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Mechanisms of Convergent and Complementary Alignment in Conversation

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ABSTRACT

Mechanisms of Convergent and Complementary Alignment in Conversation

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This dissertation explores human coordination in rhythmic, verbal, and spatial activity, and how coordination in one of these modes may subsequently impact behavior in another mode. My research examines what effects non-conversational actions have on the alignment of spatial perspectives during conversation. I hope to clarify how data about non-linguistic alignment - specifically, its fluency and the co-presence of an aligning partner - may inform expectations about the anticipated difficulty of interactions. These experiments test a claim from Pickering and Garrod's (2004) Interactive Alignment framework: "alignment at one level leads to alignment at another level." The experiments I present explore whether non-conversational alignment (or misalignment) carries over to linguistic performance - specifically, the way in which we express spatial perspective to others. This was accomplished using a quantitative approach to naturalistic conversations between adult pairs about simple spatial stimuli. The content of these conversations differs based on a task participants performed before the conversation that induced particular patterns of interpersonal alignment. These tasks were different for each experiment: Task 1 manipulated the dynamic stability of partners' physical coordination with each other, Task 2 manipulated partners' feelings of social similarity, Task 3 manipulated the dynamic stability of partners' coordination with an external rhythm, and Task 4 manipulated the difficulty of collaborative or solo achievement of a physical goal. The results of these studies show that, in the absence of collaborative activity, social similarity and rhythmic entrainment can lead to greater conversational effort, but physical alignment enhances conversational alignment best

when both partners' actions are oriented toward a mutual goal.

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Table of Contents

List of Tables

List of Figures

Introduction

This dissertation explores human coordination in rhythmic, verbal, and spatial activity, and how coordination in one of these modes may subsequently impact behavior in another mode. The experiments I present explore whether non-conversational alignment (or misalignment) carries over to linguistic performance - specifically, the way in which we express spatial perspective to others. The reasoning behind this work is based on emerging research on human communication in naturalistic contexts and the application of dynamical systems theory to the study of coordination in human interactions. Within the context of a structured naturalistic conversation, I believe that closer control of coordinated and collaborative behaviors that occur near or during conversation will clarify the influence of non-conversational interaction on cognitive alignment between speakers' representations.

Coordinating with others is commonplace in human activity. For example, imagine that you are walking to lunch with a friend. Without even knowing it, you will slowly fall into step with her. Unless you deliberately stay out-of-step with your friend (which may take some effort), you will stay in step until your pace changes – for example, if you must avoid stepping in a puddle. This happens to any physical system in which two similar objects have oscillating motions and are connected to each other – in this case, by sight and hearing. The oscillating motions each have a particular *phase* that converges to a common phase over time. Phase-matching in walking rhythm and in other motor behaviors (postural sway, speech rate, gesture) is frequently an unconscious part of human interaction. I will refer to this process of stabilizing our repetitive activities with each other as *coordination*. Coordination within a human dyad can have both automatic and controlled components, and can happen at multiple levels of the interaction.

Moreover, it is not restricted to matching each other's physical behaviors. For example, in face-to-face conversation, people coordinate their physical activity (e.g. falling into step with a walking companion) and surface speech activity (speaking at the same volume or speed), and also coordinate their conceptual semantic/referential activity (calling the same thing by the same name). Theories and observations of human behavior both suggest that physical coordination is not independent from language use. Understanding how coordination operates in different modes of human activity, and how it might transfer between these modes, can give us insight into complex behaviors like conversation.

Support for connections between coordination inside and outside conversation can be found in contemporary research in social psychology, behavioral economics, and developmental group behavior. While these studies are intriguing, the nature of the connection between motor activity and social behavior is still underspecified. The present thesis extends this research with the aim of uncovering possible mechanisms that connect social and linguistic behavior to coordinated physical activity. An assumption of my approach is that an utterance made during conversation is like one move in a tennis match: just like taking a physical action in a game, planning and making an utterance involves acts of physical coordination with others, as well as acts of conceptual representation and definition. As such, the study of conversation should draw on techniques from the study of motor coordination as well as those from the study of symbolic cognition.

Many things may be responsible for the mutual influence of motor behavior and linguistic coordination. Human motor coordination within individuals and between dyads has long been described in terms of *dynamical systems*, based on the Newtonian physics of the body and its surroundings (Haaken, Kelso, & Bunz, 1983). Similarly, a mechanistic *interactive alignment* account of conversation has been proposed by Pickering and Garrod (2004), which, instead of force, motion, and momentum, strongly posits priming as the underlying explanation for interlocutors' behavior (Pickering & Garrod, 2004). According to interactive alignment, priming across individuals drives talkers to converge on linguistic representations at multiple levels (syntactic, prosodic, semantic, etc.) simultaneously. Pickering and Garrod also assert that human communication is the sort of system in which "alignment [i.e. coordination] at one level leads to alignment at other levels." Although Pickering and Garrod were mainly concerned with linguistic levels of interaction, here I am particularly concerned with cases of alignment across both linguistic and non-linguistic levels of dyadic interaction, as in the example of a friendly chat (linguistic) while walking to lunch (non-linguistic).

Plausible alternatives or adjuncts to this mechanistic explanation come from research in social psychology that credits the "perception-behavior pathway" with the convergence of actions during conversation (Hertwig et al., 2008). Proponents of these theories claim that converged representations are not necessary to explain the alignment that arises between speakers, and that motor coordination and feelings of ease or social closeness are both products of a perception-behavior feedback loop. Briefly, in a given interaction, people who mimic each other's physical actions will feel more at ease in the conversation, and will like each other more as a result. Evidence of motor coordination during the interaction could create a sense of fluency that is misattributed as social closeness or liking (Oppenheimer, 2008). These social factors are equally likely to lead to better conversational coordination. Feelings of closeness, liking, and similarity will be measured in each of my experiments to track the influence of social factors and attempt to analyze them separately from physical coordination.

Experiment 1 of this dissertation was designed to test the impact of motor coordination on the coordination of spatial perspective in conversation (Otis & Horton, 2010). In short, based on an account of conversation that posits priming as the main force behind alignment, alignment on one level would lead to alignment at another level in a convergent manner. Better alignment at the motor level will lead to better alignment of spatial perspective and conversational goals. I expected that the influence of improved physical alignment would show up as helpful conversational behavior: specifically, explicitly marking perspective and taking the partner's point of view when giving directions. In other words, close motor coordination would lead to close representational coordination and improve measures of perspective-taking. However, as I will report here, the results display the opposite relationship between close motor coordination and linguistic signals of perspective-taking: Pairs who participated in a "close coordination" activity (clapping in time with each other) showed fewer helpful direction-giving behaviors than pairs who clapped in different rhythms from each other (low physical coordination), who showed higher levels of perspective-marking and matcher-oriented directions.

The structure of this dissertation is as follows: First, I will present the literature on human dynamical systems and interactive alignment that motivated Experiment 1, expanding upon the reasoning behind the assumptions articulated above, and discuss several alternatives to these assumptions that lead to the specific methods used in Experiments 2, 3, and 4. In Chapters 2 through 5, I will present the four experiments that I designed to explore the phenomenon of cross-modal alignment. The final chapter offers a summary of these four experiments and the conclusions I can draw from them, and suggests how remaining open questions may be pursued in future research.

Chapter 1

From the perspective of the current research, theories of language, conversation, and physical behavior can help us understand how conversation comes into being as a coordinated joint action. In this chapter, I review theories and behavioral studies that lay the groundwork for an extension of the Interactive Alignment theory (Pickering & Garrod, 2004) that accounts for both the linguistic and physical nature of human interactions. There are two approaches to interaction that inform my thesis: theories of *conversation* and theories of *coordinated movement*. The intersection between these fields provides us with the best approach to understanding the evidence from multimodal interactions: how they are carried out, and what different modalities contribute to achieving the 'goal' of a successful conversation (however that is defined). While these theories may focus on purely linguistic behavior, a comprehensive account of conversation must also be rooted in the real use of words between people, including the pragmatic, social, and physical components of conversation. The way language is used can tell us a great deal about what language users' goals are in communication, and what they are capable of doing in the pursuit of those goals.

