# Locating targets from imagined perspectives: labeling vs. pointing

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**Abstract**

Participants in one experiment adopted imagined perspectives in a perceptually available spatial scene and located targets by using either verbal terms (labeling) or arrows (pointing). Results revealed that performance was faster and more accurate for labeling than pointing and more so when the adopted perspectives were misaligned with the physical orientation of the participant. We argue that language provides a more flexible medium than pointing for responding from imagined perspectives because it relies less on the physical body.

## Introduction

The cognitive process that allows us to know at all times where the elements that constitute our environment are located in relation to our body is known as spatial updating (Avraamides, 2003; Farell & Thomson, 1999; Farell & Robertson, 1998; Loomis, Lippa, Klatzky, & Golledge, 2002; Rieser, Guth, & Hill, 1986). A typical study on spatial updating involves asking participants to point without vision toward a set of targets, first from their current standpoint and then from a novel standpoint they adopt after physical or imagined movement which may include a rotation, a translation or a combination of the two (e.g., Presson & Montello, 1994; Rieser, 1989, Rieser et al., 1986). Results generally show that when physical movement is carried out performance is equally good from the original and the novel standpoints. However, when the movement is only imagined (at least when the movement involves a rotation), participants are faster and/or more accurate pointing to the targets from the original than the novel standpoint. This dissociation suggests that information that is present only during physical movement -- proprioceptive information, vestibular feedback and efference copy -- is an important prerequisite for successful spatial updating (Loomis, Klatzky, Golledge, & Philbeck, 1999; but see Riecke, van Veen, & Bülthoff, 2002).

However, results from a number of recent studies suggest another possibility. Perhaps, pointing to targets from imagined viewpoints is more difficult because the task of responding is itself unnatural and awkward. Manual responses such as pointing with the arm or turning one's body toward a target seem strongly attached to the physical body. This strong dependence to the physical body may pose difficulties when the physical body should be ignored in order to respond from an imagined viewpoint. Furthermore the task of responding manually from an imagined viewpoint is not one that we carry out spontaneously in our daily lives and it is therefore not very well practiced.

May (2004) has suggested that locating objects in space is more difficult when it is done from imagined viewpoints that are misaligned with the orientation of the physical body because, in that case, conflicts between the objects´ physical (sensorimotor) and the objects' imagined egocentric (i.e., relative to one's self) locations occur. For example, an object that is directly to the *front* of an observer would require a response toward the *left* if the observer is requested to imagine rotating 90 degrees in place to the right. According to May, the physical location of the object (front) interferes with its imagined location (left) which specifies the correct response and the observer is left with the task of having to choose the appropriate action vector from the two. May's data corroborate this sensorimotor interference hypothesis by showing that reaction times for pointing toward targets from imagined viewpoints vary as a function of the extent of the conflict (i.e., the angular difference between the real and the imagined egocentric positions of the target object). However, even when the correct action vector is chosen, the observer still needs to specify it from her physical reference frame. This latter problem is referred to by May (2004) as *head-direction disparity* and is considered an additional source of interference.

Compatible with May´s hypothesis are the combined results from two other studies (Klatzky, Loomis, Beall, Chance, & Golledge, 1998; Avraamides, Klatzky, Loomis, & Golledge, 2004). Both studies included conditions in which participants were requested to navigate either physically or by imagination various triangular paths (e.g., "walk 3 meters to the front, turn 90 degrees to the right, walk another 2 meters") and then point to the origin by turning their body towards its direction. Results in the imagery conditions showed that participants made systematic errors; they overshot the correct angle by the extent of the intervening turn. That is, participants seemed to ignore the discrepancy between their physical and imagined facing direction. Avraamides et al. (2004) attributed this to the strong dependence of the manual response to participants´ physical body. These systematic errors evidenced in the imagery conditions did not replicate in the physical movement conditions. Furthermore, in an additional condition, included in Avraamides et al. (2004), in which verbal responses replaced manual responding, the systematic errors were absent from the imagery condition as well. These results suggest that there is a difficulty in responding from imagined viewpoints but this difficulty occurs only when responding manually.

