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Landmark recognition: What makes a landmark familiar?

Henrietta Jarva

Master Thesis Clinical Neuropsychology
Faculty of Behavioural and Social Sciences – Leiden University
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Student number: s2072521
First Examiner: Ineke van der Ham, Health, Medical and Neuropsychology Unit; Leiden University

Abstract

Previous research has found variation in navigation ability among healthy individuals. Instead of focusing on individual differences, the current online experiment compared performance across individual landmarks. Since landmarks work as reference points, navigation could be facilitated by considering their appearance and placement. Therefore, this study aimed to investigate whether perceptual saliency and the serial-position effect influence landmark recognition in healthy individuals. It was expected that perceptually salient landmarks with a significant height, a complex shape or a salient location would be perceived as more familiar than neutral landmarks. It was also expected that because of the serial-position effect, landmarks presented first and last should be perceived as more familiar than those in the middle. In total, 63 participants, aged between 18 and 35, completed the experiment. Participants saw a navigation video followed by a landmark recognition task. They had to judge whether landmarks were "new" or "familiar" (i.e., shown in the video). For familiar landmarks, they rated the level of familiarity on a 5-point Likert scale. The results showed that landmark recognition was affected by perceptual saliency, which increased the chances that landmarks were recognized as familiar. Salient landmarks were also rated higher in familiarity than neutral landmarks. The findings suggested that the last landmarks were perceived as the most familiar, which provided evidence for the recency effect. However, an overlap between saliency and the serial-position effect might have affected these results. Thus, more research is needed to confirm whether the serial-position effect affects landmark recognition. In conclusion, both saliency and the serial-position effect should be considered when designing landmarks for different environments. Human navigation could be facilitated by including these factors in guidelines for landmark design.

Layman's Abstract

Studies have found that people differ in their navigation ability. Landmarks support navigation because they mark relevant locations. For this reason, this online experiment investigated memory for landmarks. Objects that draw attention because of their looks or location are described as salient. When people are shown items, they tend to remember the first items (the primacy effect) and the last items (the recency effect) better than those in the middle. This memory tendency is called the serial-position effect. The current study investigated whether saliency and the serial-position effect affect landmark recognition in healthy people who were shown a navigation video.

In this study, familiarity referred to a feeling that something has been experienced before. Salient landmarks were either tall or had a distinctive shape or a location. It was expected that these would feel more familiar than other landmarks. It was also expected that the first and the last landmarks in a video would feel more familiar than those between them.

In total, 63 participants finished the experiment. They were aged between 18 and 35. Participants saw a navigation video, and afterwards, they saw pictures of landmarks. Their task was to judge whether these were familiar or new. Familiar landmarks were shown in the video. New landmarks were not present in the video. If participants judged a landmark as familiar, they were also asked to rate this feeling on a scale.

According to the results, salient landmarks were the easiest to recognize. These landmarks also had the highest ratings on a scale. The last landmarks from the video were the most familiar. This is evidence for the recency effect. However, this effect might have been mixed with saliency. For this reason, there should be more studies about the serial-position effect. To conclude, saliency and the serial-position effect should be considered in landmark design. Navigation could be supported by including them in design guidelines.

Introduction

When we give directions, we tend to use landmarks – for example, we can tell someone to go past a park, turn right after a museum and then walk straight ahead until they see a bus stop on the opposite side of a church. Any object, such as a building or a mountain, can serve as a landmark if it is distinct enough to stand out of the surrounding environment (Caduff & Timpf, 2007; Sorrows & Hirtle, 1999). These distinct objects facilitate navigation by functioning as reference points, which suggest whether one should take action, such as cross the street (Vinson, 1999). Landmark knowledge can be defined as an ability to meaningfully select stable objects in an environment (Janzen et al., 2007), and it is described as the "what" aspect of navigation ability (Claessen & van der Ham, 2017). Besides landmarks, navigation ability depends upon knowledge of locations, the "where" aspect, and paths, the "how" aspect (Claessen & van der Ham, 2017).

Thus, navigation ability is a cognitive function made of several components, and prior research indicates that these are functionally dissociated (Blajenkova et al., 2005; Claessen et al., 2017; Zhong & Kozhevnikov, 2016). Due to this dissociation, it is possible that only some components of navigation ability are impaired, while others remain intact (Claessen & van der Ham, 2017). For example, Rainville et al. (2005) investigated a patient who was impaired in identifying well-known monuments from pictures and learning buildings along an unfamiliar route. However, he managed to describe familiar routes and find locations in his hometown by using secondary paths. In addition, van der Ham et al. (2020) demonstrated that factors such as age, gender, spatial experience and spatial anxiety cause variation in navigation ability among healthy individuals, who performed several tasks measuring different components of navigation ability. In this way, different aspects of navigation can be studied separately.

The current online experiment investigated landmark knowledge in healthy individuals. In contrary to the study by van der Ham et al. (2020), which considered individual differences such as age and gender, this study focused on perceptual and spatial features of individual landmarks. Distinctive landmarks aid navigation in both virtual and real-life environments (Sorrows & Hirtle, 1999) and human navigation could be facilitated by utilizing design guidelines that consider the appearance and the placement of landmarks (Vinson, 1999). Therefore, findings from the current study could provide information on how to design landmarks that are easy to recognize. More specifically, this experiment investigated whether perceptual and spatial features affect the familiarity of landmarks. Previous research has already included familiarity by asking participants to indicate whether they recognize a specific landmark (van der Ham et al., 2020). Moreover, prior studies have found that impaired landmark processing can influence navigation in unfamiliar surroundings or unfamiliar and familiar environments (Claessen & van der Ham, 2017). However, unlike this previous research, the current experiment compared familiarity across individual landmarks that were categorized based on their perceptual and spatial features. To our knowledge, no similar study has been performed to date.