Broadly speaking, theories of language production and perception describe the conditions for language use within the individual, while theories of conversation help us understand how individual production and perception can interact to generate the complex system of conversation. To contextualize the perspective-taking conversations that I examine in my research, I take the view that these theories describe different processes within the individual and between individuals. Theories of conversation show us that language exists in a context of other problem-solving activities, and that the way we understand problem-solving can also help us understand conversation. Conversation is also used in ways that are only tangentially related to problem-solving, for example, to form or solidify social bonds. Studying what strengthens or weakens these bonds can lead to better understanding the impact of social closeness, attraction, and affinity on conversational coordination. Understanding how these theories explain the use of effort in conversation will inform my explanation of conversational effort in my experiments. Finally, understanding human interaction requires us to not only understand the coordination of sound and meaning between speakers, but also the coordination of movement. Theories of coordinated movement must be integrated with theories of conversation if they are to adequately explain behavioral evidence of conversational alignment that crosses modalities.

1.1 Theories of Conversation

Contemporary theories of conversation inherit many assumptions from Grice's "Logic and Conversation" (1975). Grice observed that even spontaneous conversation proceeds in an orderly fashion, and that the composition of a conversation was as tightly structured as a grammatical sentence. Grice theorized that certain guidelines govern conversations between speakers - guidelines that speakers know intuitively, but that are not discussed or taught, and that do not always follow from a logical understanding of information exchange. However, unlike the grammar of a language, the “grammar” of conversational behavior had not been codified, and it was not obvious how much of it could be formalized. Grice and his contemporaries were wrestling with tensions between logical formalism and philosophical naturalism. In the formalist framework, human behavior and thought happen in a rule-governed environment in which the mind performs operations on symbols with conceptual content; in this framework, language is the product of logical operations on semantic, syntactic, and phonetic symbols. Grice was particularly concerned with the arena of human conversation, and he attempted to flesh out a theory of conversation in a similar rule-governed way. However, any attempt to describe conversation solely in terms of logical operations on discrete content is doomed to incompleteness because speakers often “mean” more than what they actually “say.”

Grice articulated several of the more important rules that people appear to follow when speaking to each other, i.e. the Cooperative Principle and the conversational maxims. The Cooperative Principle (CP) defines conversation as a series of utterances that are "such as are required, at the stage at which they occur, by the accepted purpose or direction of the talk exchange in which [speakers] are engaged." The conversational maxims describe in more detail the rules people appear to follow most of the time when having a conversation that follows the CP, for example: be clear, be honest, make your contributions relevant, and do not give more information than is necessary. According to Grice, in order to be cooperative conversational participants, we make our contributions relevant, maximally informative, but minimally effortful based on what we think our partner already knows. Furthermore, we rely upon our partner’s powers of inference in order to efficiently convey particular communicative intentions. If I have an accurate picture of what my partner knows, then presumably I can shape my utterances to take advantage of that knowledge. Moreover, I can simultaneously rely on the fact that my partner will assume that I will use this knowledge, because with respect to the goal “having a conversation,” both parties are always assumed to be cooperative. Taking into consideration what my partner knows, what they might know about what I know, and what they know that I know that they know (and so forth) increases my likelihood of being understood, and of accomplishing conversational goals quickly and with minimal effort (Clark, 1996).

Grice’s fundamental insight was that conversation still involves a system of constraints, conventions, and rules. These rules can even be bent or broken in conventional, rule-governed ways that allow speakers to remain cooperative. Importantly to the current context, Gricean pragmatics bear heavily on any theory of effort in conversation. Since conversation is a complex and open system, there are likely to be many influences on speakers' cooperative conversational behavior and the amount of effort they expect their partner to put towards interpreting any utterance. Conversations between close friends about quotidian subjects may rely more on assumptions about common information than conversations between strangers about controversial topics. Relying on shared perspectives or assuming "common knowledge" can be risky if both speakers do not have the same level of knowledge about the subject of their conversation. However, avoiding this risk by making all knowledge explicit costs more time and effort than interlocutors are generally willing to give. In addition, explicit mutual knowledge is cognitively implausible: requiring speakers to have comprehensive mental models of each other's knowledge, even restricted to the topic of conversation, would require an implausible amount of memory dedicated to maintaining a log of what the other person knows, believes, and assumes about the topic - and maintaining a similar log for all other people the speaker is likely to talk to (Schiffer, 1972). Instead, speakers appear to manage conversational effort by observing which utterances succeed and which fail due to a lack of common information.

This idea of common information, mutual knowledge, or common ground is important for any theory of conversation that goes beyond the autonomous actions of individual speakers and listeners. If conversations are made easier by both parties' assumptions about what is known, where do these assumptions come from? In his book "Using Language" (1996), Clark articulates a view of conversation as a type of conscious joint action that shares fundamental features with other conscious joint actions, such as playing tennis or driving in traffic. This is in contrast to previous psycholinguistic theories that treated language as the product of two autonomous minds planning utterances without referring to their previous mutual experiences. These latter accounts can be collectively referred to as "language-as-product" theories due to their view of speech or writing as a token that is produced solely by the individual speaker or writer (Hempel, 1950; Carnap, 1961).

By contrast, "language-as-action" theories (Clark's being the central one) view speech or writing as an activity to which multiple parties contribute - speakers, listeners, bystanders, and readers. Language-as-product theories require both speakers to keep careful track of their partner's output, since it is their only way to know if they are being understood. Language-as-action theories only require both speakers to have compatible "game plans" for the conversation ahead of them, a much more cognitively plausible view of conversation, and one that characterizes speakers as coordinating the action of conversation with each other. Language users approach each interaction with an imperfect awareness of others' reactions, and take sequential actions based on their own goals, the space and information available to them, and others' speech acts (Lewis, 1979). Thus, conversation becomes a problem-solving game with two dimensions: coordinating content (achieving the informational goal of the conversation) and processes (e.g., accurately detecting when one's "turn" begins and ends). Speakers represent their listeners' knowledge as part of their model of the other person, and try to keep their contributions relevant not just in Grice's general sense, but relevant specifically to their listeners (Clark & Marshall, 1981). Interlocutors only need to calculate a limited set of "knowing-that" steps in order to solve the present conversational problem. These calculations are guided by heuristics rather than true mutual knowledge, and are limited both by relevance and by working memory capacity.

Because of the flexible, reparable nature of the game, full awareness of mutual knowledge is not necessary for conversation to proceed. Instead, what seems to be necessary for successful referring actions is that the representations of that referent in the minds of the speakers are assumed to be common ground, and are well-aligned enough for current purposes. If speakers discover that their representations are not well-aligned enough, or that their purposes have changed, they can repair these gaps in knowledge and carry on. Because conversation is a series of joint actions, these repairs can be initiated when one partner realizes that the conversation is no longer grounded, and that mutual understanding has lapsed. The mechanics of turn-taking may also require constant monitoring and signal processing on the part of both speakers (Sacks, Schegloff, & Jefferson, 1974; Clark, 1996, 2002). Both parties to a conversation are constantly engaged in some degree of listening and some degree of utterance planning at the same time. Critics of Clark's model of conversation point out that the burden of monitoring turn-taking cues, clues to mutual understanding, and planning one's own speech is collectively too heavy to be cognitively plausible, and that even this reduced burden does not account for how smoothly conversations – including repairs and misunderstandings – generally go (Gambi & Pickering, 2011). The joint action model of conversation may be most useful at the "intentional" level of coordination, i.e. the level of analysis at which we assume that our ability to infer another's intentions is the paramount goal of interaction. While most discussions of information exchange through interaction have been concerned with the achievement of pre-set goals, many cognitive tasks consist not in reaching a fixed state, but in increasing the value of some parameter - for example, social closeness or subjective confidence in one's location. These parameters may be harder to measure in the lab, but they represent a more realistic model of human conversation. The unconscious actions of speakers, through processes like priming and mimicry, can contribute incrementally to increased rapport even in conversations where no new information is exchanged.

Goals, intentions, and strategies may be part of an adequate top-down theory of conversation, but it is also likely that conversation is built in part from the bottom up, through general cognitive mechanisms that perform small actions but have considerable influence on the macro-structure of linguistic interactions. The Interactive Alignment account (Pickering & Garrod, 2004) is a mechanistic approach that bridges the traditions of language-as-product and language-as-action, taking elements of each in order to produce a way of looking at language that preserves its situated richness and interactive nature, while addressing concerns about the underlying mechanisms that allow for and explain that nature.

