Does body orientation matter when reasoning about depicted or described scenes? [1]

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Abstract. Two experiments were conducted to assess whether the orientation of the body at the time of test affects the efficiency with which people reason about spatial relations that are encoded in memory through symbolic media. Experiment 1 used depicted spatial layouts while Experiment 2 used described environments. In contrast to previous studies with directly-experienced spatial layouts, the present experiments revealed no sensorimotor influences on performance. Differences in reasoning about immediate and non-immediate environments are thus discussed. Furthermore, the same patterns of findings (i.e., normal alignment effects) were observed in the two experiments supporting the idea of functional equivalence of spatial representations derived from different modalities.

Keywords: body orientation, sensorimotor interference, perspective-taking, spatial reasoning

1 Introduction

While moving around in the environment people are able to keep track of how egocentric spatial relations (i.e., self-to-object directions and distances) change as a result of their movement [1-4]. To try out an example, choose one object from your immediate surroundings (e.g., a chair), and point to it. Then, close your eyes and take a few steps forward and/or rotate yourself by some angle. As soon as you finish moving, but before opening your eyes, point to the object again. It is very likely that you pointed very accurately and without taking any time to contemplate where the object might be as a result of your movement. This task which humans can carry out with such remarkable efficiency and speed entails rather complex mathematical computations. It requires that the egocentric location of an object is initially encoded and then continuously updated while moving in the environment. The mechanism that

[1] The presented experiments have been conducted as a part of an undergraduate thesis by Stephanie Pantelidou.

allows people to update egocentric relations and Stay oriented within their immediate surroundings is commonly known as spatial updating.

Several studies have suggested that spatial updating takes place automatically with physical movement because such movement provides the input that is necessary for updating [2, 4]. In the case of non-visual locomotion this input consists of kinesthetic cues, vestibular feedback, and copies of efferent commands. The importance of physical movement is corroborated by empirical findings showing that participants point to a location equally fast and accurately from an initial standpoint and a novel standpoint they adopt by means of physical movement (as in the example above). In contrast, when the novel standpoint is adopted by merely imagining the movement, participants are faster and more accurate to respond from their initial than their novel (imagined) standpoint[5]. This is particularly the case when an imagined rotation is needed to adopt the novel standpoint.

The traditional account for spatial updating [4, 6] posits that spatial relations are encoded and updated on the basis of an egocentric reference frame (i.e., a reference frame that is centered on one´s body). Because egocentric relations are continuously updated when moving, reasoning from one's physical perspective is privileged as it can be carried out on the basis of relations that are directly represented in memory. Instead, reasoning from imagined perspectives is deliberate and effortful as it entails performing "off-line" mental transformations to compute the correct response. Recently, May proposed the sensorimotor interference account which places the exact locus of difficulty for responding from imagined perspectives at the presence of conflicts between automatically-activated sensorimotor codes that specify locations relative to the physical perspective and cognitive codes that define locations relative to the imagined perspective[7, 8]. Based on this account, while responding from an actual physical perspective is facilitated by compatible sensorimotor codes, in order to respond from an imagined perspective, the incompatible sensorimotor codes must be inhibited while an alternative response is computed. The presence of conflicts reduces accuracy and increases reaction time when reasoning from imagined perspectives. In a series of elegant experiments, May provided support for the facilitatory and interfering effects of sensorimotor codes[7].

Recently, Kelly, Avraamides, and Loomis [9] dissociated the influence of sensorimotor interference in spatial reasoning from effects caused by the organizational structure of spatial memory (see also [10]). In one condition of the study participants initially examined a spatial layout of 9 objects from a fixed standpoint and perspective. Then, they were asked to rotate 90° to their left or right to adopt a novel perspective. From this perspective participants carried out a series of localization trials that involved pointing to object locations from various imagined perspectives. This paradigm allowed dissociating the orientation of the testing perspective from that of the perspective adopted during learning. This dissociation is deemed necessary in light of evidence from several studies showing that spatial memories are stored with a preferred direction that is very often determined by the learning perspective[11]. Results revealed that responding from imagined perspectives that coincided with either the learning or the testing perspective was more efficient compared to responding from other perspectives. A similar result was obtained in the earlier study of Mou, McNamara, Valiquette, and Rump [10] which suggested that independent effects attributed to the orientation of the body of the observer at test and the preferred storage orientation of spatial memory can be obtained in spatial cognition experiments. Kelly et al, have termed the former effect as the *sensorimotor alignment effect* and the latter as the *memory-encoding alignment effect*.