Results compatible with this possibility are also provided by Wraga (2003). In one experiment in which participants used a pointer to locate targets after physical or imagined rotations, performance followed the typical pattern; participants were faster pointing to targets after physical than after imagined rotations. However, in a subsequent experiment in which pointing was replaced with verbal responding, the pattern of results was the opposite; performance was superior after imagined rotations. These results suggest that pointing performance from imagined standpoints typically suffers, not because of failure to update during the imagined movement, but because the act of pointing is itself problematic when carried out from a standpoint other than the one occupied by the physical body of the person. Similar findings are provided by an earlier study by DeVega & Rodrigo (2001) which used described rather than perceptual scenes.

It follows from the above studies that language might be a more flexible, and thus more appropriate, means for responding than manual pointing. Language is used very frequently in daily life to locate objects from the perspectives of others and indeed, there is evidence that people prefer to adopt the perspectives of others when communicating locations (Shober, 1993).

We argue that because pointing is strongly anchored on the physical body, the problem of head-direction disparity is created. Participants are first called to ignore the orientation of their physical body in order to determine the response vector from an imagined reference frame, but then they are called to use their physical body to execute that vector. This creates a rather complex and unnatural situation and it is not surprising then that participants often find the task of pointing from imagined positions awkward and difficult to understand. As Presson and Montello (1994) revealed 9 out of the 40 participants in their imagined rotation condition, compared to none in their physical rotation condition, "…expressed some difficulty during the debriefing about how they should have pointed after the transformation" (p.1454). On the other hand, the problem of head-direction disparity should not occur with verbal responding. Of course, using deictic verbal terms such as "left", "back" etc, should not be expected to be devoid of any sensorimotor interference. These terms are also specified egocentrically and as shown by Avraamides (2003; Avraamides & Carlson, 2003) they are also used more easily from physical than imagined perspectives. However, once the response is determined it can be executed without any reference to the physical body.

If indeed language can be used more flexibly than pointing from imagined perspectives, performance at locating objects in the same task should be superior for verbal than manual responding. The purpose of the present study is to compare directly manual and verbal responses in a task that entails adopting imagined viewpoints. The task deviates significantly from the spatial updating paradigm as the focus of the experiment is to contrast the two response modes; nevertheless, our results have important implications for spatial updating studies.

## Experiment

The purpose of the Experiment is to contrast performance for locating targets using either verbal labels or a response that depends more strongly on the physical body.

Participants viewed displays in which they had to imagine adopting the perspective of a character depicted sitting around a table and indicate the relative position of a target character by selecting with the mouse the appropriate verbal term or arrow displayed on the screen depending on condition. This response procedure was adopted (instead of real pointing and oral responding) to equate the motor demands of the two response modes. As seen in Figures 1 and 2, the two tasks were identical except for the nature of the response mode.

We expected that overall accuracy would be lower and latencies would be longer in the pointing than in the labeling task due to the strong attachment of manual pointing to the physical body. Therefore, we also expected that the difficulty with pointing would be exemplified in those trials in which the perspective participants had to adopt was misaligned with the orientation of their own body.

### Method

**Participants** Twenty participants (10 males) volunteered to participate in the experiment**.**

**Materials**. Stimuli were presented on a laptop computer. The task was programmed and presented using E-Prime (2000). The computer screen was rotated in depth to a near horizontal position so that participants would experience an oblique view of the display. Participants responded to each trial of the experiment by using an external mouse attached to the USB port of the computer.

**Design** The experiment followed a 2 x 3 within subjects design with *task* (labeling and pointing) and *perspective misalignment* (0°, 90°, and 180°) being the two factors. The order in which the two tasks were completed was counterbalanced across subjects.

