Collaborating in Spatial Tasks: Partners Adapt the Perspective of Their Descriptions, Coordination Strategies, and Memory Representations

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Abstract. The partner's viewpoint influences spatial descriptions and, when strongly emphasized, spatial memories as well. We examined whether partner-specific information affects the representations people spontaneously construct, the description strategies they spontaneously select, and the representations their collaborating partner constructs based on these descriptions. Directors described to a misaligned Matcher arrays learned while either knowing the Matcher's viewpoint or not. Knowing the Matcher's viewpoint led to distinctive processing in spatial judgments and a rotational bias in array drawings. Directors' descriptions reflected strategic choices, suggesting that partners considered each other's computational demands. Such strategies were effective as reflected by the number of conversational turns partners took to coordinate. Matchers represented both partners' viewpoints in memory, with the Directors' descriptions predicting the facilitated perspective. Thus, partners behave contingently in spatial tasks to optimize their coordination: the availability of the partner's viewpoint influences one's memory and description strategies, which in turn influence the partner's memory.

Keywords: perspective-taking, coordination, spatial memory, dialogue.

1 Introduction

People routinely share spatial information to coordinate in a variety of tasks, from giving directions to a visitor in an unfamiliar environment to jointly moving a piece of furniture across rooms. The selection of a perspective when producing or interpreting spatial descriptions has been systematically investigated, with findings identifying some of the cognitive, contextual, and communicative constraints influencing this selection process. However, this work usually focuses either on people's linguistic choices without directly examining the representations that support perspective-taking (e.g., Schober, 1993, 1995, 1999) or focuses on processing in noninteractive tasks (e.g., Carlson-Radvansky & Irwin, 1994; Carlson-Radvansky & Logan, 1997; Mou et al., 2004a) or in tasks where the interaction between (presumably) collaborating partners is constrained (e.g., Duran et al., 2011; Shelton & McNamara, 2004). Thus, it's not yet well understood how the perspectives that people spontaneously select, both for organizing spatial information in memory and for their descriptions, are

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influenced by partner-specific factors. It's also unclear how one partner's spatial representations and description strategies influence not only their coordination with another partner in the task, but also the memory representations the other partner constructs through that coordination. In this paper, we present some of our work that addresses these questions.

We begin by reviewing, in Section 2, research that identifies some of the factors that affect the perspective of speakers' descriptions and the efficiency of partners' coordination in spatial tasks. In Section 3, we review our recent work showing that knowing in advance the partner's misaligned viewpoint influences speakers' memory representations and their subsequent descriptions. In the remaining sections, we go beyond our earlier examination of how the availability of the partner's viewpoint influences speakers' memory representations and descriptions by using the same corpus to also investigate how these partner-specific factors influence the coordination between partners (Section 4) and the partners' memory representations that result from that coordination (Section 5). In Section 6, we summarize our findings, concluding that (1) people consider the task's cognitive demands on their partner to select the perspective of their descriptions and strategies that would maximize the efficiency of communication, (2) these strategies are indeed effective in facilitating coordination, and (3) the perspective of speakers' descriptions shapes the memory representations of their partners.

2 Coordinating in Collaborative Spatial Tasks

A confluence of findings suggests that people tailor their spatial descriptions in response to their conversational partner. For instance, in tasks in which pairs jointly reconstructed arrays, the degree of misalignment between partners affected the perspective of speakers' descriptions. Speakers were more likely to use partner-centered descriptions (e.g., "to your left" or "in front of you") than egocentric ones when describing arrays to partners who didn't share their viewpoint compared to partners who did (Schober, 1993; 1995). Moreover, constraints of the communicative situation can lead to attributions about the partner that also affect the perspective of speakers' descriptions: speakers describing arrays to an imaginary partner were more likely to use partner-centered descriptions and less likely to use egocentric ones compared to those describing arrays to a real partner (Schober, 1993).