In order to investigate the boundary conditions of sensorimotor facilitation/interference, Kelly et al included an experimental condition in which participants performed testing trials after having moved to an adjacent room. Results from this condition revealed that when participants reasoned about relations that were not immediately present, no sensorimotor interference/facilitation was exerted on performance. Only a memory-encoding alignment effect was obtained in this condition.

The study by Kelly et al. provided evidence that the orientation of one´s body when reasoning about space influences performance only when immediate spatial relations are retrieved. Presumably this occurs because egocentric relations are maintained in a transient sensorimotor representation that functions to encode and automatically update egocentric directions and distances to objects in one´s immediate surroundings ([12, 13]). When reasoning about remote environments such a representation is of little, if any, use. In this case, a more enduring, perhaps allocentric, representation would more suitably provide the information needed to compute the spatial relations as needed (see [14] for a comprehensive review of theories of memory that provide for multiple encoding systems). If this is true, then the same pattern of findings (i.e., presence of memory-encoding alignment effect but no sensorimotor alignment effect) should be expected when people reason about spatial relations included in any remote environment regardless of how it is encoded. Although very frequently in our daily lives we reason about environments that we have previously experienced directly, in many cases we process spatial relations that have been committed to memory through symbolic media such as pictures, movies, language etc (e.g., planning a route after having studied a map).

While numerous studies have been carried out to examine how people reason about depicted or described experiments, most studies have either focused on examining effects caused by the misalignment between medium and actual space or have confounded the orientations of the learning and testing perspectives. As a result, it is not yet known whether the orientation of the observer's body mediates spatial reasoning for environments encoded through symbolic media. The goal of the present study is to assess whether the orientation of the body influences performance when reasoning about spatial relations contained in depicted (Experiment 1) or a described (Experiment 2) remote layout. We expect that the use of remote environments will give rise to a pattern of findings similar to those obtained in conditions in which participants are tested after being removed from the learning environment. If such a result is obtained, it would further highlight the fundamental difference between reasoning "on-line" about immediate environments and "off-line" about remote environments. An additional goal of the study is to compare spatial reasoning for depicted and linguistic spatial scenes in order to assess the functional equivalence of spatial layouts that are derived from different modalities. This is a question that has accumulated increased theoretical interest in recent years, presumably because it bears important implications for modern tools and applications that rely on sensory substitution, as in the case of navigational systems for the blind. Most previous studies tested functional equivalence using environments that were immediate to participants [15-17]. Although some indirect evidence suggests that learning an environment from a map or text engages the same parieto-frontal network in the brain [18, 19], it is important to test whether the same behavioral effects are found when reasoning for spatial relations derived from different modalities. By comparing the findings of Experiments 1 and 2 in the present study, we will be able to assess the degree of functional equivalence between scenes that are learned though pictures and language.