**Procedure** Before beginning the experimental trials for each task participants were given a number of practice trials aiming at familiarizing them with using the mouse to select the appropriate response from the set of alternatives. For the labeling task, arrows were presented on the screen as probes and participants had to select as fast as possible the verbal label describing the direction the arrow pointed towards. Similarly, for the pointing task, participants selected from the set of alternatives the arrow that matched the orientation of the probe. Before the pointing task participants were shown trials of the experimental task on paper, and they were instructed to imagine being at the position of a given character and then point with their arm towards the target. Then they were asked to indicate the arrow that pointed the same way. This was done to ensure that participants understood how they were expected to point and also to establish the meaning of the response alternatives. Furthermore, because the response alternatives were presented in the same order throughout the experiment, the practice trials also served to offer practice at locating the desired response without extensive visual search among the alternatives.

The practice trials were given before each experimental task and each time were followed by 22 real trials. In both tasks trials displayed an orthogonal table depicting six characters sitting around it (Figures 1 and 2). The depicted facing direction of two characters was aligned with the physical orientation of the participant (0° perspective misalignement), that of 2 others was misaligned by 90° (one clockwise and one counterclockwise), and that of another 2 was misaligned by 180°. Each character sitting around the table was accompanied by a common greek name printed underneath its depiction. Participants were instructed to imagine adopting the perspective of the character named "ANTREAS" (spelled ΑΝΤΡΕΑΣ in greek) which was always printed in blue ink and then report the relative position of the character whose name appeared in red ink (all other names appeared in black ink).

In the labeling task participants indicated their response by selecting via a mouse-click one out of 8 possible verbal labels (greek equivalents for "front", "back", "left", "right", "front-left", "front-right", "back-left", and "back-right") that were presented at the bottom part of the display (Figure 1).

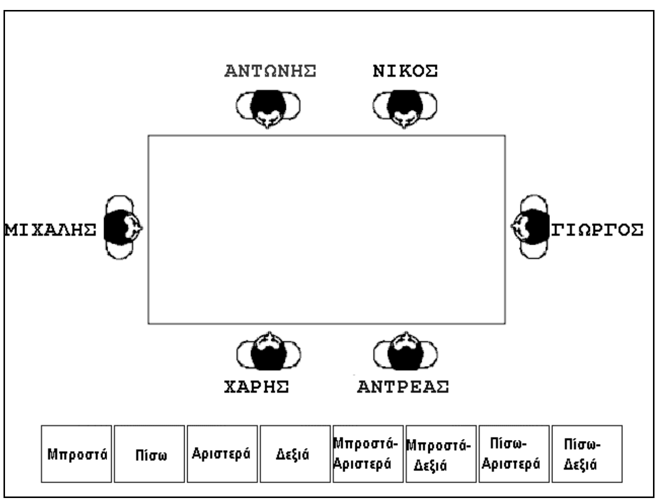


Figure 1: Sample display from the labeling task. In this trial the name ΑΝΤΡΕΑΣ is in blue ink and the name ΑΝΤΩΝΗΣ in red.

The procedure was identical for the pointing task except that participants selected arrows pointing toward these 8 directions (Figure 2).

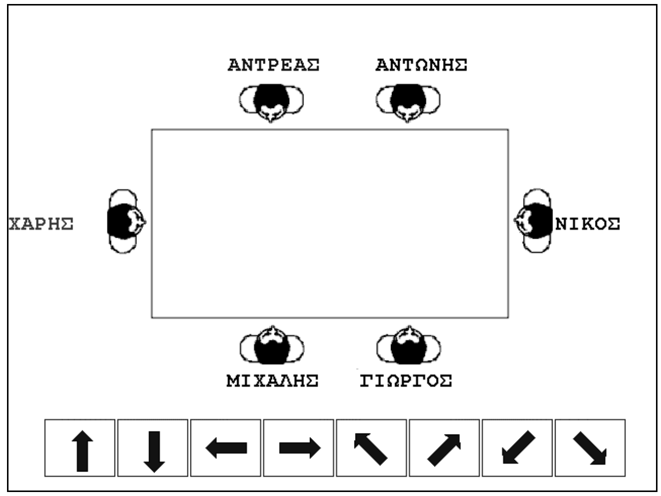


Figure 2: Sample display from the pointing task. In this trial the name ΑΝΤΡΕΑΣ is in blue ink and the name ΧΑΡΗΣ in red.