Similarly, attributions about the partner's spatial ability, arising as the interaction unfolds, can also affect the perspective of speakers' descriptions (Schober, 2009). When partners were preselected to have matched or mismatched spatial abilities, high-ability speakers were more likely to use partner-centered descriptions whereas low-ability speakers were more likely to use egocentric ones. Additionally, as high-ability speakers formed attributions about their low-ability partners during the course of the interaction, they increased their partner-centered descriptions, whereas low-ability speakers decreased their use of partner-centered descriptions when describing to high-ability partners. The pairs' efficiency and accuracy also depended on their respective abilities. Pairs with two high-ability partners used fewer words than mixed pairs or pairs with two low-ability partners, and even though low-ability partners were generally less accurate in the task, their performance was better when paired with a high ability partner.

The accuracy and efficiency of coordination in spatial tasks doesn't only depend on the partners' cognitive constraints, such as their (combined) spatial abilities, but also on the affordances of the communicative situation, such as the visibility between partners or the shape of their shared space. In a task that involved reconstructing arrangements of lego blocks, pairs who could see each other were more accurate and efficient, since addressees could exhibit, poise, point at and orient blocks, and exchange feedback contingently, while speakers could also adapt their descriptions contingently in response (Clark & Krych, 2004). Even in a narrative task, the affordances of the communicative situation can shape how speakers encode spatial information: the relative locations of speakers and addressees influence the shape of their shared space and, as a consequence, the directionality of their gestures that accompany spatial prepositions like *in* and *out* (Özyürek, 2002).

People also adapt how they plan and describe routes according to whether they do it for themselves or for a partner unfamiliar with the environment (Hölscher et al, 2011). For an unfamiliar partner, people use more words and details, navigate along fewer, larger and more prominent streets and refer to more landmarks. Similarly, they adapt the level of detail they incorporate in describing landmarks, depending on whether their partner is familiar or unfamiliar with them (Isaacs & Clark, 1987).

Such adaptation in perspective choices is not limited to production, but extends to the interpretation of spatial descriptions as well. Attributional cues about the partner affected how people interpreted the perspective of ambiguous spatial descriptions (e.g., "give me the folder on the left", when partners occupied different viewpoints) in an online task, as reflected by the temporal and trajectory characteristics of their responses (Duran et al., 2011). Believing that their partner didn't know where they were seated (and could not consider their perspective) led people to more partner-centered responding, whereas believing that their partner was real (vs. simulated) led to more egocentric responding. Similarly, beliefs about whether the partner was an adult vs. a child influenced how participants planned their moves in a "tacit communication game", in which their intentions had to be conveyed exclusively through graphical means: they spent more time signaling the location of critical information to their partner when they believed they were interacting with a child (Newman-Norlund et al., 2009).

Across these studies, findings are broadly consistent with the view that partners share responsibility for mutual understanding and adapt their behavior in trying to minimize the collective effort of themselves and their partner; this has been termed as *the principle of least collaborative effort* (Clark, 1996; Clark & Wilkes-Gibbs, 1986). In situations where speakers address a partner who is imaginary or believed to be a child, or in situations where feedback is constrained, they expend considerable effort to adopt their partner's perspective or to convey spatial information to their partner. On the other hand, in circumstances where they interact with a real (or assumed to be real) partner, or a partner who can contribute contingently to the interaction (e.g., because they can see them), they may not invest as much effort in adopting the partner's perspective and instead rely on the partner to request clarifications, as needed. Thus, the attributions that people make about their partner and their ability to contribute to the interaction are critical in determining their perspective choices in collaborative spatial tasks.

Nonetheless, few studies have examined directly how partner-specific information can affect the memory representations that people recruit or generate in collaborative spatial tasks. In one study by Shelton and McNamara (2004), speakers were more accurate to make judgments about relations between array objects from the perspective that their partner had occupied earlier, when they had described the array to them. However, in this study partners could not coordinate freely during the description: speakers were instructed to describe arrays from the partner's perspective, and addressees did not know where speakers were relative to the array and could not provide any spoken feedback. This led to speakers using mostly partner-centered descriptions regardless of the degree of misalignment from their partner, and perhaps not surprisingly led to using the partner's viewpoint as an organizing direction in memory. Without these task constraints, it's unclear whether people would spontaneously incorporate their partner's viewpoint in memory.