3 Background for the methodology used

For the present experiments we adopted the paradigm used by Waller, Montello, Richardson, and Hegarty [20] and previously by Presson and Hazelrigg [21]. In these studies participants first learned various 4-point paths and then made judgments of relative direction by adopting imagined perspectives within the paths. Trials could be classified as aligned (i.e., the orientation of the imagined perspective matched the physical perspective of the participant) or as contra-aligned (i.e., the imagined perspective deviated 180° from the physical perspective of the participant). The typical result when participants carry out the task without moving from the learning standpoint/perspective (Stay condition in [20]) is that performance is more efficient in aligned than contra-aligned trials. This finding is commonly referred to as an *alignment effect*. Additional interesting conditions were included in the study by Waller. In experiment 2, a Rotate condition was included. In this condition, participants performed the task after having physically rotated 180°. The rationale was that if the alignment effect is caused primarily by the learning orientation then a similar alignment effect to that of the Stay condition would be obtained. However, if the alignment effect is caused by the influence of the orientation of the body at the time of test, a *reverse-alignment effect* should be expected. Results, however, revealed no alignment effect (see also[22]). Two additional conditions, namely the Rotate-Update and the Rotate-Ignore, provided important results. In the Rotate-Update condition participants were instructed to physically rotate 180° in place and imagine that the spatial layout was behind them (i.e., they updated their position relative to the learned layout). In the Rotate-Ignore condition participants also rotated by 180° but were asked to imagine that the learned layout had rotated along with them. Results revealed a normal alignment effect in the rotate-ignore condition but a reverse-alignment effect in the rotate-update condition. Overall, these findings suggest that the orientation of the body is important when reasoning about immediate environments.

In the present experiments we adopted the rationale of Waller et al. to examine the presence of normal vs. reverse alignment effects in Stay and Rotate conditions. However, in contrast to Waller et al., the paths that we have used were not directly experienced by participants. Instead, they were either presented on a computer monitor as pictures (Experiment 1) or as text route descriptions (Experiment 2). If the orientation of the body of the participant at the time of test influences performance, a normal alignment effect should be found in Stay conditions and a reverse alignment effect should be obtained in Rotate conditions. However, if the learning perspective dominates performance then a normal alignment effect should be expected in both Stay and Rotate conditions. Finally, a third possibility is that both the learning and physical perspectives influence performance, as shown by Kelly et al for immediate environments. In that case, if the two effects are of equal magnitude then no alignment effect should be expected in Rotate conditions as the two effects would cancel each other out. However, without making any assumptions about the magnitude of the two effects, we should at least expect a reduced alignment effect in Rotate conditions, if indeed both learning and physical perspectives influence reasoning.

3 Experiment 1

In Experiment 1 participants encoded paths that were depicted on a computer screen and then carried out judgments of relative direction (JRD's). A Stay condition and a Rotate condition (in which neither update nor ignore instructions were given) were included. Based on previous findings documenting that the orientation of one's body does not typically influence spatial reasoning about non-immediate environments, we predict that a normal alignment effect would be present in both the Stay and Rotate conditions. We also expect that overall performance will be equal in the Stay and Rotate conditions.

2.1 Method

Participants.

Twenty-two students from an introductory psychology course at the University of Cyprus participated in the experiment in exchange for course credit. Twelve were assigned to the Stay condition and 10 to the Rotate condition.

Design.

A 2(observer position: Stay vs Rotate) x 3(imagined perspective: aligned 0°, misaligned 90°, contra-aligned 180°) mixed factorial design was used. Observer position was manipulated between subjects while imagined perspective varied within-subjects.

Materials and Apparatus.

Two 19" LCD monitors attached to a computer running the Vizard software (from WorldViz, Santa Barbara, CA) were used to display stimuli. The monitors were placed facing each other and participants sat on a swivel chair placed in-between the two monitors.

Four paths were created as models with Source SDK (from Valve Corporation). Oblique screenshots of these models constituted the spatial layouts that participants learned. Each path comprised of 4 segments of equal length that connected 5 numbered location points (Figure 1).