This experiment used a landmark recognition task based on dual-process models, which suggest that recognition memory depends on familiarity and recollection, which are independent processes supported by doubly dissociated neural populations (Vilberg & Rugg, 2007). Familiarity refers to a feeling that something has been experienced in the past, and it lacks context, while recollection includes recovering precise details of a past event. Thus, recognition memory is based on two processes, and these can be studied with the remember/know paradigm (Tulving, 1985). In this paradigm, recollection corresponds to remember responses, which are given when one can recall contextual information about their experience with an item (Diana et al., 2006). Familiarity corresponds to know responses, which refer to an acontextual sensation that one has encountered the item before. Since these two responses are thought to be dissociated, some previous studies have used modified versions of the remember/know paradigm, such as the "familiarity-only" procedure, which studies familiarity in isolation (Montaldi et al., 2006). Similarly, a previous navigation study by van der Ham et al. (2020) included a landmark recognition task based on the familiarity process. During this task, participants had to indicate whether a specific landmark was present in a navigation video shown to them. The current study extended this research: Besides indicating whether landmarks were familiar, participants rated the level of familiarity for each recognized landmark. The aim was to investigate whether this sense of familiarity was influenced by saliency and the serial-position effect.

A landmark can be described as "salient" when it draws people's attention in a bottom-up, stimulus-driven fashion, increasing chances that it will be encoded in memory and recognized later (Santangelo, 2015). A perceptually salient landmark must have a contrast with the environment based on factors such as its visual attributes or its location relative to surrounding elements (Caduff & Timpf, 2007). For example, Miller and Carlson (2010) demonstrated that perceptual saliency, defined as a potential that an element will attract attention due to its visible properties such as color, size, shape and spatial context, affected an object recognition task. In this previous experiment, participants saw a video of a virtual museum. During the following recognition test, they were more likely to recognize those objects that were rated as perceptually salient.

Besides saliency, presentation order affects memory tasks: Previous research has demonstrated that in recall memory tasks, participants perform better recalling the first items that were presented to them (the primacy effect) and the last items (the recency effect) and have poorer memory for the items presented in the middle – a tendency known as the serial-position effect (Kelley et al., 2014). For example, Helstrup and Magnussen (2001) found the serial-position effect in the context of navigation. Participants were asked to think about landmarks from different parts of a familiar journey. When they rated these landmarks based on the vividness and clearness of their memories, their ratings were affected by stable primacy and recency effects. The serial-position effect can also influence recognition memory: Neath (1993) studied recognition of snowflake pictures and found that short retention intervals produced a small primacy effect and a large recency effect. However, longer retention intervals were followed by a larger primacy effect and a smaller recency effect. Similarly, Kelley et al. (2014) asked their participants to reconstruct a chronological order of a movie and a book series and then indicate whether they "remember" or just "know" (i.e., recognized) these items. Both responses were accompanied by primacy and recency effects.

To investigate saliency the serial-position effect, the current study had two hypotheses. The first hypothesis was based on prior studies, which indicated that saliency increases the chances that an object is remembered and recognized (Miller & Carlson, 2010; Santangelo, 2015; Sorrows & Hirtle, 1999). It was expected that perceptually salient landmarks (a significant height, a complex shape, a salient location) would be perceived as more familiar than other landmarks. Therefore, landmarks with a complex shape (e.g., a gemstone), a significant height (e.g., a shipping container), or a clear contrast with the environment due to a landmark's spatial location (objects in open places, such as a buoy on the water) should be recognized more accurately and have the highest familiarity ratings. Moreover, since previous studies demonstrated the serial-position effect in recognition memory (Kelley et al., 2014; Neath, 1993) and in memories for familiar journeys (Helstrup & Magnussen, 2001), the second hypothesis stated that due to the serial-position effect, landmarks presented first and last should be perceived as more familiar than landmarks shown between them. Prior research observed a U-shaped serial position curve for primacy and recency (Kelley et al., 2014), and for this reason, it was expected that the first two and the last two landmarks presented would be recognized more accurately and have the highest familiarity ratings. By addressing the research gap on attributes that make landmarks feel familiar, investigation of saliency and the serial-position effect led to a better understanding of factors influencing landmark recognition. This information can be used to improve landmark design and to facilitate human navigation.

Methods

Participants

Participants were recruited via a participant management tool SONA (https://ul.sona-systems.com/Default.aspx?ReturnUrl=%2f) and social media channels for students. Participants studying at Leiden University could sign-up for the study in SONA, and they received two credits as compensation. Other participants could access the study via an anonymous link and received no compensation. All participants were asked to give an informed consent before they could begin the study. According to the study requirements, they had to be between 18-35 years old and have no brain damage or psychiatric complaints. In total, 63 participants from the following countries completed the experiment: Finland (28), the Netherlands (18), Germany (3), Italy (3), Spain (2), Brazil (2), Mexico (1), Thailand (1), Romania (1), Czech Republic (1), the United Kingdom (1), the United States (1) and

Turkey (1). The sample included 44 females and 19 males. On average, participants had completed 15, 81 years of education.

Measures

Post hoc explanations were used to investigate factors that could have caused variability in performance across landmarks. The experiment included eight target landmarks that were present in a short navigation video (69 sec), which was also used in the previous study by van der Ham et al. (2020). The video was shown to participants before they were asked to complete the landmark recognition task. To investigate saliency, all target landmarks were categorized as salient or neutral before starting the data collection. Perceptual saliency was operationalized as a significant height, a complex shape, and a salient location (landmarks that had a clear contrast with the environment due to their locations). Thus, the following four target landmarks were grouped as perceptually salient: a shipping container (a significant height and a salient location), a gemstone (a complex shape), a car (a salient location) and a buoy (a salient location). The other four target landmarks – oil drums, a boat, a shield, and a crate – were grouped as neutral landmarks. In addition, the experiment included eight false landmarks that were not shown in the video but were presented during the landmark recognition task as distractor items (see Appendix for the list of landmarks with pictures). It was expected that perceptually salient landmarks are perceived as more familiar than other landmarks. This hypothesis would be confirmed if the salient target landmarks were recognized more accurately as familiar or rated more familiar on the 5-point Likert scale. The second hypothesis stated that due to the serial-position effect, landmarks presented first and last are perceived more familiar than landmarks shown between them. This hypothesis would be confirmed if compared to landmarks shown in the middle (a crate, a boat, a car and a shipping container) the first two target landmarks from the video (oil drums and a shield; evidence for the primacy effect) and the last two target landmarks (a buoy and a gemstone; evidence for the recency effect) were recognized more accurately as familiar or rated more familiar on the 5-point Likert scale.