3 The Partner Affects Memory Representations and Description Strategies

We recently adapted Shelton and McNamara's (2004) study to examine factors that affect whether people *spontaneously* represent their partner's viewpoint in spatial memory and to identify the description strategies that they *spontaneously* adopt when communicating spatial information. To do so, we dissociated the learning of the arrays from their description, and we did not constrain the interaction of partners when they reconstructed arrays.

In 18 pairs in our study, one participant, the Director, learned a table-top array of seven objects and later described it from memory to another participant, the Matcher, who reconstructed it by following the Director's descriptions. Across three blocks, Directors learned arrays under different conditions, which varied in terms of what Directors knew about their Matcher's viewpoint (i.e., the salience of the partner's viewpoint). In the first block, Directors didn't know that they would have to describe the array to a Matcher (No Intent condition). In the subsequent two blocks, Directors either knew that they would have to describe the array to a Matcher without knowing the Matcher's viewpoint (Intent condition), or knew that they would have to describe the array to the Matcher and also knew the Matcher's viewpoint, as the Matcher was co-present in the room during learning (Co-presence condition). The order of these two latter conditions was counterbalanced across pairs of participants, as was the degree of misalignment between partners during the description phase, which was 90°, 135°, or 180° across the three blocks.

The Directors' memory of arrays was assessed *prior* to descriptions through two tasks. The first involved *judgments of relative direction* (JRDs), which asked Directors to imagine a specific location and orientation, and to point, using a joystick, to another object from that imagined perspective (e.g., *Imagine being at the vase, facing the orange. Point to the button.*). The 48 JRD trials included eight imagined headings (0°, 45°, 90°, 135°, 180°, 225°, 270°, 315°) and their order was randomized. Performance was assessed in terms of participants' orientation latency (the time from the offset of the instruction to adopt an imagined perspective to pressing the joystick button to indicate that they adopted that perspective) and their response latency (the time from the offset of the instruction to point to the target object to pressing the button to log their response after having deflected the joystick). Performance on JRD trials allowed us to determine the preferred direction participants used to organize the spatial relations in memory (e.g., Kelly et al., 2007). In a second task, Directors reconstructed the array by indicating the position of each object on a grid circle representing their table. This allowed us to assess their memory for relative positioning of objects and for systematic biases (e.g., Friedman & Kohler, 2003). The Matchers' memory of the arrays they reconstructed was assessed through the same tasks after the description phase, allowing us to examine the extent to which their representations were organized similarly to the Directors' and the extent to which these representations depended on the perspective of their Directors' descriptions.

In Galati et al. (2011), we focused on the Directors' performance in the memory tests and on the spatial perspectives they adopted in their linguistic descriptions. We found that, in the absence of advance information about the Matcher's viewpoint (in the No Intent and Intent conditions), Directors encoded arrays egocentrically, being faster to imagine orienting to and to respond from perspectives aligned with their own. On the other hand, when the Matcher's viewpoint was known in advance (in the Co-presence condition) it showed distinctive processing, at least when Matchers were known to be misaligned by 90° or 135°: Directors took longer to imagine orienting to headings aligned with these known viewpoints of their Matchers. We proposed that this was because, when orienting to headings aligned with their Matcher, Directors recalled their experience at learning and linked the Matcher's viewpoint to their representation of the array, incurring a processing cost. The Directors' array drawings also provided converging evidence for having represented their Matcher's viewpoint in memory: in the Co-presence condition, when Directors knew their Matcher's viewpoint in advance, their drawings showed a reliable rotational bias towards the Matcher and, to some extent, affected how distorted the relative positions of array objects were.

Directors also adapted the types of spatial descriptions they used according to the conditions at learning. However, advance knowledge of the Matcher's viewpoint did not determine on its own the perspective of their spatial expressions—that is, Directors didn't necessarily use more partner-centered expressions advancing the Co-presence condition. Instead, Directors' descriptions suggested strategic choices: when perspective-taking was relatively easy for both partners (at the small offset of 90º), they used Matcher-centered expressions more frequently, whereas when coordination was more difficult and perspective-taking was more computationally demanding for them (at the oblique 135°), they opted for their own perspective, often upon explicitly agreeing with their Matchers to do so. In fact, such explicit agreement between partners happened most often in the Co-presence condition, when partners had known in advance they'd be offset by 135°. Thus, knowing in advance each other's viewpoint enabled partners to mutually recognize when the communicative situation would be more demanding for each of them and to adapt their strategies accordingly to facilitate coordination.