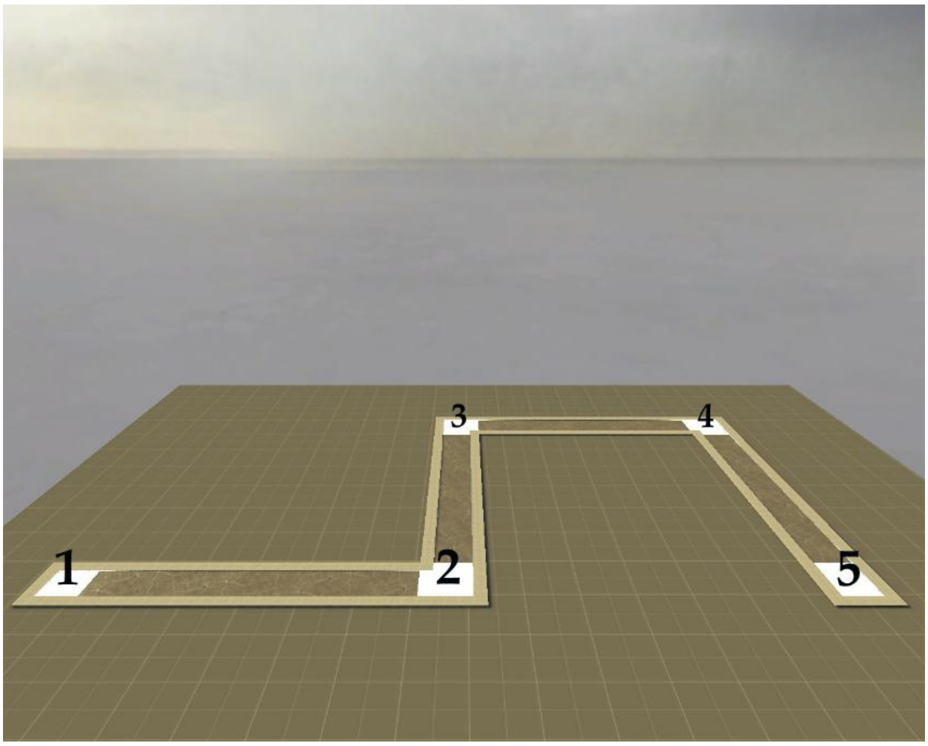

Fig. 1. Example of a path used in Experiment 1

Pointing responses were made using a joystick with the angle of deflection and latency of pointing being recorded by the computer at each trial.

2.2 Procedure

Prior to the beginning of the experiment participants were shown example paths on paper and were instructed on how to perform JRD's. JRD's involve responding to statements of the form “imagine being at x, facing y. Point to z” were x, y, and z are objects/landmarks from the studied layout. Prior to the beginning of the experiment participants were asked to perform various practice trials with JRD’s using campus landmarks as targets and responding both with their arms and the joystick. Then, participants were seated in front of one of the monitors and were asked to study the first path. They were instructed to visualize themselves moving on the path. They were given unlimited time to memorize the path and then proceeded to perform the experimental trials. Each trial instructed them to imagine adopting a perspective within the memorized path (e.g., Imagine standing at 1 facing 2) and point from it with the joystick toward a different position in the path (e.g., Point to 3). Participants in the Stay condition performed the trials on the same monitor that they have previously viewed the path. Those in the Rotate condition were asked to rotate 180° and perform the pointing trials on the other monitor. Participants were instructed to respond as fast as possible but without sacrificing accuracy. Sixteen trials for each path were included yielding to a total of 64 trials per subject. Four imagined perspectives (i.e., aligned 0°, misaligned 90° left, misaligned 90° right, and contra-aligned 180°) were equally represented in the 64 trials. Furthermore, correct pointing responses, which could be 45°, 90°, and 315° to the left and right of the forward joystick position, were equally distributed across the four imagined perspectives. The order of trials within each path was randomized. Also, the order in which the four paths were presented to participants varied randomly.

2.3 Results

Separate analyses for pointing accuracy and latency for correct responses were carried out. In order to classify responses as correct and incorrect, joystick deflection angles were quantized as follows. Responses between 22.5° and 67.5° from to forward position of the joystick were classified as 45° responses to the left or right depending on the side of deflections. Similarly, responses that fell between 67.5° and 112.5° were considered as 90° responses to the left or right. Finally, responses between 112.5° and 157.5° were marked as 180° responses. Initial analyses of accuracy and latency involving all four imagined perspectives revealed no differences between the 90° left and the 90° right perspectives in either Stay or rotate conditions. Therefore, data for these two perspectives were averaged to form a misaligned 90° condition. A 2(obsever position) x 3 (imagined perspective) mixed-model Analysis of Variance (ANOVA) was conducted for both accuracy and latency data.

Accuracy.