As an alternative to cognitively-implausible accounts of mutual knowledge (following Clark, 1996), Pickering and Garrod propose a priming-driven account of conversation and interaction. In their model of human conversation, speakers' representations are aligned through computationally cheap, bottom-up automatic processes. Priming[1] and mimicry, specifically, drive the alignment of interlocutors' situation models to a degree that satisfies the immediate goals of the talkers. In the Interactive Alignment Theory, priming acts to make our representations more similar to each other.

Importantly, this model assumes that our representations of concepts and words exist in a network where they are connected to each other by frequent association or thematic similarity. Metaphorically, priming opens cognitive pathways between items or concepts.[2] The more these pathways are used, the easier it is to use them. According to the Interactive Alignment account,

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[1] Priming in this case can be taken to mean congruent priming or assimilation rather than contrast priming; see Herr, Sherman, and Fazio (1983) for further work on contrast priming.

[2] The mechanism by which these pathways are created does not bear directly on my research, but could be any one of: spreading activation, resonance, or integration.

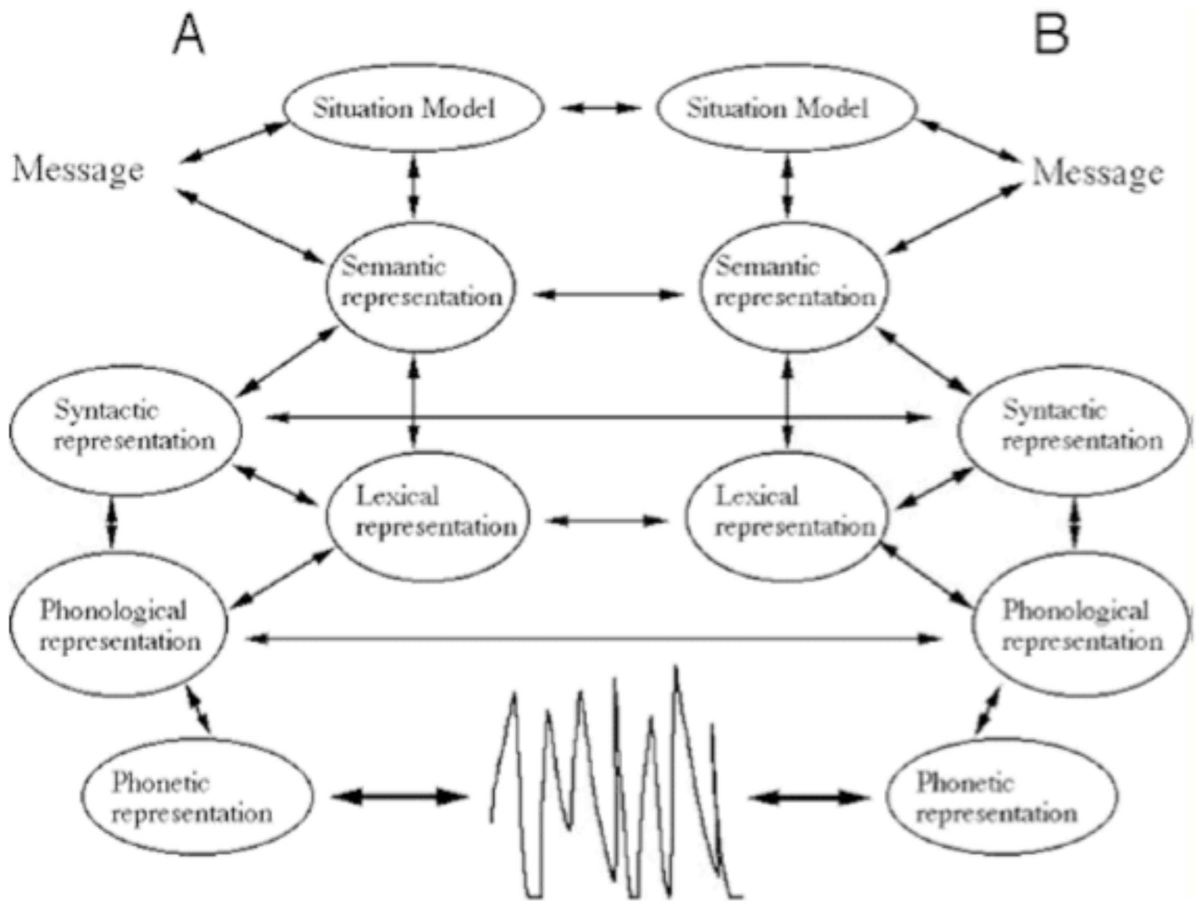
during conversation this convergent activation of relevant representations across two (or more) individuals allows them to come into greater alignment with each other. This similarity of representations at any level of language facilitates conversation, as can be seen in the contrast between two native speakers talking to each other, and a native speaker talking to a recent second-language learner. When our phonological representations of words are dissimilar, decoding another's speech stream takes work. When our representations are similar, that work can be applied to other cognitive processes (Lev-Ari & Keysar, 2010).

Situation models, lexical semantics, and syntax are all thought to participate in this "resource-free and automatic" priming process that allows gradual alignment of representations during conversation. This has important implications for conversation. For example, syntactic structures used by one partner are primed for subsequent use by the next speaker, just as recently-used lexical representations and, by extension, semantic representations (i.e. situation models) are made more available to listeners by residual activation. Although first developed outside of the study of dialogue, evidence from structural priming experiments (Levelt & Keller, 1982; Bock, 1983; Branigan, 2000) supports this interactive alignment view. Priming mechanisms cause us to adopt regular patterns that make interactions easier by making the context for new information more predictable. If conversations follow Grice's maxims strictly, speakers will minimize verbosity in order to ensure they are not violating the maxim of relevance. However, if a speaker uses more words than are strictly necessary to ask a question, the addressee is likely to use the same phrasing in her answer, verbose or not. This indicates that syntactic frames, like referential terms, can increase comprehension when re-used between speakers (Pickering & Branigan, 1998; Luka & Barsalou, 2005; Thothathiri & Snedeker, 2008). When participating in a structured conversation with an experimental confederate (or even a computer), people are significantly more likely to re-use the syntactic frame employed by the confederate than any other frame, even a simpler or shorter one. This phenomenon also extends to referring expressions, and is not restricted to syntax (Brennan & Clark, 1996). These results demonstrate that speakers are sensitive to both the form and the content of their partner's utterances when planning their own contributions.

Linguistic alignment does more than merely make our conversations easier; alignment (or lack of alignment) can profoundly affect our feelings and behavior toward other speakers. In a study by Lev-Ari and Keysar (2010), information given by speakers with an accent was trusted less than information given by native-accent speakers. Listeners apparently used their phonological model of words to inform their assessment of the semantic content of those words. Trust and other social factors are not accounted for in most models of language processing because language is viewed as a separate channel of social interaction that is distinct from other modalities. Social psychologists, though, have demonstrated that priming can cross conceptual boundaries, e.g. between physical warmth and social warmth (Williams & Bargh, 2008), and the research described above (Lev-Ari & Keysar, 2010) suggests that listeners use their stereotype of a "trustworthy voice" to determine the factual value of information. Listeners' internal sense of disfluency when processing non-standard phonetic arrangements may be misconstrued as a sign that "something is off" about this speaker, and attributed to an assessment of their trustworthiness.

However exciting these cross-modal alignments are, it is still unclear what connections are being made within and between the cognitive systems that produce them. No matter how powerful priming may be in aligning representations within the same modality, it is not immediately clear how it alone would operate as a mechanism for cross-modal alignment. Initial formulations of the interactive alignment asserted that "alignment at one level leads to alignment at another," citing evidence that stronger semantic relations between words, for example, can boost syntactic priming (Branigan et al., 2000; Cleland & Pickering, 2003, cited in Pickering & Garrod, 2004). The notion of "level" here is somewhat problematic, since it is unclear what the relationship is between the linguistic levels described by Pickering and Garrod (and depicted in the diagram of interactive alignment, Figure 1.1), and other uses of the term.

Figure 1.1. Illustration of interactive alignment within an individual; from Pickering and Garrod, 2004.