Converging evidence regarding the partners' mutual commitment to maximize efficiency in communication came from other global strategies, like the Directors' overall perspective preference (which required over 70% of all person-centered expressions of a given block to be Director-centered or Matcher-centered). When Directors preferred their own perspective overall, they did so more frequently when offset by 135° from their Matcher, whereas when preferred their Matcher's perspective overall, they did so more frequently when offset by 90°. The Directors' initial description choices were also congruent with these strategies, as reflected by the alignment of the first two objects of their descriptions (i.e., whether these objects were aligned with the Director, the Matcher, or neither partner). When Directors knew about the subsequent description at learning, the initial perspective of their descriptions was more likely to be aligned with their own viewpoint when offset by 135° with their Matcher, and more likely to be aligned with their Matcher's viewpoint when offset by 90° with their Matcher.

Together, these findings suggest that partners shared responsibility for mutual understanding and adapted to the communicative situation flexibly; the burden of perspective-taking wasn't exclusively on the Director. Consistent with the principle of least collaborative effort (Clark & Wilkes-Gibbs, 1986), when partners recognized that one of them was likely to find the interaction difficult (e.g., when the Director described an array from a 135° offset), the other invested greater cognitive effort to ensure mutual understanding (e.g., the Matcher opted to interpret descriptions from the Director's perspective) to minimize their collective effort.

In the next two sections, we focus on behavioral adjustments beyond those of Directors in order to assess, first, how the conditions under which Directors learned arrays affected the efficiency of partners' coordination during the description, and then how the Matchers' resulting memory representation were affected by these conditions and by their Directors' description strategies.

4 Partners Consider Each Other's Cognitive Demands When Coordinating in Spatial Tasks

Partners in a joint activity monitor and coordinate their behavior by *grounding,* or exchanging ongoing evidence about what they do or do not understand (e.g., Clark & Brennan, 1991; Clark, 1996; Brennan, 2004). As an index of the partners' collaborative effort, we considered the number of conversational turns pairs took to reconstruct a given array. Uninterrupted stretches of speech by a Director or Matcher were counted as turns. Decreases in the number of turns suggest facilitation in grounding, whether due to a reduced cognitive cost of perspective-taking or due to successful coordination strategies (e.g., Clark & Wilkes-Gibbs, 1986).

In our study, practice on its own did not reliably influence the partners' collaborative effort as reflected by their number of conversational turns: although pairs took overall fewer turns across the three blocks, this was only a numerical trend. As Figure 1 shows, the number of turns patterned differently across the different levels of misalignment between partners according to what the Directors knew about their Matchers at learning. During the first block, the No Intent condition, when Directors had learned arrays without knowing about the upcoming description, partners took numerically (though not reliably) fewer turns to reconstruct arrays at the smallest offset of 90º relative to the other offsets. In the Intent condition, when Directors had learned arrays while knowing about the description but not their Matchers' viewpoint, pairs took fewer turns numerically when they were counter-aligned relative to the other offsets. And in the Co-presence condition, when the Directors had learned arrays while knowing in advance the Matcher's subsequent viewpoint, they took the fewest turns numerically when they knew the Matcher would be offset by 135º.