Design and procedure

The current study had a within-subjects design because all participants were required to complete all parts of the experiment, including demographic questions and five experimental navigation tasks. Approval of the Psychology Research Ethics Committee of Leiden University was obtained before starting the data collection (the approval number is 2020-09-22-Ham, Dr. C.J.M. van der-V1-2642), and the study applied the Declaration of Helsinki. Since this was an online experiment, participants could complete it at any time and place. First, they read an information letter and then they were asked to provide informed consent. At the beginning of the study, participants had to answer demographic questions such as age, gender, nationality and how many years of education they had completed counting from the age of six onwards.

Next, participants saw instructions related to a navigation video (van der Ham et al., 2020) they were going to watch. They were asked to imagine being astronauts exploring an unknown planet, walking a route through a forest while encountering different objects. They were told to memorize as much information as possible because they would be asked questions related to the video. Participants were warned that the video could not be paused or restarted, and therefore, they should pay attention to it. After watching this video, participants proceeded to navigation tasks, which started with short instructions. As the original study by van der Ham et al. (2020), the current experiment included five navigation tasks: the landmark knowledge task, the egocentric location knowledge task, the allocentric location knowledge task, the path route knowledge task and the path survey knowledge task. However, since this study investigated landmark knowledge, the description of the other four tasks is beyond the scope of this paper.

In the landmark knowledge task, participants saw 16 landmark pictures in randomized order. These included eight target landmarks that were present in the video and eight false landmarks that were not shown in the video. By clicking the right option with their computer mouse, participants had to indicate for each of the 16 landmarks whether it was “familiar”, meaning that they saw it in the video, or “new”, meaning that they did not see it in the video. For landmarks that were judged as familiar, participants had to rate the level of perceived familiarity on a 5-point Likert scale (1 = A little bit familiar, 2 = Somewhat familiar, 3 = Moderately familiar, 4 = Very familiar, and 5 = Extremely familiar).

Statistical analysis

The data analysis was done by using a semi-manual method. The raw data from Qualtrics (https://www.qualtrics.com/) was scored in Microsoft Excel 2010, and the final data set was analyzed in IBM SPSS Statistics version 26 after assumptions and outliers were investigated. The aim was to compare performance across target landmarks by investigating differences in mean scores under different conditions, and therefore, a one-way repeated-measures ANOVA was performed to analyze the data. First, all landmarks were included in direct comparison to examine differences between individual items in familiarity judgements and familiarity ratings. The dependent variables were familiarity judgements (new versus familiar) and familiarity ratings (on a 5-point Likert scale). The independent variable was target landmarks (i.e., eight landmarks from the video). The one-way repeated-measures ANOVA was performed once with both dependent variables, using landmarks as the within-subjects factor. The results from the data analysis were interpreted as statistically significant if the p-value was below the threshold of five per cent ($p < .05$). Since only landmarks from the video were included in analyses, these target landmarks are referred simply as landmarks in the rest of this paper.

Besides comparing all individual landmarks, they were also compared as groups corresponding to the hypotheses. These groups were created based on landmarks´ saliency and presentation order during the video (groups were defined in the measures section). To investigate saliency, the one-way repeated-measures ANOVA was performed with the salient and the neutral group as the within-subject factor and familiarity judgements as the dependent variable. This analysis was repeated with familiarity ratings (on a 5-point Likert scale) as the dependent variable. To investigate the serial-position effect, the one-way repeated-measures ANOVA was performed with the first, the middle and the last group as the within-subject factor. Familiarity judgements was the dependent variable. This analysis was then repeated with familiarity ratings (on a 5-point Likert scale) as the dependent variable.

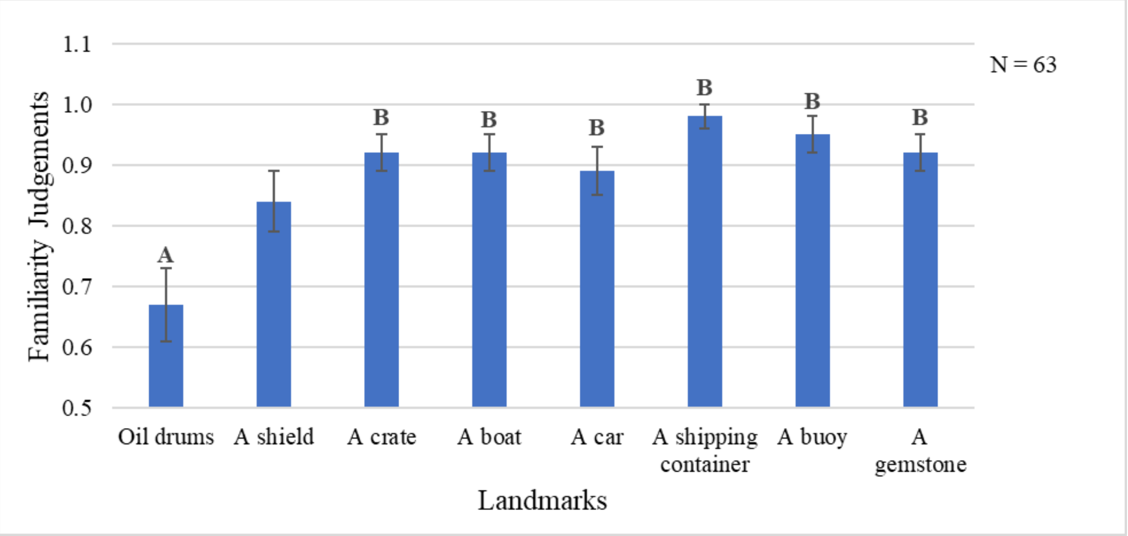
Results

The data had non-normal distribution, but due to the large sample size, statistical tests were considered robust against this violation. Since the assumption of sphericity was violated, outcomes from multivariate tests were investigated instead of univariate results. To investigate possible outliers, Z-scores were obtained from participants' scores. These scores indicated that all participants performed above the chance level in all conditions, and therefore, no removal took place.