Relationships between the situation model, semantic representation, syntactic representation, lexical representation, phonological and phonetic representations seem to be of a different character than relationships between different modes of activity during conversation – e.g. actions on a cognitive level, a linguistic level, a social level, or a physical level. Thus, it is an open question whether a simple Interactive Alignment account could successfully predict instances of cross-modal alignment that involve disparate representation types – e.g. motor movement and linguistic representations.

Yet, there is evidence for connections between these domains in studies of aligning postural sway and involuntary eye movements during conversation. People who talk to each other, especially using repetitive speech patterns, tend to align their micro-movements with each other while standing, a phenomenon known as postural sway (Shockley, Santana, & Fowler, 2003). This happens without any top-down guidance – or indeed, any visual contact between partners. Similarly, the eye movement patterns of conversation partners who are both looking at the same object become coupled (Richardson & Dale, 2005). These studies suggest that alignment is possible between linguistic actions and physical actions. But what path connects the physical and linguistic levels that align in this way? Why does this alignment happen and what conditions are required for it to occur?

1.2 Theories of Coordinated Movement

To address the questions above, a more thorough understanding of physical coordination is required. Alignment at the physical level is completely different from alignment of language or representation, in that the movements being aligned are generally larger than any movement involved in speech. Physical movement as I describe it in this section is also non-symbolic, in contrast to the alignment of representations or meanings. So while the coordination of manual gestures during conversation may be a good example of alignment between language and physical action, gesture has been thoroughly treated in the linguistics literature and will not be discussed here. Instead, I will explore the literature on physical coordination from a basic, mechanistic level, developing as thorough an understanding of coordinated movement as I have an understanding of conversation.

Theories of coordinated movement were not originally developed to answer questions about human language, but rather, as general approaches to understanding interactions between physical systems. A typical example of these interactions is the behavior of two clocks mounted on the same wall, an experiment first described by the 17th-century scientist Christiaan Huygens (Pikovsky & Rosenblum, 2007). The period of each clock's pendulum may peak at a different place when they are first set in motion, but they will eventually synchronize with each other, and they re-synchronize quickly after any disturbance. This synchronization is only possible because the clocks are both mounted on the same wall – their connection through the wall makes them *interacting* systems, even though each clock's oscillations can be described independently of the other clock.

Research on the alignment of physical systems has focused on oscillation because it is easier to show that convergence (or divergence) has happened; oscillations provide a recurring comparison point (Kelso & Engstrøm, 2006). In oscillating patterns, a system goes from one state to the other, and back, in the same way over and over again. If the repeating pattern of states can be detected, the next state of the system can be predicted based on what state it is in now. The body performs a number of natural oscillatory movements: heartbeat, breathing, walking, and neural firing all follow oscillating patterns. Our uncanny ability to predict others' physical and conversational actions may, some think, be based on the synchronization of internal oscillators (Dittman & Llewellyn, 1968; Wilson & Wilson, 2002). Examples of human synchronization to external oscillators are easy to find – clapping in rhythm, marching to a beat - but is this unidirectional syncing really the same as the synchronization of internal oscillators? And if our ability to predict others gets better because we are synchronizing our internal oscillators with theirs, which oscillator is the most important?

Recent work demonstrates that oscillatory movements in a human dyad follow similar physical laws (Ouillier et al., 2008; Shockley, Richarsdon, & Dale, 2009). These movements can be either intentional (pendulum-swinging, finger-tapping, clapping, rocking in rocking chairs) or unintentional (step timing/stride length while walking, postural sway, EEG frequency in the centro-parietal cortex). The fact that we synchronize our recurring movements with one another in both consciously-controlled and non-conscious activities suggests that dynamic pattern stability is not just a feature of unintentional actions in which the physical dominates the cognitive.

Studies that have demonstrated dynamic stability in intentional actions also show that this stability is guided by a perception-behavior feedback loop using vision, hearing, or both. For example, in a study by Smith and Richardson (2008), pairs of participants were asked to either sit in rocking chairs that gave distinct auditory feedback using sandpaper to amplify contact between the chair's rockers and the floor, or in chairs placed so that they could observe the other participant rocking. Both types of feedback led to tighter coupling of each individual's rocking oscillations. In another study, the importance of the visual channel in aligning oscillations was demonstrated during a finger-tapping exercise (Ouillier et al., 2008). In the key experimental condition, participants seated facing each other closed their eyes and started tapping one finger on their own table, "as if they were going to have to do this all day." Upon a signal from the experimenter, they opened their eyes for a predetermined period of time. During this time, the relative phases of their finger-tapping switched from being completely independent of each other to stabilizing at a common frequency. This stability falls apart in the absence of visual contact:

when pairs are asked to close their eyes again, their finger-tapping reverts to being un-coordinated with each other.

Postural sway is an unintentional action that, at first glance, appears to be unrelated to the dynamics of interaction: we adjust our posture incrementally based on the movement or stability of the surface we are standing on, the condition of our weight-bearing joints, and our cardiovascular activity. However, a series of studies by Shockley and colleagues show that conversation and co-present speech positively influence postural sway entrainment. Whether pairs of participants were having a conversation about a map, or merely reading words on a screen together, their postural sway patterns entrained to a similar relative phase (Shockley et al., 2003; Shockley et al. 2007). This suggests that both the meaningful linguistic behavior of conversation and the act of merely articulating words together have a similar effect on coordination of non-linguistic movements: in both cases, stable convergent periodic patterns emerge.

Likewise, speakers who are having a conversation via cell phone while walking tend to step at the same time as the person on the other end of the phone, bringing their walking rhythms into phase with each other even when they cannot hear their partner's foot striking the ground (Murray-Smith et al., 2007). Recent research by Tognoli and colleagues (2011) indicates that activity in particular EEG bands is highly correlated with behavior that is synchronized with another person (phi-2) or unsynchronized with another (phi-1). Using the experimental method described in the finger-tapping experiment above, researchers detected activation and inhibition of motor cortex regions, which suggests that social coordination involves the inhibition of intrinsic premotor activity, and that an observed lack of coordination is correlated with greater activity in areas associated with intrinsic premotor activity. This implies that social coordination may involve focusing more awareness on another's actions and inhibiting planning one's own actions, and that being uncoordinated with someone you are observing may involve a focus on planning one's own motor movements or inhibiting attention to another's movements.

These studies shed light on the way that physical coordination works, both within and between individuals. Gradual physical coordination within a pair involves the entrainment of oscillations that are happening all the time in behaviors like breathing and walking, but entrainment also happens between intentional movement patterns. Two related insights may also be applicable in the study of conversation: (1) entrainment decreases overall effort within the system (as shown by Porzel, Scheffler, and Malaka, 2006), and (2) coordinating with another person involves inhibiting one’s own planning while attending to the other person’s actions. The first insight may also describe what happens within the ‘system’ of conversation as utterances become more routine and turn-taking patterns become more regular. The second insight describes how this decrease in effort may be accomplished, cognitively speaking.

1.3 Theories of Social Coordination

Not all useful aspects of conversation can be described in terms of information exchange or the entrainment of oscillations, however. Many times, a speaker’s most salient goal is to make their partner feel comfortable, and any apparent exchange of information is trivial, as in “small talk” about traffic or the weather. This kind of conversation is prevalent between strangers, as suggested by Tickle-Degnen and Rosenthal’s model of rapport (Tickle-Degnen & Rosenthal, 1990). During the course of an interaction, speakers will begin with high levels of positivity toward each other, but low levels of coordination. Over time, this balance will shift so that later in their interaction history, they will be well coordinated but will display less positivity. In this model, positivity seems to substitute for coordination so that it can be established naturally over time, but without either person leaving the interaction before coordination is established, due to negative feelings. This also provides a framework for understanding differences between friends' and strangers' conversations: strangers may be poorly coordinated, but more positive or polite; friends' speech may sound more negative, but their communication is better coordinated.

Behavioral evidence for differences between friends and strangers' conversation supports this framework: strangers' conversations may be more stilted and less content-heavy, but overcoming poor coordination leads to feelings of positivity, and conversations between close friends contain fewer politeness markers and more references to implicit knowledge. A study of conversational fluency and emotion suggests that brief silences or interruptions in conversation have negative emotional impact, making mutual positive feeling itself a function of close conversational coordination (Koudenburg, Postmes, & Gordijn, 2011). In this study, conversations that flowed produced feelings in listeners of greater belonging, self-esteem, validation, and consensus, while those that included a brief silence or a non-response were perceived as awkward, isolating, and discordant. A close analysis of recorded natural conversations between close friends or acquaintances directly coded several aspects of conversation identified by naive judges as typical of the speech of friends vs. acquaintances (Planalp & Benson, 1992). This study showed that friends' conversations were characterized by references to mutual knowledge and greater self-disclosure or detail, while acquaintances' conversations were "more superficial, demographic, shallow and contained more surface information" (Planalp, 1993: 340).