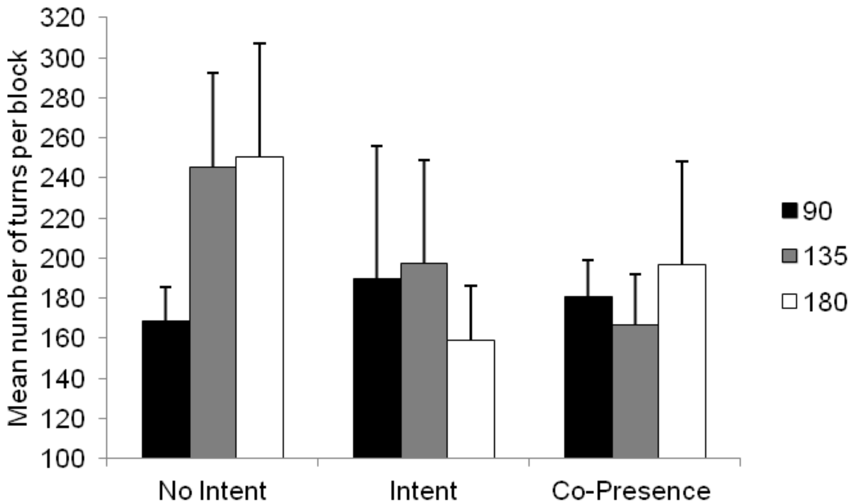

Fig. 1. Mean number of conversational turns across the three different levels of misalignment between partners, for each condition of partner salience

It may seem counterintuitive that partners tended to be more efficient when misaligned by the oblique and presumably computationally demanding offset of 135º, but their description strategies help contextualize this pattern. As we have found in Galati et al. (2011), when Directors knew they would be offset by 135º, they were more likely to use Director-centered expressions in their descriptions, having frequently agreed explicitly to do so with their Matchers, usually on their Matchers' own initiative. Indeed, the Directors' use of more egocentric expressions predicted the effort they expended when collaborating, as reflected by a reliable correlation with the number of turns: the greater the proportion of Director-centered expressions in the Co-Presence condition, the fewer turns partners needed to reconstruct the array.

Previously, we have claimed that when partners knew each other's viewpoint in advance, they were better able to mutually recognize when coordinating would be difficult and to agree on a strategy that would alleviate the demands on the partner with the greatest responsibility for mutual understanding in the task. Here, with turns as a proxy of partners' collaborative effort, we can corroborate that the partners' selected strategy (of reconstructing arrays with descriptions from the Director's perspective) was apt and successful in making their coordination more efficient.

5 Speakers' Descriptions Shape Their Partners' Memory Representations

Given the strategies that partners deployed during spatial descriptions, we wanted to determine whether the Matchers' memory representations were affected accordingly. Descriptions that differ in perspective, in terms of whether they involve a survey, bird's eye perspective or whether they guide the reader or listener along a route, have been shown to lead to comparable performance in spatial tasks, presumably because in interpreting them people construct equivalent mental models for the environment (Taylor & Tversky, 1992). However, it's unclear whether descriptions differing in person-centered viewpoint (i.e., whether they are egocentric vs. partner-centered) result in equivalent representations. Even though, based on such descriptions, people may construct spatial mental models that are equivalent in maintaining the spatial relations between objects, the preferred direction around which these spatial relations are organized may differ (see McNamara, 2003; Mou et al., 2004b, for a discussion of such allocentric representations having a preferred direction). This question hasn't been addressed with spontaneously produced descriptions.

In Section 3 we reviewed our findings from Galati et al (2011), where we examined how the availability of the partner's misaligned viewpoint influenced speakers' spatial memories and descriptions. We established that the perceptual information available during the description influenced the perspective of Directors' descriptions, with Directors using more Matcher-centered expressions when adopting their Matcher's viewpoint was relatively easy (when misaligned by a small offset). Additionally, we established that when partners knew each other's viewpoint in advance (in the Co-presence condition) they were better able to mutually recognize when perspective-taking would be most difficult for the Director (at the oblique offset of 135º) and agree on appropriate description strategies (describing arrays from the Director's perspective). Given these findings, in this section, we address whether the distribution of perspectives in the Directors' descriptions did in fact have an impact on how their Matchers organized their memory representations.

As we described in Section 3, the Matchers' memories were examined in the same way as the Directors', through JRDs and array drawings, after the description phase. To assess the preferred direction of Matchers' memory for the reconstructed arrays, in the JRD task, we examined Matchers' performance from headings aligned with their Director, from headings aligned with their own, and from all the remaining headings combined. Our goals were twofold: (1) first, to examine whether the Matchers' performance would be affected by the conditions during the description (the misalignment between partners and what Directors had known about the description phase in advance), and (2) insofar as these conditions affected the Directors' descriptions, as we had established in Galati et al. (2011), to examine whether Matchers' performance from either person-centered perspective in the JRD task correlated with the perspective of the Directors' descriptions.