The analysis revealed that overall accuracy was somewhat higher in the Stay (79,9%) than in the Rotate (73,9%) condition. However, this difference did not reach statistical significance, $F(1,20)=.92$, $p=.35$. A significant main effect for imagined perspective was obtained, $F(2,40)=8.44$, $p<.001$, $\eta^2=.30$. As seen in Table 1, accuracy was higher for the aligned 0° perspective (84,4%), intermediate for the misaligned 90° perspective (76,2%), and the lowest for the 180° contra-aligned perspective (70,2%). Within-subject contrasts verified that all pair-wise differences were significant, p´s<.05. Importantly, this pattern was obtained in both the Stay and Rotate conditions as evidenced by the absence of a significant interaction, F(2,40)=.40, p=.68.

Table 1. Accuracy (%) in Experiment 1 as a function of observer position and imagined perspective. Values in parentheses indicate standard deviations.

	Aligned 90°	Misaligned 90°	Contra-Aligned 180°
Stay	86.27 (18.40)	78.57 (17.55)	75,00 (23.23)
Rotate	82.45 (13.11)	73.75 (13.28)	65.42 (15.63)

Latency.

The analysis of latencies yielded similar findings with the accuracy data. No differences were obtained between the Stay (11,63s) and the Rotate (11,45s) conditions, F(1,20)=.03, p=.87. However, a significant main effect was obtained for imagined perspective, F(2,40)=19,96, p<.001, η^2=.50.

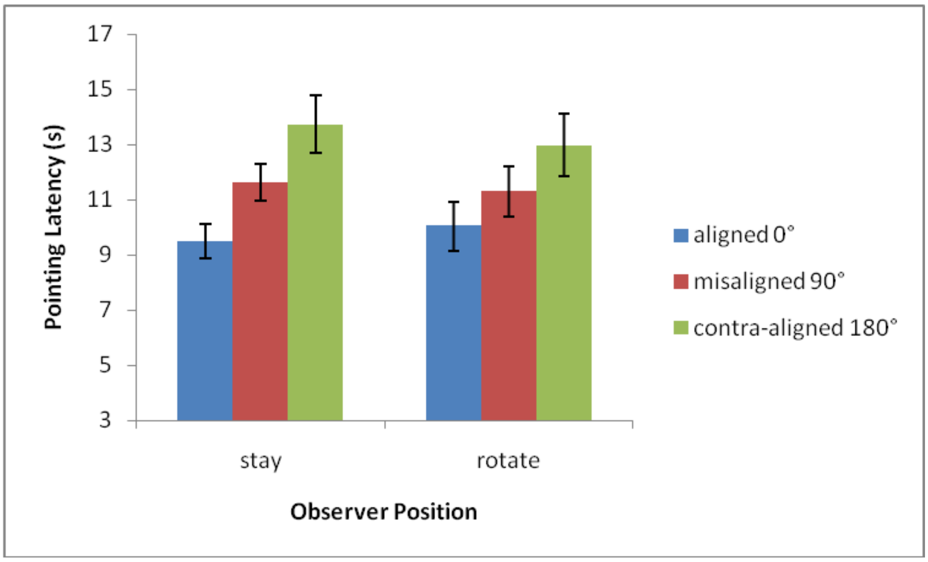

Fig. 2. Latency for pointing responses as a function of observer position and imagined perspective in Experiment 1. Error bars represent standard errors.

As seen in Figure 2, pointing was faster in the aligned 0° condition (9,80s), intermediate in the misaligned 90° condition (11,47s), and the slowest in the contra-aligned 180° condition (13,35s). All pair-wise comparisons were significant, p´s<.01. Finally, the interaction between observer position and imagined perspective was not significant, $F(2,40)=.72$, $p=.50$.

2.4 Discussion

Results from Experiment 1 clearly documented the presence of a normal alignment effect in both Stay and Rotate conditions. This effect was present in both accuracy and latency. These findings contrast those of Waller et al, who found no alignment effect in the Rotate condition and a reverse-alignment effect in the Rotate-Update condition. The critical difference between the two studies is in our opinion the fact that our depicted scenes referred to non-immediate environments while the layouts in Waller et al's study were immediate to participants. We will return to this issue in the General Discussion.