Guided by the rapport framework, I interpret these studies to mean that conversational coordination and speakers' positive affect are interdependent. Speakers' emotional states could easily be incorporated into an expanded model of interactive alignment between speakers like that in Figure 1. Because most acquaintances have the initial goal of maintaining positivity with their partner; this may lead to choosing topics of conversation that are easier to manage while partners are simultaneously working to coordinate everything from turn-taking to terminology. Likewise, more fluent conversations are experienced as positive because they require less effort, implying that coordinative effort and positive affect should have an inverse relationship in conversations between strangers. Coordinating a conversation can be difficult, and speakers' ability to make it pleasant (if they cannot make it easy) is required in order to convert acquaintances into friends over time.

1.4 Theories of Coordination in Conversation

Two recent theoretical proposals involve elements of each of the approaches that I have outlined above: the "emulation" approach articulated by Garrod and Pickering (2009), and the dynamical systems approach (Shockley, Richardson, & Dale, 2009; Spivey, 2010). To some extent, these are complementary proposals. Shockley and colleagues draw on a tradition of descriptive research in coming up with an optimal mathematical approach to the study of human interaction. Garrod and Pickering are more concerned with the cognitive mechanics behind these interactions, and with determining the nature of conversational coherence. These two branches approach the problem of conversational coordination differently, but they may be compatible as the theoretical and descriptive arms, respectively, of a slightly-more-unified theory of conversational coordination.

Dynamical systems research on physical interaction during conversation draws on earlier descriptive studies of posture and sway coordination (Condon & Ogston, 1971; Newtson, 1994; Kendon, 1970). These studies showed that face-to-face conversation was not just a convenient medium for exchanging words and meaningful facial expressions, but also an activity that encouraged physical synchronization. Based on these observations, researchers in human kinetics have shown that the mathematical techniques used to predict dynamical entrainment of physical movements in other systems can be applied to conversation as well (Shockley et al., 2003; Richardson, Dale & Shockley, 2004). Language use serves as a coordination device; the dynamics of conversational coordination can be described by the same means used to describe other cases of coordination.

Recent work by Garrod and Pickering points to predicting others as a motivator of cross-modal alignment (2009; 2013). The authors focus on the importance of prediction as a goal that promotes coordination and alignment between joint actors. They point out the central role of interpersonal similarity in the achievement of aligned representations: "Alignment is typically achieved... because people start off at a very good point... they can, in principle, use knowledge about themselves to understand and, in particular, predict their interlocutor" (Garrod & Pickering, 2009: 294). Garrod and Pickering refer to this as *emulation,* importantly different from the concept of *simulation* in which speakers generate a model of their listener, including their listener's representation of the conversation, in order to tailor their contribution to their audience. Simulation is conceived of as a strategic process that is not fully automatic but requires the investment of cognitive resources – the opposite of automatic, resource-free priming.

A basic assumption of the emulation approach is that interlocutors are intrinsically motivated to predict each other's actions. This seems to be necessary in order for priming to produce useful alignment; for example, the authors claim that "[f]or joint activity to be successful, [interlocutors] need to predict those actions" (Pickering & Garrod, 2009: 1163). However, several questions remain concerning the relationship between priming and having shared goals or intentions of mutual prediction, for example: Is priming facilitated by shared intentions to predict each other? Can conversations be carried out without the goal of mutual prediction?

Pickering and Garrod acknowledge that there are coincidentally joint actions (especially non-linguistic ones) that are not guided by goals of coordination – for example, the phenomenon of clapping in sync that sometimes happens spontaneously in concert halls (Neda et al., 2000). However, they also assert that non-linguistic alignment may indirectly lead to alignment of mental models. Intentions in a loose sense, e.g. the "need to predict" articulated above, appear to be important for the emulation account as a bridge between language and non-linguistic behavior. Unintentional joint actions, e.g. those not guided by this "need to predict" or by any goal by which the joint activity can be judged "successful," may still produce alignment between individuals. Just as Huygen's clocks aligned when they were physically connected by a wall, interlocutors may align merely by virtue of their connection through sound and vision. Their unintentional alignment could even be linguistic, as in the case of structural priming and word learning from overheard speech (Shneidman et al., 2014). In this case, overhearers are clearly not trying to align with the conversations around them, nor do they have any need to predict the speech of others with whom they are not in conversation. Yet, mere exposure to language and other patterned human behaviors (e.g. clapping, walking) seems to bring alignment along in its wake. How much influence does such unintentional alignment have? Or to put the question differently, is goal-oriented alignment privileged in the influence it has across levels of representation?

1.5 Behavioral Evidence for Cross-Modal Alignment

These theories pose interesting questions about the relationship between non-linguistic and linguistic behavior in humans. Language has a special function among the other gesture types that humans have developed: it is the best system we have for representing and accurately communicating symbolic or semantic information. However, this special function does not necessarily make it a completely different beast from other kinds of gestures. With that in mind, here are a few questions that the above theories leave open:

- How many "levels" are in play in coordinative contexts?
    - Which ones can influence alignment at other levels?
    - Which are primarily internal, and which are primarily external?
- Does conversation always involve the need or desire to predict another person's behavior?
- Is alignment primarily intentional, or primarily unintentional?
    - Which of these exerts the most influence across levels?
- Is dynamic stability important in determining the strength of alignment that crosses levels?
- Which has more power to align our representations: dynamically stable rhythms, or goal-directed collaboration?

It is beyond the scope of this dissertation to answer all of these questions. The present work will focus on issues related to the last three questions – about intentionality, dynamic stability, and goal-directed collaboration. The earlier questions are mentioned because it may be necessary to make assumptions that answer them in order to coherently interpret the results of my research.

Recent behavioral data may address one or more of these questions by illuminating possible connections between conversational alignment and physical alignment. Research conducted by Wiltermuth and Heath (2009) showed that specific rhythmic actions - walking in step, passing a cup from left to right, and singing at the same tempo – can be related to cooperative choices in a public-goods game, and also to higher ratings of closeness and trust. The authors interpreted their results to be in line with anthropological work showing that highly cohesive, altruistic groups frequently use rhythmic cultural activities, and may do so in order to maintain members' feelings of closeness. Several mechanisms may be at the root of this finding, for example the synchronization of internal oscillators across participants, or activation of the perception-behavior pathway by physical mimicry. Seeing others moving synchronously with oneself may activate this pathway in the same way overt or conscious mimicry does, and may bring about the same affective consequences: feeling closer to others, being more likely to acquiesce to their requests (Burger et al., 2001). A fluency-based interpretation is also possible: groups who were told to walk in step were given a trivially easy task that they could all accomplish fluently. This may have given rise to a feeling of social similarity or task fluency, or both. It is not hard to imagine that this feeling of ease, whether it has a cognitive or a social source, may have affected later thoughts and behaviors.

Another study that addresses the effect of physical rhythm on cooperative behavior comes from the developmental literature. Kirschner and Tomasello conducted a study in which 4 and 5-year-old children participated in one of two directed play scenarios, and then followed by participating in several dyadic problem-solving games (Kirschner & Tomasello, 2009). The difference between the directed play scenarios was whether the joint task was rhythmic/musical or not: in one scenario, children were instructed to play with and "wake up" several toy frogs presented to them; in the second, they were directed to sing a song about the frogs and use them as percussive musical instruments. The problem solving games were meant to provoke cooperative behavior between children, and involved several simple mechanical puzzles in which collaboration solved the problem faster than independent behavior. The authors hypothesized that children in the rhythmic/musical task would be more cooperative and faster to realize the collaborative solutions. After adjusting for gender differences, the initial directed play phase had a small but significant positive effect on the later cooperative behavior. This effect was evident in results from counts of cooperative acts, amount of time spent helping the other child, and collaborative language (e.g. uses of the word "we," question proposals instead of imperatives). The authors interpreted their results as showing that the ritualized context and routinized activities involved in the musical game produced better bonding through the “chameleon effect” mediated by the perception-behavior pathway. This pathway is hypothesized by Chartrand and Bargh (1999) to link perceptions of similar behavior in others to beliefs about their likeability or similarity. Kirschner and Tomasello also suggest that the musical condition in their study may have raised mood and thus induced a prosocial bias in participants.