Matchers' orientation and response latencies were affected somewhat differently by the conditions during the description. In terms of orientation latencies, the Director's perspective showed facilitation overall, as Figure 2 illustrates: Matchers were faster to orient to headings aligned with their Director than with themselves or all other headings. Notably, this facilitation of the Director's perspective was reliable in the No Intent and Intent conditions, but not in the Co-Presence condition where both partners had known each other's viewpoints in advance. The misalignment between partners during the description did not affect orientation times reliably, although, as Figure 2 suggests, when Matchers reconstructed arrays while offset by 135º from their partners, they were overall slower to adopt imagined headings than while offset by 90º or 180º.

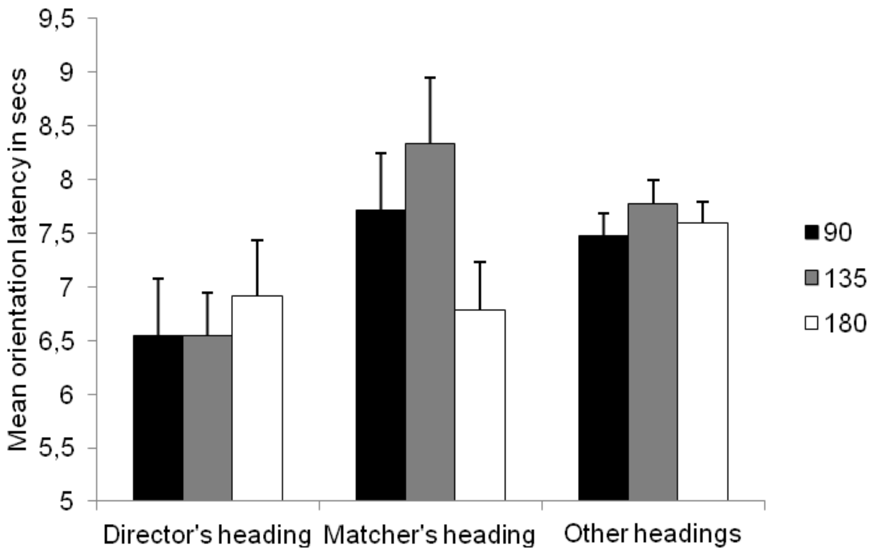

Fig. 2. The Matchers' mean orientation latencies from headings aligned with Directors, from headings aligned with themselves, and from other headings, across the three levels of misalignment between partners

On the other hand, in terms of response latencies, it was the Matcher's perspective that showed facilitation, as shown in Figure 3. Matchers were significantly faster to respond from headings aligned with their own than the Director or other headings. This pattern that held (reliably or marginally so), regardless of what the Director had known in advance about the description. As with orientation latencies, the misalignment between partners did not affect response latencies reliably, although, again, when Matchers reconstructed arrays while offset by 135º from Directors they were slower to respond than while offset by 90º or 180º.

