect-laden pictures were significantly better recognized than neutral ones. This supports the results of Kensinger and Corkin (2003) which indicated that affect-laden information is remembered better over time than neutral information.

Theoretically, if these pictures were integrated as landmarks in the virtual maze and were linked to learning a path, we would expect higher wayfinding performance with affect-laden landmarks. However, our results show that this is not the case. One reason for that could be that we have presented positively and negatively laden landmarks together in the maze. Studies show that negative emotions are more likely to have a much greater influence on memory consolidation and attention than positive emotions (Cheng and Holyoak 1985; Spies et al. 1996). The lack of differentiation could have led to decreased statistical sensitivity. Another reason for that could be the design of our study. We used a between-subject design to investigate group differences between affect-laden and neutral landmarks. In a maze consisting of solely neutral landmarks, neutral landmarks stand in contrast to other neutral landmarks. This could artificially lead to interpretation differences. If a maze consists of mixed landmarks, then each neutral landmark stands in contrast with affect-laden landmarks. First, this could increase ecological validity because highly negative stimuli happen to be an exception in our everyday environment. Second, it could also diminish the high variance in our results.

In the following experiment, we tried to address these issues while maintaining the experimental paradigm in general.

Experiment 2: affective valence of landmarks

In this experiment, we focused on the distinction between the affective valences and addressed the aforementioned issues by mixing different landmark-type categories in a maze.

Method

Participants

A total of 24 Psychology students from the University of Giessen participated (22 females). They had 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) due to presentation in the virtual environment. All had normal or corrected-to-normal visual acuity and received course credits for participation.

Material

The same setup as in Experiment 1 was used, but this time we differentiated landmarks in regard to their affective valence (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. The pictures were presented in a randomized order. A total of 18 emotional images (six positive, six negative, six neutral) were positioned at the decision points (within-subject factor). As in Experiment 1, we again created two mirrored mazes to avoid direction and sequence effects and participants again filled in the German PANAS version before and after the experiment.

Procedure

The procedure was identical to Experiment 1.

Results

This time we differentiated landmarks in regard to their affective valence (positive, negative, neutral). Both affective valence of a landmark and the time of testing [immediate (t_1) and 1 week (t_2)] served as within-subject factors. Data analysis was performed as in Experiment 1. In case of post hoc comparisons we used Bonferroni corrections.

PANAS

As in the first experiment, we controlled for mood changes. 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. Thus, any effect on wayfinding and recognition performance would be a result of the affect-laden landmark and not due to differences in participants' mood.

Recognition

Figure 4 depicts participants' performance in the recognition task. They showed significantly better recognition performance at t_1 ($M = .95$, $SEM = .01$) than at t_2 ($M = .90$, $SEM = .01$), $F(1, 23) = 16.788$, $p < .001$, $\eta_p^2 = .422$.

There was no significant main effect of valence ($p > .5$). However, the results show an interesting interaction between time of testing and valence, $F(2, 46) = 3.625$,

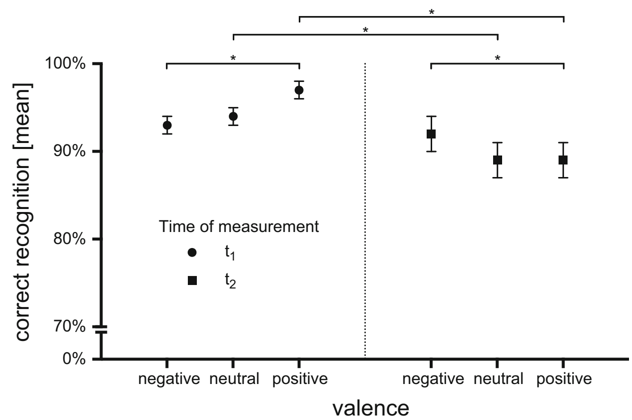

Fig. 4 Results for participants' performance in the recognition phase of Experiment 2 with significant differences after pairwise comparisons. The SEM is depicted with the error bars. Mean correct recognition of landmarks and distractors for the affective valences at t_1 and t_2 are shown. *$p < .05$

$p = .035$, $\eta_p^2 = .136$. If we look at the first time of testing (t_1), we see higher recognition performance of negative stimuli compared to positive stimuli ($p = .004$). If we then look at the second time of testing (t_2), this pattern is inverted: recognition performance for positively laden landmarks decreased while recognition performance for negatively laden landmarks did not. Additionally, the time of testing (t_1 and t_2) differed significantly from each other when neutral ($p = .015$) or positive ($p = .001$) stimuli were used. Recognition performance for both decreased at t_2.