Coordination is not just an artifact of co-present conversations, as recent research on telecommunication has shown. Most of the research addressing our behavior while on the phone has focused, quite naturally, on language output (Godfrey, Holliman, & McDaniel, 1992; Canavan, Graff, & Zipperlen, 1997). However, it seems that several types of physical coordination that were thought to be co-presence-specific persist even when a conversation partner is not visible. Tele-present speakers frequently make emphatic (but rarely deictic) gestures while talking, albeit at a lower rate than physically-present speakers (Bavelas, Gerwing, Sutton, & Prevost, 2008). Other research shows that pairs having conversations via cell phone fall into step with each other during natural conversation even without supplemental step-timing signals (Murray-Smith et al., 2007). In the latter study, participants walking in a park talked to each other on mobile phones, some of which were augmented to give feedback indicating their partner’s movements. Several speech conditions were used, including natural conversation, a picture description task, and scripted conversation (reciting a Monty Python sketch). Speakers’ walking rhythms were found to entrain to each other in all cases, but most strongly in the natural conversation condition and in the picture description with force feedback condition. These results support the authors' prediction that free conversation would produce the greatest synchrony in walking rhythms. However, the feedback-augmented phones did not significantly add to gait synchrony in a reliable way across all conditions.

These studies demonstrate convergence between actions at the motor level and actions at the social or linguistic level. What they do not demonstrate is directionality: participants talking on mobile phones (linguistic) started out walking at different paces, but converged to similar paces (motor). Children who played a musical game (motor) talked to their peers more when solving problems later (linguistic/social). The number of modalities involved in a conversation (social) influenced the amplitude and frequency of gestures accompanying speech (motor/linguistic). And adults who walked in a group, played a rhythmic game, or sang at the same tempo (motor) were less likely to make selfish choices in an economic scenario (social). This suggests that there may be more than one route of influence between levels that become aligned; at the very least, it shows that the route is bi-directional.

The "spooky-action-at-a-distance" character of the results in these studies suggests a lack of clarity about the levels of analysis needed to adequately describe conversation as an interactive system. Specifically, more clarity is needed to distinguish between intrinsic and collaborative actions, and to determine the importance of intentionality. Increased alignment may be equally likely to come from unintentional joint actions as intentional ones, calling into question the role of intentionality. In a framework that relies on automaticity and priming to do the basic mechanistic labor of alignment, it is troubling that intentionality may be required to trigger the emulation that alignment relies on (Pickering & Garrod, 2004; 2009).

One reason the Interactive Alignment account is so appealing is its focus on automatic processes that do not tax cognitive resources, making it possible to explain why conversation happens so easily. Priming, imitation, and routines help interlocutors create the path of least collaborative resistance that conversations follow. Similarly, physical imitation and routines help us coordinate with each other physically. When performing a repetitive activity with another person, our movements become more similar because oscillating physical behavior tends to entrain to a common frequency. The entrainment of oscillations is not only - perhaps not even primarily – found across pairs, but occurs pervasively within individuals. Whenever one gesture is performed simultaneously with another gesture, the two patterns have a tendency to constrain each other (Port, Tajima, & Cummins, 1998). These constraints work to reduce the total amount of effort required by the system; if this system is a human being, then entrainment of oscillations will reduce the amount of attention and work required to perform the actions involved. The most familiar example of this phenomenon in humans may be the poor coordination and difficult internal entrainment involved in fulfilling the request to "pat your head and rub your tummy," an action many of us attempted in childhood. Performing these two actions at once requires a nontrivial amount of attention and executive control even as an adult. As with other exercises in inter-limb coordination, the patterns of the two motions settle into the same relative frequency, in this case usually a 2-to-1 (pats to rubs) frequency ratio. When they settle into these frequencies the action becomes easier, and can be carried on indefinitely. This example calls attention to the entrainment of rhythms, but entrainment applies equally to less-obvious oscillating behaviors like postural sway and the breath cycle during speech (Shockley, Santana, & Fowler, 2003).

Conversation is certainly more complicated than patting your head and rubbing your tummy, but by adulthood it has become much more practiced, and many routine conversations require minimal attention to be successful. Studies of internal and external sources of coordination can shed light on the many levels at which we must coordinate actions during conversation. Sources of internal coordination during conversation can include the interface between word selection and sound production (Dell, 1986), timing of gesture beats with syllable emphasis (Rusiewicz, 2011), and timing of breaths or other physical movement within phrase structures. External things that talkers coordinate themselves with during conversation can include a conversation partner's accent, volume, pitch, or speech rate, audible rhythm or music, a conversation partner's gesture timing or syllable timing (Shockley, Santana, & Fowler, 2003), and their motor activities, goal-directed or otherwise (Chartrand & Bargh, 1999; Murray-Smith et al., 2007; Richardson, Dale, & Kirkham, 2007). Not all of these things may be coordinated over the course of any single conversation, but the examples above reiterate the complex nature of what is coordinated during conversation.

The literature leaves us with a provocative question to pursue: What is the precise relationship between "helpful" conversational effort towards the alignment of perspective, and non-isochronous embodied rhythms? Studies of cross-modal coordination have thus far been either fine-grained examinations of spontaneous coordination dynamics in limited experimental conditions (e.g. Ouillier et al., 2008; Richardson et al., 2005) or have used more realistic tasks that do not preserve the level of detail at which coordination dynamics are important (Wiltermuth & Heath, 2009; Kirschner & Tomassello, 2009). One purpose of my research is to bridge these literatures by observing the influence of coordination dynamics on a more open-ended activity. To explore the cross-modal influence of joint physical coordination on conversational coordination, I conducted the following experiments in order to investigate whether the convergent results seen in the studies above would obtain in a more controlled situation.

1.6 Description of Experiments

Experiment 1 was designed to explore the relationship between physical coordination and conversational behavior – in this case, between clapping in rhythm and helpful perspective-taking behavior while giving directions. I manipulate the degree of physical coordination by varying the dynamic stability of clapping, allowing me to investigate this source of interpersonal coordination and its potential impact on conversation. Varying clapping patterns based on their dynamic stability provides greater specificity than the binary "on/off" approaches to physical coordination that have been used in both social and purely kinetic studies of this topic. The impact I am looking for in conversation is helpful language, similarly to Kirschner and Tomassello (2009), but also more specific: in Schober's (1995) study of helpful language used by speakers when recording directions versus speaking to a live partner, he identified three features of helpful language that can vary based on a speaker's intended audience. In Experiment 1, I count these features in participants' speech as a measure of effort toward the mutual goal of identifying a target object on a simplified map. The features represent a departure from the director's default perspective and may involve mental rotation or other representation changes in order to align the director and matcher's perspectives through conversation. In the following chapter, I present a detailed analysis of the results from Experiment 1, and explore different theoretical approaches and behavioral evidence that suggest a coherent reason why directors who were more closely physically coordinated were actually less likely to show evidence of close coordination in their language.

In Experiment 2, I examine the influence of social similarity on the effort expended toward coordinating perspective. In Experiment 1, worse motor alignment (operationalized as out-of-sync clapping patterns) actually led to more helpful behavior. This may be because rhythmic dissimilarity may have produced a feeling of cognitive dissimilarity that required more effort from directors. However, this cognitive distance may be mediated by feelings of social closeness. Experiment 2 directly manipulates feelings of social closeness in order to see whether they are responsible for the "less helpful" linguistic behavior seen in Experiment 1's synchronous condition. I use a task developed by Burger et al. (2001) intended to produce "fleeting attraction," which is associated with greater rates of request compliance. The spatial task I use can be construed as a request-fulfillment task: the matcher is attempting to comply with the director's request to draw an X in the indicated circle, and the director is attempting to give the matcher clear and concise directions that help her construct an accurate mental image of the target location.