## Results

Accuracy data and latencies for correct responses were analyzed using a repeated measures analysis of variance (ANOVA) with task and perspective misalignment as factors[1].

**Accuracy**

Accuracy was higher in the labeling task than in the pointing task (94% and 78% respectively), $\underline{F}(1,19)=20.23$, $\underline{MSE}=.04$, $\underline{p}<.001$. Furthermore, performance varied as function of perspective misalignment, $\underline{F}(2,38)=21.40$, $\underline{MSE}=.01$, $\underline{p}<.001$. However, as shown by the significant task x perspective misalignment interaction this was the case only in the pointing condition, $\underline{F}(2,38)=14.82$, $\underline{MSE}=.02$, $\underline{p}<.001$ (Figure 3).

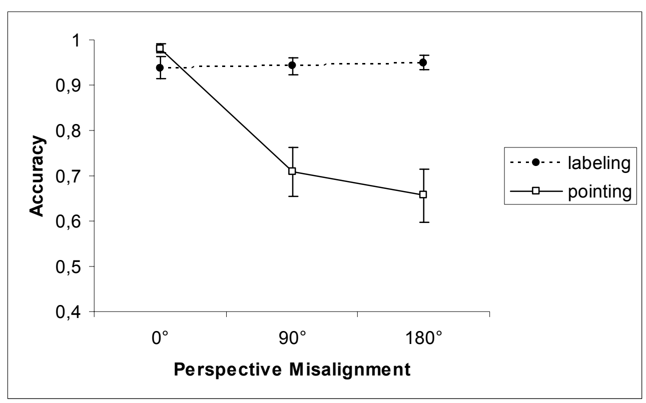


Figure 3: Accuracy as a function of task and perspective misalignment. Error bars indicate standard errors.

[1] Initial analyses indicated no differences in either accuracy or latency between the two positions with the same angular difference from the physical orientation of the participant (e.g 90° clockwise and 90° counterclockwise. Therefore accuracy and latency data were average to form means for each angle (0°, 90°, and 180°)

Pair-wise comparisons using 2-tailed t-tests revealed that the accuracy in the pointing task was substantially higher in the 0° misalignment condition than both the 90° and 180° conditions, $t(19)=4.78$, $p<.001$ and $t(19)=5.57$, $p<.001$ respectively. Accuracy was higher in the 90° than the 180° condition but the difference did not reach statistical significance, $p=.26$.

None of the pair-wise tests revealed any differences among the three perspective misalignment levels in the labeling task. Furthermore, while accuracy for the 0° misalignment condition was higher for pointing than labeling, this difference was only marginally significant, $p=.10$.

Finally, male participants tended to perform more accurately than females (89% vs 85%). Again, this difference was not statistically significant, $p=.17$.

**Latency**

Overall, latencies in the pointing task were longer than those in the labeling task (4690 ms and 3739 ms respectively), $F(1,19)=13.26$, $MSE=2046170$, $p<.01$. Furthermore, latencies generally increased with greater perspective misalignment, $F(2, 38)=23.40$, $MSE=597092$, $p<.001$. However, a significant interaction between task and perspective misalignment was obtained, $F(2,38)=3.61$, $MSE=437563$, $p<.05$. As seen in Figure 3, the increase of latency with greater perspective misalignment was steeper in the pointing than the labeling condition. In fact, pair-wise t-tests revealed that the difference between 0 and 90 in the labeling condition was not significant, $t(19)=1.31$, $p=.21$. All other differences were significant except for the difference between labeling and pointing in the 0 perspective misalignment which was only marginally significant, $t(19)=1.88$, $p=.08$.