The analysis of response times revealed that participants were significantly faster at t_1 ($M = 1114.72$ ms, $SEM = 62.74$) in the recognition of landmarks compared to t_2 ($M = 1418.28$ ms, $SEM = 88.52$), $F(1, 23) = 29.533$, $p < .001$, $\eta_p^2 = .562$. This time, however, we found a significant main effect of valence, $F(2, 46) = 6.558$, $p = .006$, $\eta_p^2 = .222$ (Huynh–Feldt corrected *df*). Pairwise comparisons reveal a significant difference between negatively laden ($M = 1344.51$ ms, $SEM = 77.08$) and positively laden landmarks ($M = 1173.99$ ms, $SEM = 55.95$), $p = .001$, indicating that participants' recognition response times for positively landmarks were significantly faster than for negatively laden landmarks.

Wayfinding

Figure 5 depicts participants' performance in the wayfinding task. Performance in the wayfinding task was significantly better at t_1 ($M = .84$, $SEM = .03$) than at t_2 ($M = .80$, $SEM = .02$), $F(1, 23) = 12.234$, $p = .002$, $\eta_p^2 = .347$. Additionally, there was a significant main effect

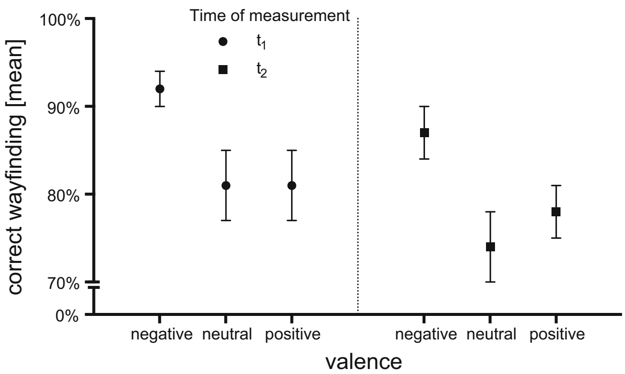

Fig. 5 Participants' performance in the wayfinding phase of Experiment 2. Mean percentages for correct wayfinding (correct directional decisions) for the affective valences at t_1 and t_2 are shown. The error bars represent the SEM

of valence $F(2, 46) = 6.668$, $p = .003$, $\eta_p^2 = .225$, which was followed by pairwise comparisons. These show that performance with negatively laden landmarks ($M = .89$, SEM $= .03$) was significantly better compared to positively laden ($M = .79$, SEM $= .03$, $p = .028$) or neutral landmarks ($M = .77$, SEM $= .03$, $p = .002$). There was no significant time of testing × valence interaction ($p > .5$).

For response times, pairwise comparisons following the significant main effect of valence show that the response times for neutral landmarks ($M = 746.89$ ms, SEM $= 63.70$) were significantly longer than for negatively laden ones ($M = 568.57$ ms, SEM $= 35.10$), $p = .017$; $F(2, 46) = 3.246$, $p = .048$, $\eta_p^2 = .124$.

Discussion

Same as it was the case in the first experiment, recognition performance decreased after 1 week (t_2). However, the more interesting result is the interaction between time of testing and valence. At the first time of testing (t_1), positively laden landmarks were superior compared to negatively laden landmarks. One week later, at the second time of testing (t_2), negatively laden landmarks were better recognized than positively laden ones. In other words: positively laden landmarks are better remembered initially but worse consolidated in long-term memory compared to negatively laden landmarks. 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.

Again the response times increased at t_2 which could be explained by primary effects at t_1 that helped decreasing the response times when initially learned and tested. Interestingly, participants had higher response times in negatively laden landmarks compared to positively laden landmarks. If we assume that the depth of encoding goes hand in hand with higher retrieval times, then these findings support the results of recognition performance. The results could also indicate that participants might have been more emotionally involved, as the negatively laden 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 it has a self-reference.

In the wayfinding phase, participants showed significantly higher performance for negatively laden landmarks than for positively laden or neutral landmarks. When positive, negative and neutral pictures are linked to learning the path (within-subject), then the path is remembered better with negatively laden 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 when the same amount of emotional arousal was triggered. Information which is linked to the highly aroused stimuli is remembered better (Bradley et al. 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 affective valence of the landmarks.