Experiment 3 manipulates rhythmic entrainment in the absence of social influences. In the current literature, it is unclear whether the critical element in cross-modal alignment, as in Kirschner and Tomassello's work, is social co-presence or the dynamic entrainment of motor rhythm (Kirschner & Tomassello, 2009). Thus, to separately examine the components of a social rhythmic task, Experiment 3 employs a form of rhythmic entrainment that is not social. In this study, the perspective task alternates with a "solo" version of Experiment 1's motor task: participants individually clap to a metronome in either a "difficult" rhythm (analogous to the Asynchronous condition in Experiment 1) or an "easy" rhythm (analogous to the Synchronous condition). Participants them come together as pairs to perform the dyadic spatial location task. Importantly, because they are unaware of whether their partner used a fluent or disfluent rhythm in the initial task, their feelings of similarity to each other should not differ on the basis of the clapping conditions. This addresses the "emulator" hypothesis of Pickering and Garrod's (2009, 2013) more recent work, in that participants' motor coordination while alone should not inform the content of the emulator they use to direct their behavior in the spatial location task. However, subjective motor disfluency may carry over into the spatial location task and covertly inform the degree to which speakers put effort towards being helpful. The observation that "effort breeds effort" may come from the influence of non-goal-oriented motor feedback on the emulator.

In Experiment 4, I isolate the influence of motor fluency from the social and rhythmic components that accompany it in Experiment 1. As previously alluded to, fluency – especially motor fluency – may be misattributed as liking (Bornstein & D'Agostino, 1994) or task ease (Casasanto & Chrysikou, 2011) and may carry over to later tasks. This misattribution of subjective fluency would affect alignment by leading speakers who participate in disfluent motor actions to believe that they are less well-aligned with their partner, and thus to put more effort towards alignment. In order to manipulate motor fluency separately from a rhythmic motor movements such as clapping, pairs in Experiment 4 performed a motor fluency task involving moving plastic cups using chopsticks (Disfluent condition) or their hands (Fluent condition) before the direction-giving task. Also, to explore the interaction between co-presence and physical fluency in the absence of rhythm, pairs perform the motor fluency task together, as a collaborative activity (Together condition) or alone and not visible to each other (Solo condition) in the induction phase of the experiment. This produces a 2 (Fluency) by 2 (Co-presence) by 3 (Stimulus Angle) design, in which the three forms of conversational effort will again be the dependent measures.

Chapter 2

Previous research on the relationship between physical coordination and conversational behavior has shown a bi-directional influence: pairs that are physically better-coordinated tend to have better-coordinated conversations, and pairs that engage in conversations that require some degree of coordination end up better physically coordinated as well. Sometimes, the form of physical coordination allows for a great deal of variation in performance, as in Kirschner and Tomasello's (2009) rhythmic musical games; in other studies physical alignment is closely controlled and can be described in terms of its dynamic stability, as in Ouillier and colleagues' (2008) finger-tapping protocol.

Unlike social games or self-directed musical rhythms, simpler limb oscillations can be highly dynamically stable. Finger-tapping and pendulum-swinging experiments show that in dyads as in individuals, different rhythmic patterns have different relative strengths in terms of their cohesion, i.e. how likely one element is to vary from the established pattern. The pattern with the strongest cohesion is when both members of a dyad have their oscillating behaviors synchronized: pendulums up at the same time, down at the same time, moving at a consistent speed that neither accelerates nor slows down. The second strongest pattern cohesion is seen in 'anti-phase' coordination: when A has her pendulum up, B has her pendulum down, and vice versa. If the dyad is instructed to speed up, this anti-phase pattern eventually entrains to a synchronous pattern. Less cohesive patterns of coordination can vary in their complexity, but under speeded conditions all of them settle first to an anti-phase and then synchronous oscillation, or directly to synchrony. To take advantage of these facts about dynamic stability, the task developed for this experiment uses a Synchronous pattern, an anti-phase or Alternating pattern, and an Asynchronous pattern that is deliberately less cohesive.

Naturalistic movements that can be cleanly linked to patterns of dynamic stability have, with a few notable exceptions (Murray-Smith et al., 2007) not been paired with naturalistic conversation tasks in previous research. Substituting a motor task with synchronous, anti-phase, and asynchronous conditions for the mixed social/motor tasks used in previous research allows allow me to observe whether the influence of motor coordination on conversational alignment is directly related to the stability of that motor coordination. And while undirected conversation is the most natural, and would allow for the greatest insight into conversational alignment "in the wild," I am interested in detecting the influence of physical coordination on the alignment of representations, so the conversation task I chose is one in which the language produced can be easily linked to the alignment of talkers' representations.

One situation in which mental coordination between speakers matters in a measurable way is in the communication of spatial instructions. In general, people have a very consistent way of thinking about and talking about space. Almost all languages provide speakers with a direction-giving toolkit that includes allocentric (externally-referring) and egocentric (self-referring) terms for describing space and locations (Levinson, 2003). This consistency is important, because successfully navigating spaces can help us achieve goals, and failing to successfully navigate can be not only frustrating, but sometimes dangerous, as anyone who has been lost in an unfamiliar city can attest. Spatial language needs to be clear and consistent in order to give accurate directions, and it *can* be clear and consistent to the extent that humans navigate their environment in largely similar ways. So while "my left" and "your left" currently describe very different locations, if we were standing together and facing the same direction, the location that "my left" and "your left" refer to would be the same location. Confusion can still occur, however, when people do not specify (e.g.) from whose left the oncoming train is approaching, use a landmark that is not in common ground, or are unaware of the most helpful perspective from which to give directions (Bowerman & Pederson, 1992; Talmy, 2000; Levinson et al., 2003; Khetarpal, Neveu, Magid, Michael, & Regier, 2010). In these cases, the pair must spend time and energy negotiating a common representation of the space in question. By examining these negotiations interleaved with cases of varying rhythmic coordination, I hope to shed light on an undecided issue: whether coordination between pairs at one level influences coordination at another, and whether the strength of this influence is based on the dynamic stability of a pair's oscillating physical coordination.

In order to induce motor coordination while predictably varying levels of dynamic stability, I asked pairs to clap along to an electronic metronome at 82 beats per minute in one of three distinct rhythms: Synchronous (both clapped on identical beats), Alternating (each clapped on alternating beats), or Asynchronous (one partner clapped on every third metronome beat and the other clapped on every fifth metronome beat). These rhythms are depicted in Figure 2. Metaphorically, the clapping behavior of each partner can be represented as an angular wave. Partners who clapped together participated in synchronous motor coordination, moving at the same time and in the same way, as though the waves representing their behavior were overlaid; each partner clapped 82 times per minute. Partners who clapped in the Alternating rhythm participated in anti-phase coordination, as though the waves representing their behavior had the same period, but the frequencies of the claps were offset by half a period, resulting in no overlapping behavior between partners; each partner clapped 41 times per minute. Partners who clapped in the Asynchronous condition participated in a complex coordination scheme in which only 1 of every 15 beats produced simultaneous clapping; the 3-beat partner clapped 28 times per minute and the 5-beat partner clapped 17 times per minute. This pattern was expected to be the least "stable" of the three clapping conditions.

Previous research in dynamical systems has shown that under speeded conditions, asynchronous movements shift to a pattern of synchronous movements, sometimes with an intermediate stage in which movements alternate or the frequency of one partner's movement is double that of the other partner's movement (Kelso & Engstrøm, 2010). Since the tendency is always for these movements to shift from chaotic to synchronous, the synchronous pattern acts as an attractor. Synchronous patterns of movement are the strongest attractors, Alternating patterns the second strongest, and Asynchronous patterns (a category more diverse than the 3-versus-5 pattern I chose here) are the weakest attractors, and the most likely to converge toward any other, stronger pattern over time (Schmidt & Richardson, 2008). In this experiment, the stability of these clapping rhythms is a reflection of the strength of each pattern as an attractor in interpersonal motor coordination. These patterns were the same through all four rhythm-induction blocks of the experiment. In a fourth, Control condition, participants worked on problems from the Embedded Figures Task (Witkin, Oltman, Raskin, & Karp, 1971) instead than clapping to the metronome.