A one-way repeated measures ANOVA was conducted to compare familiarity judgements (new versus familiar) across different landmarks. Landmarks were specified as a factor with eight levels, which corresponded to the following objects in order of their appearance in the video: oil drums, a shield, a crate, a boat, a car, a shipping container, a buoy and a gemstone. Mean scores for these landmarks are illustrated in Figure 1. Next, a one-way repeated measures ANOVA was conducted to compare familiarity ratings (on a 5-point Likert scale) across different landmarks. Landmarks were specified as a factor with eight levels that corresponded to their familiarity scales. Mean scores for these scales are illustrated in Figure 2.

Figure 1

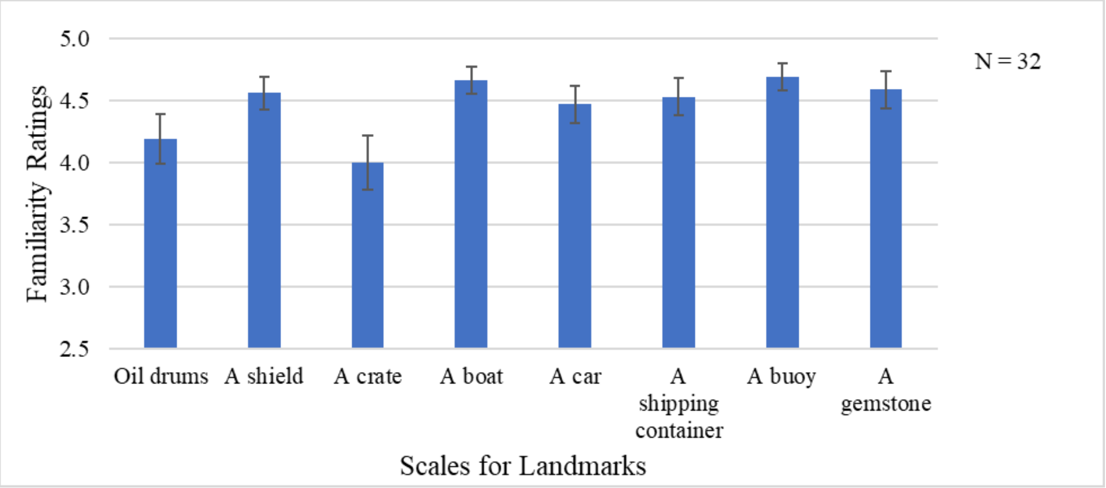
Mean Scores for Landmarks



The figure above, which includes SEM error bars, illustrates how accurately different landmarks were recognized as familiar. The landmark in category A differed significantly from the landmarks in category B.

Figure 2

Familiarity Ratings Across Landmarks



The figure above, which includes SEM error bars, demonstrates how familiar different landmarks were rated on a 5-point Likert scale (1 = A little bit familiar, 2 = Somewhat familiar, 3 = Moderately familiar, 4 = Very familiar, and 5 = Extremely familiar). There were no significant differences.

There was a significant effect for familiarity judgements (new versus familiar), Wilks´ Lambda = .58, F(7.56) = 5.75, p < .001, η_p^2 = .42, which suggest a large effect. This finding indicates that the accuracy of familiarity judgements varied across landmarks. Post hoc analysis with a Bonferroni adjustment showed that recognition of oil drums significantly differed from the performance on six other landmarks, p < .05 in all cases (see Table 1). Thus, compared to a crate, a car, a buoy, a gemstone, a shipping container and a boat, oil drums were more frequently incorrectly judged as a new landmark. Post hoc analysis showed no other significant differences between landmarks, but a trend effect was found for the shipping container and the shield. This finding provides slight evidence that compared to the shield, the shipping container was more often correctly recognized (M = .14, 95% CI [0.00, .29], p = .06). No significant effect was found for familiarity ratings on a 5-point Likert scale, Wilks´ Lambda = .71, F(7.25) = 1.45, p = .23, indicating that the level of perceived familiarity did not significantly vary across landmarks.

Table 1

Pairwise Comparisons

						95% CI	95% CI
Mean	**vs**	**Mean**	**Mean difference**	**Std. Error**	**Sig.**	**Lower bound**	**Upper bound**
A		**B**					
Oil drums	–	A crate	-.25	.07	.02	-.49	-.02
Oil drums	–	A boat	-.25	.06	.01	-.46	-.05
Oil drums	–	A car	-.22	.07	.04	-.44	-.01
Oil drums	–	A shipping container	-.32	.06	0.00	-.51	-.12
Oil drums	–	A buoy	-.29	.07	0.00	-.50	-.07
Oil drums	–	A gemstone	-.25	.06	0.00	-.45	-.06

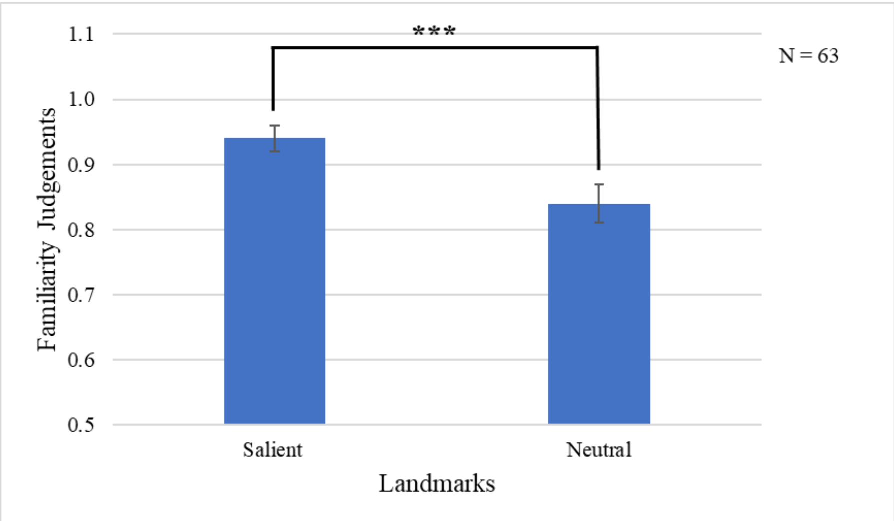
The table demonstrates that categories A and B differed significantly. Compared to a crate, a boat, a car, a shipping container, a buoy and a gemstone, participants recognized oil drums significantly less accurately.