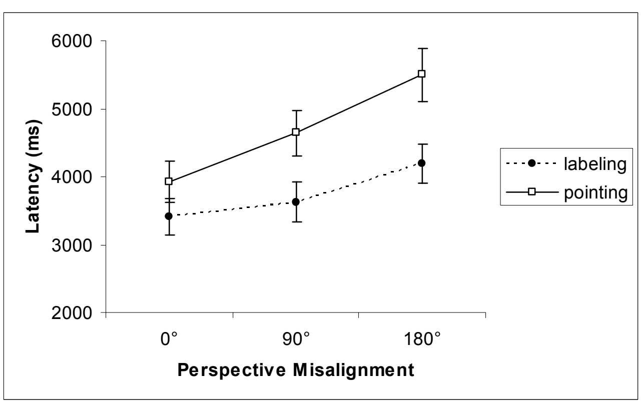


Figure 4: Mean latencies as a function of task and perspective misalignment. Error bars indicate standard errors.

Furthermore, an analysis examining gender effects revealed that males were faster than females (3739 ms vs 4690 ms), $F(1,18)=5.30$, $MSE=6160557$, $p<.05$. Gender did not interact with any other factors.

## Discussion

The present experiment compared two modes of responding, pointing and labeling, in a task that required localizing targets after adopting imagined perspectives in a perceptually available spatial scene. Our findings corroborated our expectation that performance would be inferior when participants pointed to the targets with arrows than when they described their relative positions by selecting verbal terms.

Furthermore, our results showed that the difficulty with pointing is enhanced when the perspectives to be adopted are misaligned with respect to the physical orientation of the participant. Latencies in the pointing condition increased as perspective misalignment increased from 0° to 90° and then to 180°. Also, accuracy in the pointing task diminished with greater perspective misalignment. In contrast, the increase of latencies in the labeling condition was not very steep. In fact, only latencies for misalignments of 180° were longer than the rest. One possible explanation for this finding is that for the 180° the mapping of the verbal labels “left” and “right” to the appropriated regions of space is reversed (i.e., imagined left is where physical right is). Furthermore, accuracy was equally high for all levels of perspective misalignment.

Of course, the decrement of performance as perspective misalignment increased in the pointing task can be explained by a mental rotation account. The classic mental rotation studies (e.g., Cooper & Sheppard, 1971) have established that latencies for certain judgments (e.g., normal vs mirrored alphanumeric characters) increase with greater angular deviations of the stimuli from the upright position. Similarly, Parsons (1996) has shown that similar results are found when participants make judgments on human figures presented at various orientations. Presumably, this occurs because participants mentally adopt the orientation of the presented human figure in order to make the judgment. Based on these findings, it should not be surprising that latencies in the present study increased with greater perspective misalignment. However, if we assume that the slope of the mental rotation function is the same for the labeling and pointing tasks then our finding of a steeper increase of latency in the pointing task should be indicative of the presence of an additional cost exclusive to pointing. Nevertheless, it seems imperative that further research -- possibly with an experiment that separates the time to adopt the orientation from the time to locate the target -- disambiguates the two possible sources of latency cost.

Our results clearly indicate that pointing and verbal responding are not equivalent tasks in terms of difficulty. When the perspective to be adopted was aligned with the orientation of the physical body the two tasks did not differ much. While pointing was marginally faster than labeling in the 0° perspective misalignment level, accuracy was higher for labeling. This possible speed-accuracy trade off could be attributed to the fact that the 0° trials were inter-mixed with misaligned trials and participants adopted a strategy of being more careful and cautious in the pointing task as a whole. In contrast, when the perspective to be adopted was misaligned from the participants' physical orientation, performance in the pointing task was both less accurate and fast.