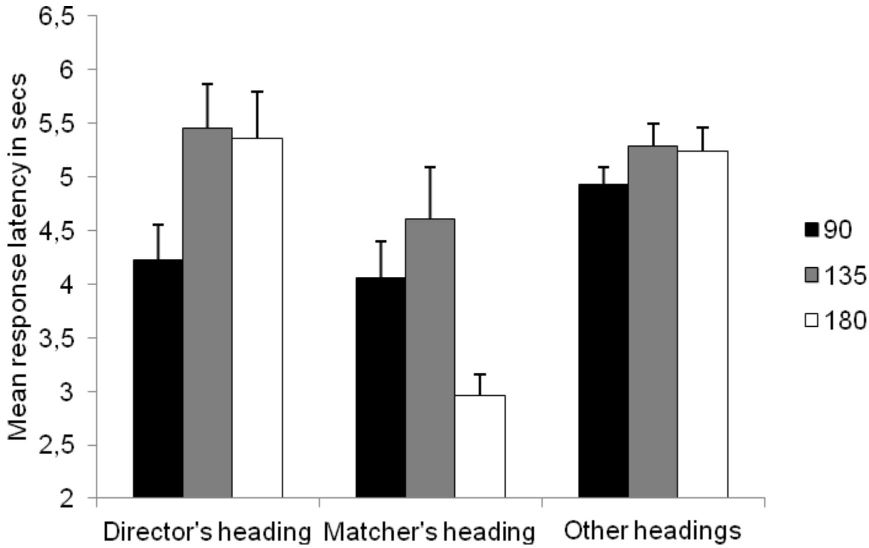

Fig. 3. The Matchers' mean response latencies from headings aligned with Directors, from headings aligned with themselves, and from other headings, across the three levels of misalignment between partners

Both latency measures, however, were affected similarly by the Directors' descriptions: the person-centered perspective of the Directors' descriptions was associated with facilitation in terms of both orienting to and responding from that heading. For orientation latencies, this was the case when partners had been offset by 90º: the greater the proportion of Matcher-centered expressions in the Directors' descriptions, the faster Matchers were to orient to headings aligned with their own, as suggested by a significant negative correlation. Considering that Directors were more likely to use Matcher-centered descriptions when offset by 90º than at greater offsets (Galati et al., 2011), we propose that the Directors' descriptions reinforced the Matcher's viewpoint as an organizing direction, and thus facilitated orienting to it. This negative correlation with Matcher-centered expressions also held for both latency measures in the Co-Presence condition, when Directors described arrays while knowing their Matcher's viewpoint in advance: the greater the proportion of Matcher-centered expressions in the Directors' descriptions, the faster Matchers were to orient to and respond from headings aligned with their own. Conversely, the greater the proportion of Director-centered expressions, the slower Matchers were to orient to and respond from headings aligned with their own. Additionally, when partners had been offset by 135º, as Matcher-centered expressions increased, Matchers were faster to respond from headings aligned with their own. That is, Matchers benefited especially from Matcher-centered expressions at the 135º offset, from which perspective-taking was demanding and from which Directors used primarily egocentric expressions in their descriptions (Galati et al., 2011).

6 Summary and Conclusions

The findings we report here contribute to a more nuanced understanding of partners' coordination in spatial tasks and of the memory representations that support and emerge from this coordination. Our study allowed us to examine whether certain circumstances (namely, the misalignment between partners' viewpoints and speakers' advance knowledge of it) affect whether speakers spontaneously incorporate their partner's viewpoint in memory and the description strategies they select to coordinate with their partners (Section 3). Additionally, our study allowed us to determine how these circumstances affect the efficiency of communication between partners (Section 4) and the memory representations that partners construct on the basis of speakers' descriptions (Section 5).

The first main conclusion emerging from our work is that, in collaborative tasks, when encoding spatial information and when subsequently describing it, people consider the cognitive demands of perspective-taking on themselves and on their partner, and adapt their representations and description strategies accordingly. When the partner's viewpoint is known while encoding spatial information, it seems to be represented, such that in spatial judgments orienting to it is slowed and in drawings the spatial configuration is rotated towards it. Also, knowing the partner's viewpoint in advance seems to enable partners to mutually recognize when coordinating is difficult, and to explicitly agree on strategies that reduce the cognitive demands on the partner with the greatest responsibility for mutual understanding. Speakers readily adopt their partner's perspective when perspective-taking is relatively easy, as when misaligned from their partner by a small offset. On the other hand, they opt for their own perspective, with their partner's consent or even initiative, when perspective-taking is difficult, especially when this is known while encoding the spatial information.

This adaption is consistent with the view that the attributions people make about their partner's ability to contribute to mutual understanding shapes behavior and leads to strategies that maximize the efficiency of communication (e.g., Duran et al., 2011; Brennan, 2004; Clark & Wilkes-Gibbs, 1986). Moreover, it underscores that the principles that govern coordination during spatial perspective-taking are not unlike those governing non-spatial perspective-taking (e.g., concerning their partner's conceptual perspective, their knowledge, or agenda; Schober, 1998). Partner-specific adjustments during both spatial and non-spatial perspective-taking appear to emerge from cognitive constraints acting on memory representations for shared experiences (see also Horton & Gerrig, 2005; Metzing & Brennan, 2003): if information about the partner is readily available or easily computed, it can be represented in memory and affect perspective-taking behavior; otherwise it won't.