Additionally, landmarks were compared as groups that corresponded to the hypotheses. First, to examine differences in familiarity judgements (new versus familiar), the salient group (a car, a shipping container, a buoy and a gemstone) was compared to the neutral group (oil drums, a shield, a crate, a boat and a car). A one-way repeated measures ANOVA was conducted, and saliency was specified as a factor with two levels corresponding to salient landmarks and neutral landmarks. Mean scores for these groups are illustrated in Figure 3. A significant effect was found for saliency, Wilks´ Lambda = .77, $F(1,62) = 18.59$, $p < .001$, $\eta_p^2 = .23$, which suggest a large effect. Post hoc analysis with a Bonferroni adjustment showed that compared to neutral landmarks, salient landmarks were recognized significantly more accurately (*M* = .10, 95% CI [.05, .15], $p < .001$), indicating that the accuracy of recognition varied based on saliency.

To examine whether familiarity ratings on a 5-point Likert scale were also influenced by saliency, a one-way repeated measures ANOVA was conducted again. Saliency was specified as a factor with two levels that corresponded to scales for salient and neutral landmarks. Figure 4 shows the mean scores for these groups. The results showed a significant effect for saliency, Wilks´ Lambda = .88, $F(1,61) = 8.14$, $p < .05$, $\eta_p^2 = .12$, indicating a moderate effect. Post hoc analysis with a Bonferroni adjustment illustrated significantly higher saliency ratings for landmarks in the salient group than in the neutral group (*M* = .25 95% CI [.08, .43], $p < .05$).

Figure 3

Mean Scores for the Salient and Neutral Group

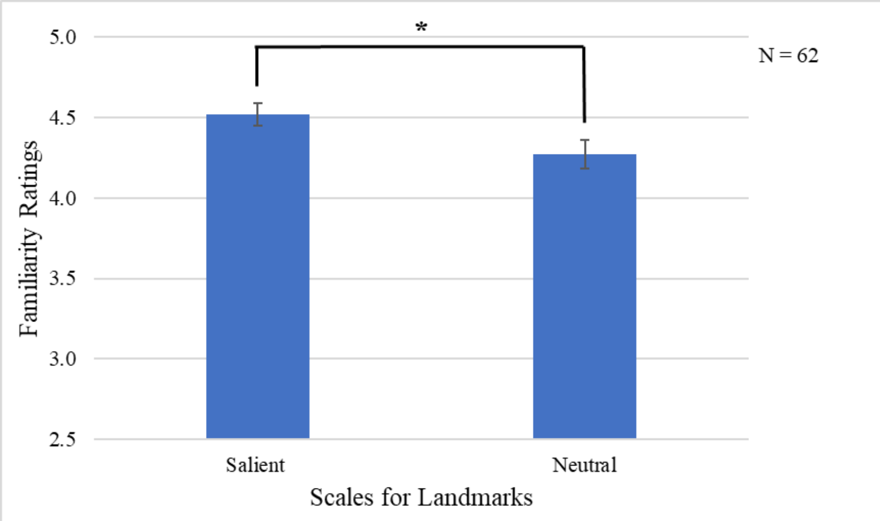


This figure with SEM error bars demonstrates that landmarks in the salient group were recognized significantly more accurately than landmarks in the neutral group.

***p < .001.

Figure 4

Mean Scores for the Salient and Neutral Scales



This figure with SEM error bars shows that landmarks in the salient group had significantly higher familiarity ratings than landmarks in the neutral group.

*p < .05.

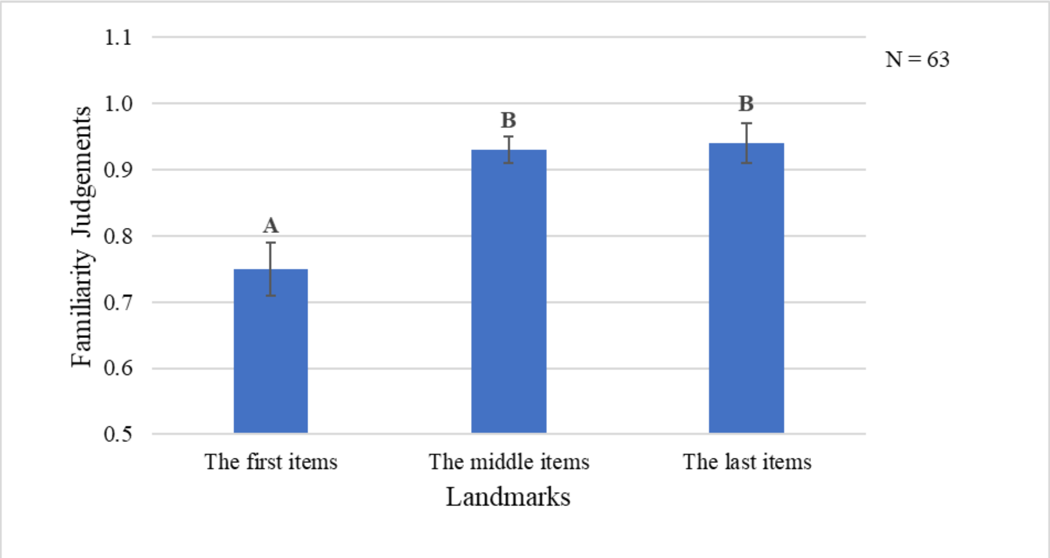
Furthermore, to investigate possible differences in familiarity judgements (new versus familiar) due to the serial-position effect, landmarks were compared as groups that corresponded to their presentation order in the video: the first two items (oil drums and a shield), the four middle items (a crate, a boat, a car and a shipping container) and the last two items (a buoy and a gemstone). A one-way repeated measures ANOVA was conducted, and the serial-position effect was specified as a factor with three levels corresponding to the first, the middle and the last group. Mean scores for these groups are presented in Figure 5. There was a significant effect for the serial-position effect, Wilks´ Lambda = .76, $F(2,61) = 9.77$, $p < .001$, $\eta_p^2 = .24$, suggesting a large effect. Post hoc analysis with a Bonferroni adjustment demonstrated that compared to the first landmarks, those in the middle were recognized significantly more accurately ($M = .17$, 95% CI [.07, .28], $p < .001$), but there were no significant differences between the middle and the last items ($M = -.01$, 95% CI [-.09, .08], $p = 1.00$). Compared to the first landmarks, the last landmarks were recognized significantly more accurately ($M = .18$, 95% CI [.07, .29], $p < .001$).