3 Experiment 2

Experiment 2 was identical to Experiment 1 with the only exception being that instead of presenting the paths in pictures, route descriptions were shown. Previous studies with route descriptions have documented the presence of a strong influence of the orientation of the first travel segment of the path on spatial performance; this suggests that the way the path is represented in memory determined the ease of spatial reasoning. Based on these findings we expect that no influence of body orientation would be evidenced in our experiment. Like Experiment 1, we predict the presence of a normal alignment effect in both Stay and Rotate conditions.

3.1 Method

Participants.

Twenty-two students, none of which were included in Experiment 1, participated in the experiment in exchange for course credit. Half were randomly assigned to the Stay condition and the other half to the Rotate condition.

Design.

As in Experiment 1, the design adopted was a 2(observer position: Stay vs rotate) x 3(imagined perspective: aligned 0°, misaligned 90°, contra-aligned 180°) mixed factorial with observer position and imagined perspective as between-subject and within-subject factors respectively.

Materials and Apparatus

In contrast to Experiment 1, the paths were learned through text descriptions presented on the screen. These descriptions were presented in Greek, the native language of all participants. Prior to the experiment participants were shown a picture as the one in Figure 1, which however included no path. They were told that this was an environment in which they should imagine themselves standing in. The text description described the same paths of Experiment 1. An English-translation of an example description would read as follows:

> Imagine standing at the beginning of a path. The position that you are standing at is position 1. Without moving from this position, you turn yourself to the left. Then, you walk straight for 10 meters and you reach position 2. As soon as you get there you turn towards the left again and you walk another 10 meters to reach position 3. At this position, you turn to your right and walk another 10 meters to position 4. Finally, you turn again to your right and walk another 10 meters towards position 5 which is the endpoint of the path.

3.2 Procedure

The procedure was identical to that of Experiment 1. Prior to reading the descriptions participants were instructed to visualize themselves moving along the described path. They were also told to execute 90° turns.

3.3 Results

As in Experiment 1, no differences were obtained between the 90° left and the 90° right imagined perspective in either accuracy or latency. Therefore, data were averaged across these two perspectives to form a 90° misaligned perspective condition. Separate 2 x 3 repeated measures ANOVA were then conducted for accuracy and latency.

Accuracy.

The ANOVA on accuracy data revealed that overall performance was equivalent between the Stay (68,7%) and the rotate conditions (70,3%), $F(1,20)=.40$, $p=.84$. A significant main effect for imagined perspective was obtained, $F(2,40)=17.60$, $p<.001$, $\eta^2=.47$. As seen in Table 2, accuracy was higher for the aligned 0° perspective (77,1%), intermediate for the misaligned 90° perspective (69,8%), and the lowest for the 180° contra-aligned perspective (61,7%). Within-subject contrasts verified that all pair-wise differences were significant, p´s<.05. These difference among perspectives were present in both the Stay and rotate conditions as suggested by the lack of a significant interaction, F(2,40)=.22, p=.81.

Table 2. Accuracy (%) in Experiment 2 as a function of observer position and imagined perspective. Values in parentheses indicate standard deviations..

	Aligned 90°	Misaligned 90°	Contra-Aligned 180°
Stay	76.96 (20.59)	69.24 (20.84)	59.94 (23.67)
Rotate	77.15 (16.89)	70.38 (18.85)	63.45 (17.37)

Latency.

The analysis reveal no difference in performance for the Stay (12,39 s) and the Rotate (11,79 s) conditions, F(1,20)=.12, p=.74.. A significant main effect was present for imagined perspective, F(2,40)=24,22, p<.001, η^2=.55.