General discussion

In a series of two experiments, we explored the role of affect in the sense of hedonic states from pleasure to displeasure in spatial cognition. We described affect as the underlying basis of an emotion. Our two theoretical starting points were that (1) emotion research did not only show that perceptual and cognitive abilities are affected by emotions but (2) also semantic landmark salience emphasizes the idiosyncratic relevance of a landmark. If a landmark happens to evoke an emotional response of pleasure, this might happen due to the fact that the semantic of that particular landmark plays an important role.

First, we asked if affect-laden landmarks improve wayfinding performance and related measures. Our results demonstrate that, when it comes to recognizing landmarks, this is indeed the case. On the downside, we could not obtain such an effect in regard to correct decisions during the wayfinding task.

Second, we wanted to take a closer look and investigate both positive and negative valence separately in a slightly different experimental design. Our results show that especially landmarks associated with the negative emotional response of displeasure seem to have a positive effect on wayfinding performance and its related measures. Participants were not only better in recognizing negatively laden landmarks, but they also showed superior associations between landmark and route direction information during the wayfinding task.

Lastly, we investigated the issue of memory consolidation with respect to different valences. Again we found support that negatively laden landmarks were better recognized after a period of 1 week compared to positively laden or neutral landmarks.

As a next step, this fact can be used in spatial memory trainings to improve spatial memory skills for patients with hippocampal atrophy due to a major depression (Gradin and Pomi 2008) or other psychiatric disorders in conjunction with spatial memory difficulties. Moreover, our results support the concept of cognitive (Caduff and Timpf 2008) and semantic (Nothegger et al. 2004) landmark salience. The affective valence of the landmarks contributes to a higher wayfinding performance and could be seen as another aspect of cognitive/semantic salience. Furthermore, the affective valence of the landmarks could act as a moderating variable between observer and object in Caduff and Timpf's (2008) trilateral relationship between environment, observer and object. The observer is located in the environment and perceives some salient geographic features which contrast with the environment. With increasing arousal, triggered by the affective valence of an object, attention and memory for this object increase and thus its semantic salience. In conclusion, affect-laden landmarks indeed serve as an extended aspect of semantic or cognitive salience.

Our results in regard to negative stimuli are also in line with findings of Parkin et al. (1982) and Bradley and Baddeley (1990), who suggested that negative stimuli are better remembered over time than positive and neutral ones. Another 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 the key for survival. Negative emotions, especially fear-relevant stimuli, capture attention automatically for control settings needed for survival (Folk et al. 1992; Öhman et al. 2001).

A limitation of our study is that we could not control the arousal level evoked by the landmarks, even though we pretested the valence (positive, negative, neutral) of the landmarks in a preliminary study. According to the circumplex model of affect (Russel 1980), all affective states arise from two fundamental neurophysiological systems: one related to emotional valence and the other to arousal. Fear, for example, is a state characterized by a high level of arousal associated with negative valence. However, sadness is characterized by a low level of arousal but also associated with negative valence. The use of negatively laden images could have led to different levels of arousal. Hence, these images cannot be clearly distinguished from each other in all aspects of emotionality.

For decades, studies have emphasized the relation between increasing memory functionality and arousal. For example, Berry (1962) found that a moderate level of arousal increases memory functions. Other studies also linked the level of arousal with memory performance (Bradley et al. 1992). Thus, our findings could also be explained by differences in the level of evoked arousal. A negatively laden landmark could be associated with a high level of arousal and could have led to superior encoding and retrieval of information (such as the direction of turn). In future studies, individuals' arousal could be measured during the learning phase by means of galvanic skin response.

Another limitation of our virtual reality study is that, in contrast to the IAPS pictures, the images and situations people are exposed to in daily life are more dynamic and often more continuous, so future research should consider more natural affective state induction effects on wayfinding.

Despite these limitations, our findings still extend the concept of semantic salience in landmark-based wayfinding. This concept, however, lives from interindividual differences with respect to meaning and function of a landmark. Further studies should consider this factor in regard to wayfinding strategies that agents employ in different affective states. These findings could also help to explain performance differences in landmark recognition and wayfinding. Finally, one should also be aware that understanding landmark-based wayfinding has enormous potential for application purposes such as route guidance systems and signage.

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