Lastly, to investigate whether familiarity ratings on a 5-point Likert scale were affected by the serial-position effect, a one-way repeated measures ANOVA was conducted again. The serial-position effect was specified as a factor with three levels corresponding to the scales for the first, the middle and the last landmarks. Figure 6 illustrates the mean scores for these groups. The results showed a significant effect for the serial-position effect, Wilks´ Lambda = .84, $F(2,53) = 5.13$, $p < .05$, $\eta_p^2 = .16$, indicating a large effect. Post hoc analysis with a Bonferroni adjustment showed that the last landmarks were rated significantly higher in familiarity than the first landmarks ($M = .35$, 95% CI

[.05, .64], *p* < .05) and the middle landmarks (*M* = .25, 95% CI [.03, .46], *p* < .05). There was no significant difference between the first and the middle group (*M* = -.10, 95% CI [-.34, .14], *p* = .96).

Figure 5

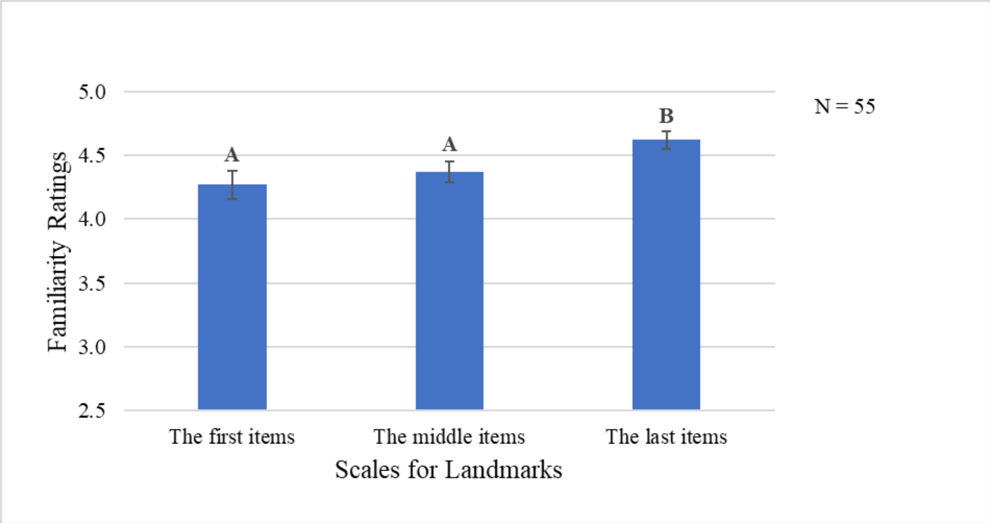
Mean Scores for the First, the Middle and the Last Items



Categories A and B differed significantly. This figure demonstrates that the four middle landmarks and the last two landmarks were recognized more accurately than the first two landmarks. The figure shows SEM error bars for the groups.

Figure 6

Mean Scores for the Scales Corresponding to the First, the Middle and the Last Items



Categories A and B differed significantly. The last two landmarks were rated higher in familiarity than the first two landmarks and the four middle landmarks. The figure includes SEM error bars.

Discussion

Previous studies have found variation in navigation ability among healthy individuals (van der Ham et al., 2020). The current study extended this research by focusing on landmark knowledge, the "what" aspect of navigation ability (Claessen & van der Ham, 2017) and whether it is influenced by perceptual and spatial features of landmarks. More specifically, to address the research gap on how landmark presentation affects landmark knowledge in healthy individuals, the aim was to investigate the influence of perceptual saliency and the serial-position effect. The study was conducted online, and it included a navigation video and a landmark recognition task based on a familiarity process. It was expected that salient landmarks (a significant height, a complex shape, and a salient location) would be perceived as more familiar than neutral landmarks. It was also expected that the first two and the last two landmarks would be perceived as more familiar than those in between.

In line with the hypothesis, the results show that saliency affected familiarity judgements across landmarks. Although there was little significant variation among individual landmarks, a neutral landmark (oil drums) was recognized significantly less accurately than six other landmarks. Slight evidence indicates that a combination of significant height and salient location increased chances that a landmark was recognized: The shipping container, a salient landmark, was recognized more accurately than the shield, a neutral landmark. However, this was a trend effect, and no significant differences were found in familiarity ratings on a 5-point Likert scale across individual landmarks. Landmarks were also compared as groups: Those categorized as salient were more likely to be recognized than those categorized as neutral, and the salient group was rated higher in familiarity on a 5-point Likert scale. As expected, these results indicate that landmarks with a significant height, a complex shape, and a salient location were more likely to be recognized than neutral landmarks.