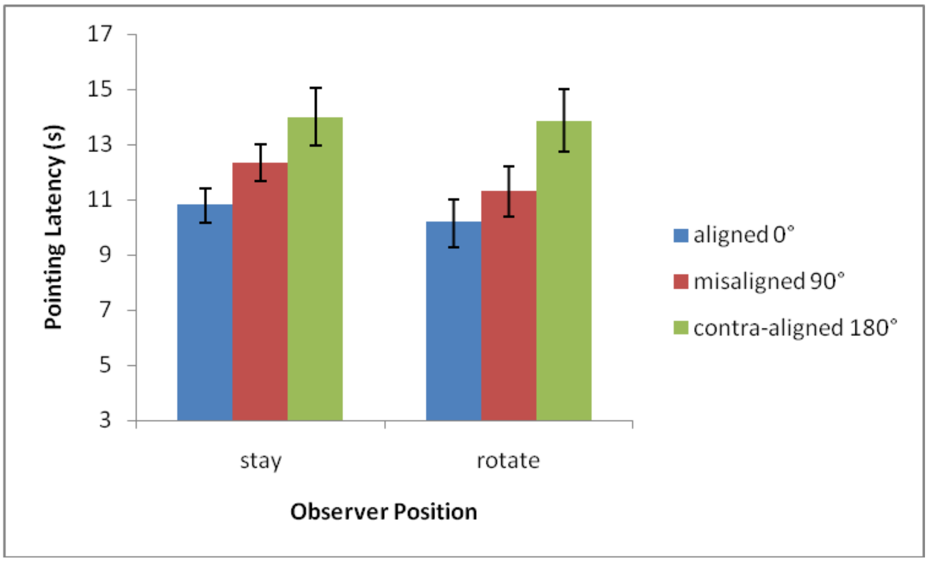

Fig. 4. Latency for pointing responses as a function of observer position and imagined perspective in Experiment 1. Error bars represent standard errors.

As seen in Figure 4, participants pointed faster in the aligned 0° condition (10,51 s), intermediate in the misaligned 90° condition (11,82 s), and the slowest in the contra-aligned 180° condition (13,94 s). All pair-wise comparisons were significant, p´s<.05. Finally, the interaction between observer position and imagined perspective was not significant, $F(2,40)=.41$, $p=.67$.

3.4 Discussion

Results from Experiment 2 replicated closely those of Experiment 1. Specifically, a normal alignment effect was evidenced in both Stay and Rotate conditions. This effect was present in both accuracy and latency data. Furthermore, performance did not seem to be influence by rotation as indicated by the equal overall performance between the Stay and Rotate conditions. The presence of a similar pattern of findings with depicted and described scenes is compatible with recent accounts of functional equivalence of representation derived from various modalities. To further assess functional equivalence we conducted a cross-experimental analysis using the data from Experiments 1 and 2.

4 Cross-experimental Analyses

Separate 3 x 2 ANOVA's using imagined perspective as a within-subject factor and experiment (visual vs. verbal) as a between-subjects factor were carried out for accuracy and latency data.

Accuracy was higher in the visual task of Experiment 1 (77,2%) than in the verbal task of Experiment 2 (69,4%). However, this difference fail short of significance, $F(1,42)=2.37$, $p=.13$. The interaction between experiment and imagined perspective was also non-significant, $F(2,84)=.18$, $p=.84$. $\eta^2=.37$.The only significant effect was the main effect of imagined perspective, $F(2,84)=24.12$, $p<.001$, $\eta^2=.37$.

Similarly, the only significant effect in the latency analysis was the main effect of perspective, $F(2,84)=45.21$, $p<.001$, $\eta^2=.52$. In support of the functional equivalence hypothesis, neither the main effect for experiment nor the interaction between experiment and imagined perspective were significant, $F(1,42)=.32$, $p=.58$ and $F(2,84)=.14$, $p=.87$ respectively.

5 General Discussion

The experiments presented here provide evidence for the lack of sensorimotor influence for reasoning about spatial relations contained in depicted or described environments. The current findings deviate from those obtained from experiments with real visual scenes in which the influence of body orientation was substantial [9, 10].

While our findings suggests that reasoning through symbolic media might not always be equivalent to reasoning about actual environments, in our opinion, the critical variable is not whether the environments are experienced directly through our senses or indirectly through symbolic media but rather whether the spatial relations they contain are immediate or not (see [9]). We believe that reasoning about remote locations is free of sensorimotor facilitation/interference. Because symbolic media are typically used to encode non-immediate spatial relations while immediate relations are encoded through direct experience, the difference in findings occurs. Compatible with this explanation are the findings of Kelly et al which showed that no sensorimotor influence occurs when participants are removed from the spatial layout they had previously encoded by means of visual perception [9].