Secondly, our findings suggest that the description strategies that partners select upon recognizing that coordination would be difficult are appropriate and successful in reducing their collective effort (thus maximizing the efficiency of communication). Partners who had known in advance that they would be misaligned by an oblique and computationally demanding offset were more efficient than partners who hadn't known, as reflected by the turns they took to reconstruct arrays. In fact, partners were numerically more efficient when they knew they would be misaligned by this oblique offset than by the other orthogonal offsets. The partners' efficiency is consistent with their explicit agreement to use the perspective of the partner for whom the task was most difficult in this perspective-taking situation. Thus, when partners were better able to realize that coordinating would be difficult, they selected appropriate and successful strategies. Currently we are examining other aspects of partners' coordination, beyond the effort they expended when coordinating. Specifically, by assessing the degree of distortion and rotational biases in how Matchers reconstructed the arrays on their tables (based on digital photographs of their reconstructions), we are investigating whether the strategies that partners deployed during the description affected not only their efficiency but also their accuracy in the task.

Additionally, our findings demonstrate that speakers' descriptions affect their conversational partners' resulting memory representations. The perspective of speakers' descriptions predicted the perspective that was facilitated when the partner subsequently made spatial judgments. This was especially so when partners had known each other's viewpoint in advance. The more speakers used partner-centered expressions in their descriptions, the more facilitation the partners showed for their own perspective; and conversely, the more speakers used egocentric expressions, the more facilitation the partners showed for the speakers' perspective.

Finally, our findings suggest that the partner who is reconstructing arrays based on another's spontaneous descriptions may represent both of their viewpoints in memory. Our Matchers' orientation latencies showed facilitation of their Directors' perspective, whereas their response latencies showed facilitation of their own perspective. It's not clear why the two latency measures were affected differently. Perhaps Directors served as a salient cue that helped Matchers to quickly adopt their imagined heading, thus facilitating orientation latencies. This cue may have been less relevant when identifying the location of a target after having adopted an imagined heading, in which case only headings aligned with Matchers' own showed facilitation in terms of response latencies. Nonetheless, Matchers appear to have represented both perspectives. This may be because Matchers, unlike their Directors, knew both of their viewpoints while they were reconstructing and learning arrays, and also because, despite any overarching preference, Directors' descriptions in all pairs included both Director-centered and Matcher-centered expressions.

Here, a comparison of the two collaborating partners' memory performance is pertinent. Previous studies have demonstrated that spatial information acquired through language results in memory representations that are functionally equivalent to those acquired through different sensory modalities (e.g., Avraamides & Kelly, 2010). Our findings don't address the issue of functional equivalence directly, as Directors and Matchers learned arrays under circumstances that differed not only in whether spatial information was acquired from vision vs. from language, but in other ways as well. For instance, Matchers learned arrays during the course of reconstructing them, on the basis of spontaneous descriptions, and while always knowing their partner's viewpoint. Directors, on the other hand, learned arrays through vision under non-interactive circumstances that were controlled, including with respect to whether or not they knew their partner's viewpoint. Despite these differences, both Directors' and Matchers' memory performance highlights that people construct their memory representations using the partner-specific information that is available, whether this information is available through the perceptual environment of the communicative situation (including the partner's position and orientation) or through descriptions emphasizing a particular viewpoint.

Together, our findings highlight some of the complex ways in which people adapt their memory representations and behavior when communicating spatial information. Future research can further clarify how coordination in spatial tasks, and the spatial representations supporting this coordination, are influenced both by partner-specific information and by egocentric preferences for organizing spatial information. But so far, it's evident that partners do consider each other's cognitive demands on the task when encoding and communicating spatial information. They are able to represent the partner's perspective when available—whether perceptually or through language—and they behave contingently: one partner's viewpoint influences the other's memory and description strategies, and in turn that partner's description strategies influences the other's memory.

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