The results offer inconsistent support for the presence of the serial-position effect. Although comparison of individual landmarks did not suggest recency or primacy effects, landmarks were also compared as groups: The four middle landmarks were recognized more accurately than the first two landmarks, but there was no significant difference between the middle group and the last group. These results indicate no primacy or recency effect. However, the last landmarks were recognized more accurately than the first landmarks and rated higher in familiarity on a 5-point Likert scale than the first and the middle group. These results provide some support for the recency effect.

The findings are in line with prior research, which has found differences in landmark recognition among healthy individuals caused by factors such as gender, age, spatial experience and spatial anxiety (van der Ham et al., 2020). Instead of these individual differences, the current study focused on perceptual and spatial features of landmarks and found variation in performance across individual landmarks. This variation can be explained by previous research, which has demonstrated that salient objects are more likely to be remembered than neutral objects (Miller & Carlson, 2010; Santangelo, 2015; Sorrows & Hirtle, 1999). According to Santangelo (2015), saliency increases the chances that objects are successfully stored in memory. Since salient objects consume processing resources at the memory encoding phase, neutral objects are less likely to be remembered. Thus, memory has been biased by saliency. This theory might explain why in the current study, the oil drums, a neutral landmark, were recognized less accurately than a shipping container, a gemstone, a car, a buoy, a boat and a crate. In addition, slight evidence indicates that participants were more likely to recognize the shipping container, which was salient due to its height and location, than the shield, a neutral landmark. Based on the research by Santangelo (2015), it can be hypothesized that the oil drums and the shield were not as likely to be remembered because encoding resources were used to represent more salient landmarks. However, there were no significant differences in familiarity judgements across other individual landmarks or familiarity ratings on a 5-point Likert scale.

The study design, which did not include saliency manipulation, might explain why there was little variation across individual landmarks and no significant familiarity ratings. It is possible that items were too similar in saliency – for example, all items were colourful. Consequently, differences between individual landmarks might have been small. The shipping container was the only landmark that was categorized salient based on more than one factor (height and location), which might explain why it stood out. Unlike the current study, which categorized previously created items based on their saliency, Miller and Carlson (2010) designed salient objects that were 68% larger than objects surrounding them and richer in colour. In their landmark recognition experiment, an independent group of subjects ranked all these items based on their saliency, and afterwards, participants saw a video of a virtual museum. In the following recognition task, they indicated which objects they saw in the video. Those ranked as highly salient were the most likely to be recognized. Similarly, significant differences were found when landmarks in the current study were compared as groups (salient versus neutral). The salient group was judged more familiar and rated more familiar on a 5-point Likert scale, suggesting that small differences between individual landmarks – caused by their height, shape and location – became prominent when landmarks were grouped. These findings are in line with the study by Miller and Carlson (2010), which demonstrated that factors such as colour, size, shape and spatial context cause an object to be perceptually salient.

Besides saliency, the current study investigated whether the serial-position effect affects landmark recognition. The four middle landmarks from the navigation video were more likely to be recognized than the first two, indicating no primacy effect. There were no significant differences between the middle landmarks and the last two landmarks, demonstrating no recency effect. However, the last landmarks were more likely to be recognized than the first landmarks. They also had higher familiarity ratings on a 5-point Likert scale than the first and the middle group, which provides some evidence for the recency effect. The first and the middle group did not significantly differ in familiarity ratings. Thus, the current study found no evidence for the primacy effect, but the recency effect might have affected perceived familiarity across landmarks. Similarly, Helstrup and Magnussen (2001) investigated the serial-position effect in the context of navigation: Participants were asked to mentally divide familiar home-to-cabin journeys into four parts based on time and distance. Afterwards, they chose a set of landmarks for each of these travel units and rated them based on the vividness and clearness of their mental image. It was found that memories of the first and the last landmarks were rated more vivid and clear than those in the middle, indicating that ratings were affected by primacy and recency. This prior experiment investigated the serial-position effect in retrieved memories, while the current study included a recognition task. Therefore, differences in study designs might explain why the previous study found more robust evidence for the serial-position effect in the context of navigation.

In line with the current study design, previous research has found the serial-position effect in recognition tasks: Neath (1993) presented participants with a list of snowflake pictures while varying the length of retention intervals. When participants indicated whether the fifth snowflake had been present in the list, short retention intervals led to large recency effects and small primacy effects. Longer retention intervals caused the opposite effect. When asked how confident participants were about their answers, they had more confidence for the last snowflake compared to the first in the list. Similarly, participants in the current study rated the last landmarks higher in familiarity than other landmarks, but this recency effect was barely reflected in recognition (new versus familiar): Although the last landmarks were recognized more accurately than the first landmarks, there was no difference compared to the middle group. A possible reason is that retention intervals were not manipulated. Unlike in the study by Neath (1993), participants saw the items in a random order, and they could look at them as long as they wanted before making a decision.

However, in a study by Kelley et al. (2014), retention intervals were not manipulated, but the serial position effect was still found. Participants reconstructed a chronological order of Harry Potter movies and books and indicated whether they "remembered" or just "knew" (i.e., recognized) them. Regardless of the response, reconstructions were accompanied by primacy and recency effects that could be visualized with a U-shape curve. Thus, the literature discussed so far cannot explain why the current study found no U-shaped serial position curve. It is possible that perceptual saliency abolished the impact of the serial-position effect due to the distribution of landmarks in the navigation video. Two salient landmarks were shown in the middle of the video and the other two at the end of the video, meaning that there were no salient landmarks at the beginning of the video. Therefore, saliency might explain why the middle landmarks and the last landmarks were more likely to be recognized than the first landmarks and why there was no difference in accuracy between the middle and the last group. Consequently, no evidence for the primacy effect was found, and the evidence for the recency effect is inconclusive, providing only partial support for the hypothesis that landmark recognition is affected by the serial position effect. It is likely that the last landmarks were rated highest in familiarity on the 5-point Likert scale because they were perceptually salient, suggesting that the serial-position effect had little or no impact on the results.