We attribute this difficulty with pointing to the fact that manual responses are by definition strongly attached to the physical body and are therefore more dependent on the body's orientation. Even when participants are able to determine the vector that locates a target from their imagined position, they still need to execute that vector using a reference frame that is based on their physical body. We believe that the difficulty with pointing lies at the level of translating the response vector from the imagined egocentric reference frame to the misaligned physical egocentric reference frame in order to execute the response. This translation is a deliberate process demanding of cognitive resources and it could be similar to the processes involved in the mental rotation of external objects[2].

Results compatible with the premise that performance in spatial tasks is affected by the orientation of the physical body are also provided by May (1996) and Waller, Montello, Richardson, and Hegarty (2002). Both studies have used disorienting conditions that reduced sensorimotor awareness by rotating the blindfolded participants for a few seconds before asking them to perform a localization task. May (1996) reported that although performance in the disorienting condition was worse compared to a physical rotation condition, it was substantially better than performance in an imagined rotation condition. Similarly, Waller et al. (2002) showed that the alignment effect -- that is, the performance difference between trials in which the imagined perspective was aligned with the orientation of the body and those that it was misaligned --was attenuated in the disorienting condition. Both studies used pointing as the response medium and their results suggest that being unaware of the orientation of the physical body is beneficial for responding from an imagined perspective.

The present results have important implications for studies aimed at assessing spatial updating failures with imagined movements. Because most of the studies in this field of research employ some kind of manual responding, an ambiguity in interpreting the findings is created: is the inferior performance with misaligned trials due to spatial updating failures or is it simply a result of a difficulty with the response mode?

Related to spatial updating is the literature that examines the organizational structure of spatial memory. A vast number of studies have concluded that memory is orientation specific; that is, people store memories that have a preferred direction (see McNamara, 2003 for a review). The typical paradigm for spatial memory studies is as follows. First, participants experience an arrangement of objects from a particular viewpoint and they are given time to study it. Then, with their vision occluded, they are asked to make judgments from memory about the locations of objects by responding to statements of the form "you are at x facing y, point to z" where x, y, and z are objects contained in the layout. For some trials, called aligned trials, the orientations participants adopt in imagination are parallel to the studied viewpoint. For other trials, called misaligned trials, the orientation are not parallel to the studied view. With a few exceptions (e.g., Presson & Hazelrigg, 1984; but see Sholl & Nolin, 1997), studies show that performance is better for aligned than misaligned trials (Waller et al., 2002; Christou & Bulthoff, 1999; Richardson, Montello, & Hegarty, 1999). Most of these studies test participants in the same room in which learning occurred (but see Avraamides & Kelly and the work of McNamara and colleagues -- e.g. Shelton & McNamara, 1997 -- for exceptions). As with the spatial updating, a question is raised: Is performance for aligned trials better because memory is viewpoint-dependent[3] or is it because aligned views are free of any reference frame conflicts?

At this point, we should clarify that the evidence for sensorimotor conflicts and head-direction disparity effects does not necessarily dispute the widely-accepted views that spatial updating occurs effortlessly only with physical movements and that spatial memories are organized in preferred directions. With regards to spatial updating, we, in fact, believe that the sensorimotor interference occurs as result of a spatial updating failure with imagined movement. In our view, if participants could truly update the locations of targets during the imagined movement and as a result were able to experience full presence at the imagined position they would face no interference from their physical body.

In closing, we should note the gender effect that was found in our latency data (the effect was in the same direction for accuracy but it was not statistically significant). This effect is in line with previous findings showing that males tend to perform better in active spatial tasks such as following mental paths (Vecchi & Girelli, 1998).

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[2] if the process of translating the response vector to the physical reference frame is indeed done with mental rotation, this could account for the finding that latency varies as a function of object-direction disparity (i.e., the angular difference between actual and imagined egocentric positions) that is reported by May (2004)

[3] McNamara (2003) discusses evidence that spatial memory is not viewpoint dependent. Instead he argues that we use intrinsic axes to organize it and we orient this axes based on cues that might exist; egocentric experience is one of various possible cues.

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