The current findings are compatible with theories of spatial memory and action that posit separate systems for encoding egocentric and allocentric relations [8, 23, 24]. In these theories, egocentric relations are maintained in a transient sensorimotor memory system and are updated as one moves within the environment. On the other hand, allocentric relations (i.e., inter-object directions and distances) are maintained in an enduring memory system. As Mou et al [10] suggested memories in the enduring system are stored with a preferred orientation which can be chosen based on a variety of factors that include viewing perspective, instructions, the internal structure of the layout etc.

In their critical evaluation of spatial memory theories, Avramides and Kelly [14] argued that when reasoning about immediate spatial relations, both the transient sensorimotor and the enduring systems are relevant to the task. When a participant is asked to point to a location from her actual perspective performance is facilitated by the fact that the self-to-object vector signifying the correct response is directly represented in the sensorimotor system and is automatically activated as suggested by May [7]. However, in order to point from an imagined perspective, the participant must suppress this self-to-object vector and compute a response using the inter-object relations from the enduring system. As Waller and Hodgson [24] have recently suggested, computations from the enduring system are cognitively effortful. Reasoning from imagined perspectives is thus expected to take longer and be prone to sensorimotor interference. Avraamides and Kelly also argued that when reasoning about non-immediate spatial relations only the enduring system is relevant to the task. This is the case because the transient egocentric system functions to encode the current surroundings and not the layout one reasons about. As a result, performance is neither facilitated by nor interfered with the physical orientation of the participant.

The tasks we used in this experiment seem to fall under the second type of reasoning described by Avraamides and Kelly. We have used pictures and descriptions that referred to spatial layouts that were remote to participants. We have also instructed participants to visualize themselves within the environment that was shown or described. As a result, no egocentric relations should have been formed between the self and the locations contained in the layouts. Thus, we believe that the task was executed solely on the basis of an enduring allocentric system. Therefore, we attribute the alignment effect that was found in all our conditions to the way the paths were represented in memory. In the case of Experiment 1, we believe that paths were organized in memory on the basis of viewing experience (i.e., as a snapshot taken from a vantage point that coincided with the physical observation point of the participant). In the case of Experiment 2, paths were maintained in memory from the direction of the initial imagined facing direction. Although no instructions were given to participants in terms of imagining an initial facing direction, adopting one that is aligned with their actual facing direction seems less taxing on cognitive resources. Indeed, a number of previous studies have suggested that people have difficulty in maintaining misaligned imagined perspectives [25].

At this point it should be pointed out that while we claim that no egocentric relations between the self and the elements of the path were formed, we acknowledge that the transient egocentric systems of participants would have been used to encode and updates egocentric relations to objects from the laboratory, including the two computer monitors used to present stimuli. Moreover, spatial relations between each path location and an imagined representation of the self within the path could have been formed. But, such relations could be more easily classified as allocentric rather than egocentric if the self in the imagined path is regarded as just another location in the layout.

A secondary goal of our study was to assess the degree of functional equivalence between spatial representations created from depicted and described sccenes. An important result is that the same pattern of findings was observed in the two experiments. While performance was somewhat more accurate for depicted over described scenes, our cross-experimental analysis revealed that the difference was not significant. Tthe difference in mean accuracy is not surprising given findings from previous studies showing that it takes a longer to reach the same level of learning when encoding spatial layouts through language than vision [15-17]. In the current study we have used no learning criterion. Instead, participants were provided with unlimited time to study the layouts in the two experiments. The accuracy and fidelity of their spatial representations was, however, not assessed prior to testing. It is possible then that the overall performance difference between described and depicted was caused by differences in encoding. Previous studies suggest that functional equivalence for representations acquired from different modalities is achieved after equating conditions in terms of encoding differences [3, 15]. A future direction for research would thus to examine functional equivalence for representations of remote environments after taking in account the differences that may exist across modalities in terms of encoding.

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