The overlap between saliency and the serial-position effect was a limitation that could be controlled in future experiments. Moreover, due to the use of existing materials, it was not possible to manipulate the saliency of landmarks presented in the navigation video. Items might have been too similar in saliency, and therefore, upcoming navigation research should design landmarks that are significantly different. For example, in line with Miller and Carlson (2010), an independent group of subjects should rate all items before they are used in an experiment. Furthermore, the lack of control over retention intervals and random presentation of landmark pictures in the recognition task might have affected the serial position effect unpredictably. Since Neath (1993) suggested that the length of retention intervals influences primacy and recency, this factor could be controlled in futures studies, which are needed to establish whether the serial-position effect affects landmark recognition.

Despite this study's limitations, the strength of this experiment was that the study design allowed familiarity comparison between individual landmarks that were categorized based on their perceptual and spatial features. The findings are in line with prior research, which has demonstrated that saliency increases the chances that landmarks are remembered (Miller & Carlson, 2010; Santangelo, 2015; Sorrows & Hirtle, 1999). Landmarks are relevant for navigation because they work as reference points that indicate which way to go (Vinson, 1999), and landmark knowledge has been described as the "what" aspect of navigation (Claessen & van der Ham, 2017). Therefore, the findings of the current study implicate that by designing landmarks that are salient enough to stand out of the environment, human navigation can be facilitated. Moreover, our results hint at a possibility that most recent landmarks are perceived as the most familiar, and this recency effect should also be acknowledged. In other words, both saliency and the serial-position effect should be considered when designing landmarks to aid navigation in virtual and real-life environments. In practice, this could be done by creating guidelines for landmark design. Vinson (1999) already emphasized the importance of landmarks in navigational guidelines for virtual spaces: Distinctive landmarks are essential because large-scale environments require navigation, and navigation in real or virtual, unfamiliar environments is difficult. For example, the lack of distinctive objects explains why navigation in mazes leads to disorientation (Passini, 1996). Since the current study suggested that perceptual and spatial features contribute to the familiarity of landmarks, both should be considered when creating guidelines for landmark design. Thus, to design an easily recognizable landmark for a real or virtual environment, it should have a distinctive shape, a significant height and a location that allows it to stand out from its surroundings.

To summarize, previous studies have already found variation in landmark knowledge among healthy individuals (van der Ham et al., 2020). The current experiment extended this research by focusing on perceptual and spatial features of landmarks instead of individual differences. The findings of this study indicate that landmark recognition is affected by perceptual saliency, caused by factors such as a significant height, a complex shape, and a salient location. Saliency increased chances that landmarks were recognized as familiar and salient landmarks were perceived more familiar than neutral landmarks. Due to the overlap between saliency and the serial-position effect, which might have affected the results, further research is needed to establish whether the serial-position effect influences landmark recognition. Nevertheless, the current study hints that the last landmarks are perceived as the most familiar. In conclusion, to answer the question of what makes a landmark familiar, this study suggests that a landmark should be at least perceptually salient to be remembered. To facilitate navigation, these findings should be considered when designing landmarks for real and virtual environments. In practise, this could be done by creating guidelines for landmark design that take into account both saliency and the serial-position effect.

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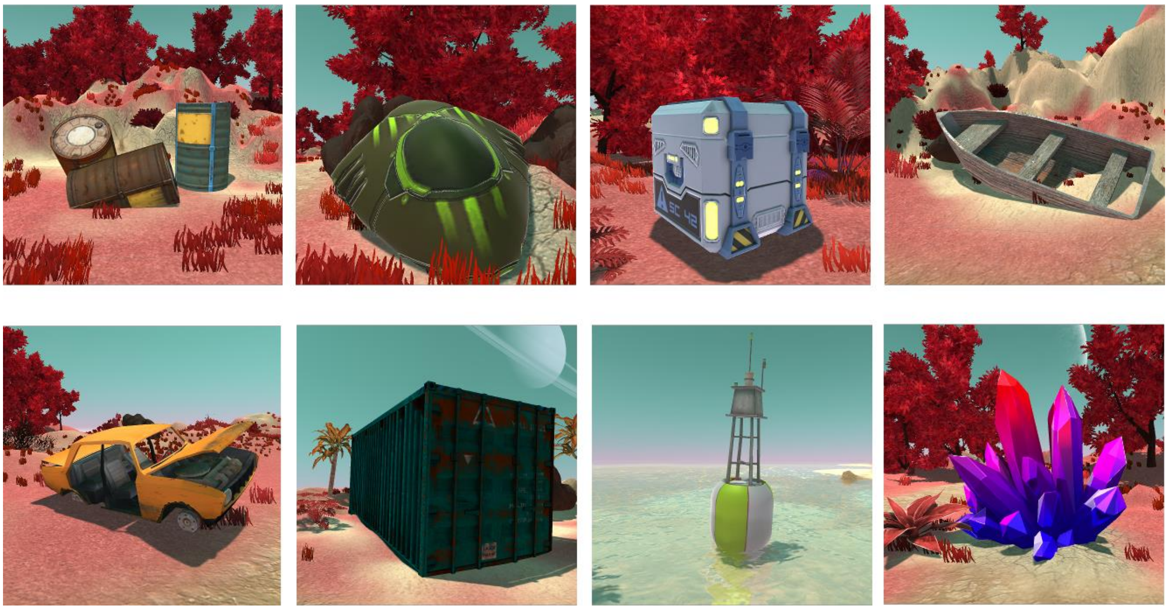
Appendix

List of Landmarks

Figure A1

Target Landmarks Present in the Video



Target landmarks were encountered during the video in the following order, starting from the upper left corner: oil drums, a shield, a crate, a boat, a car, a shipping container, a buoy and a gemstone.

Figure A2

False Landmarks in the Recognition Task

These false landmarks, starting from the upper left corner, were included in the recognition task as distractor items: an engine, a sundial, a well, a treasure chest, a canon, a sculpture, a slot machine and a scooter.