The conversational coordination task I used is drawn from Schober's (1993) experiments on the language of perspective-taking. This task was designed to elicit spatial descriptions by speakers in monologue and dialogue situations. Speakers are directed to describe a simple diagram that includes two objects in a field, and clearly depicts the location of the speaker and the listener on the perimeter of the field. Three examples are shown in Figure 1, and the complete set is shown in Appendix A. Because my interest is in the development of the interaction between speaker and listener over time, I replicated the dialogue condition, but not the monologue or new-listener conditions of Schober's original study. For each diagram, one partner had an 'x' in a particular location and the other partner did not. The partner with the 'x' was referred to as the Director (the person giving information about the location of the 'x') and the partner without the 'x' as the Matcher (the person seeking information). Partners switched Matcher and Director roles at every diagram, in order to balance out the possible demands of information-giving and information-seeking roles.

Spatial and perspective information can be presented in a variety of ways. Different location descriptions, or "locative expressions," can imply particular ways of conceptualizing the relevant spatial relations, and can also indicate the perceived balance of "least collaborative effort" toward the locating task. Schober (1993) describes locative expressions in terms of two dimensions: spatial perspective and conceptual perspective. Spatial perspective can be indicated relative to the speaker or to the hearer, e.g. by describing an object as being "on my right" (in these experiments, the Director's perspective) or "on your right" (the Matcher's perspective). In addition, this spatial perspective can be expressed explicitly or not: "on your right" and "on the right" may refer to the same location, but the first phrase articulates the perspective that is left implicit in the second phrase. These two different phrases demonstrate that speakers can contribute effort towards spatial alignment by altering their utterances directly by explicitly marking whose perspective is being taken, or by altering the orientation of the mental map they use to plan their utterances; they do not have to do both. Conceptual perspective can be classified as *static* ("on the right"), *implied path* ("towards me"), or *directional* ("the first one you get to"). Static descriptions may demonstrate a less detailed spatial representation, since they only specify the location of the object in an absolute sense. Implied path and directional descriptions involve locating not only the target object, but also another object in the scene relative to which the target is described. All else being equal, the explicit marking of the matcher's perspective through a path description can be taken as representing stronger effort toward producing a clear description for the matcher in this task. As in Schober's (1993) experiment, I also manipulate the degree of effort needed for perspective taking by presenting diagrams at varying offsets between the director's and matcher's spatial perspective. Specifically, the two perspectives were arranged at 0-degree offset (identical), 90 or 270-degree offsets (right angles), or 180-degree offset (reciprocal).

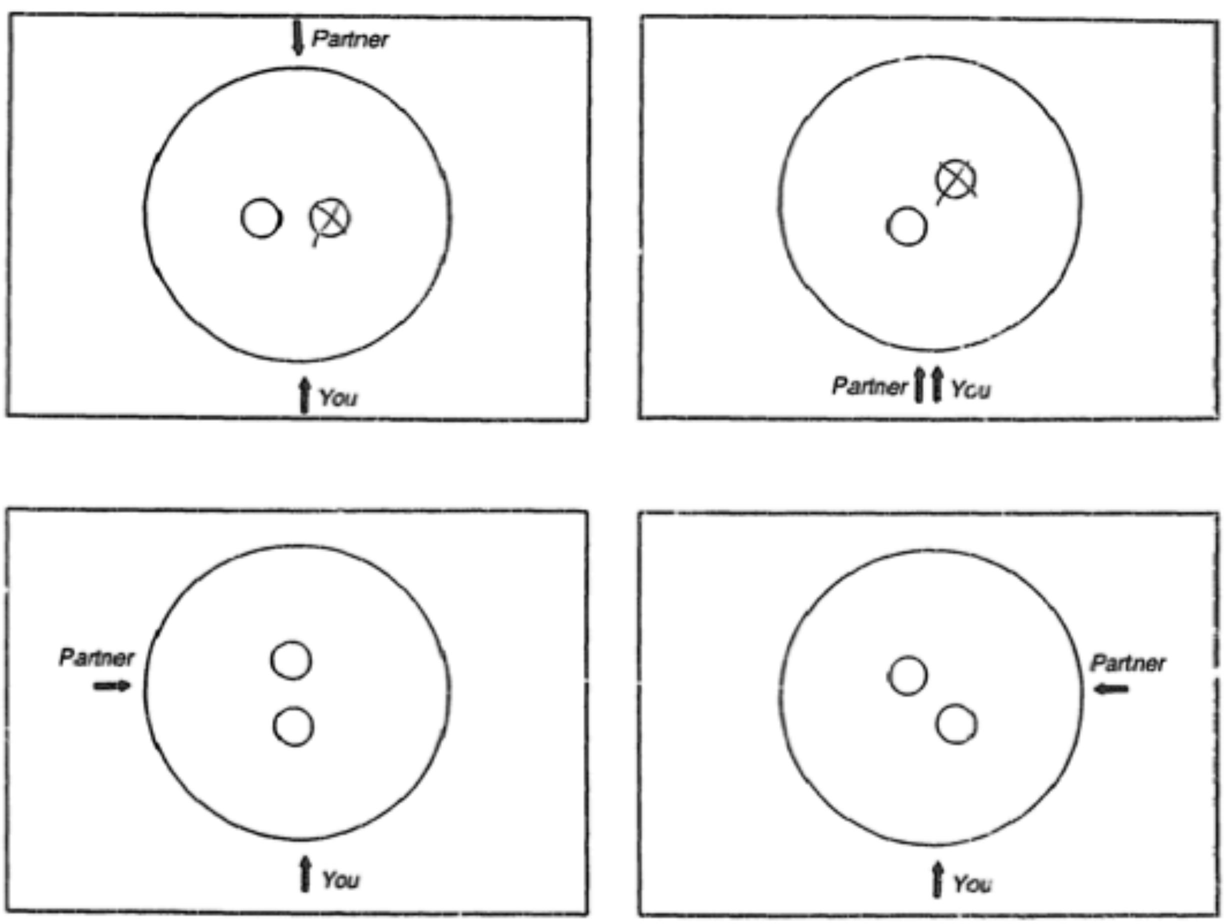
Of interest, then, is whether the motor coordination present during the clapping task would have a direct impact on markers of perspective taking in the spatial coordination task. Specifically, the act of clapping together should produce different levels of physical alignment between partners: the most between pairs in the Synchronous condition, less in the Alternating condition, and the least in the Asynchronous condition. Will this physical alignment influence *cognitive* alignment between partners, resulting in greater propensity for taking the other person's perspective? Since pairs in the Synchronous condition will have already put effort into aligning behaviors physically – by coordinating well enough to clap at exactly the same time for 60 seconds – the amount of effort they must use to mentally rotate the map between perspectives or to describe a location from their partner's perspective may be reduced. By contrast, in the Asynchronous clapping condition, individuals must maintain separate rhythms that are not easily alignable. Will this lack of physical alignment result in less evidence for alignment toward their partner's perspective and partner-oriented descriptions?

2.1 Method

Participants. Seventy-two Northwestern University undergraduates participated in this experiment for partial course credit. All participants – 47 female, 25 male - were native speakers of English. Participants were scheduled in pairs: 9 pairs in the Synchronous condition, 9 pairs in the Alternating condition, 10 pairs in the Asynchronous condition, and 8 pairs in the control condition.

Materials. The materials used are the same simplified perspective diagrams used by Schober (1993) in his experiments on the language of spatial perspective-taking. Speakers are directed to describe a simple diagram that includes two objects in a field, and clearly depicts the location of the speaker and the listener on the perimeter of the field. Three examples are shown below in Figure 1, and the complete set is shown in Appendix A.

Figure 2.1. Diagrams Showing 0˚, 90˚, and 180˚ Separation Between Perspectives (from Schober, 1993).



The diagrams presented two simplified circular objects that forced speakers to describe them in terms of their position and relationship to other objects in the diagram. Circles are used because they lack an intrinsic spatial orientation. On each trial, Directors and matchers each received a separate diagram with their own perspective marked as "You" and their partner's perspective marked as "Partner." Four of 16 diagrams were set up with both perspectives at the same point (0˚ apart). In describing these diagrams, Directors did not have to perform any mental rotation – describing the location of an object from their partner's perspective was only as effortful as describing the location from their own perspective. Previous research has found evidence that even with no separation between perspectives, speakers do put a degree of effort into taking the listener's perspective (Duran, Dale, and Kreuz, 2011). However, I believe the contrast between this "shared" perspective and the offset perspectives shown in Figure 1 is enough to produce significant differences from baseline, even if, as Duran and colleagues suggest, baseline use of perspective-taking language is nontrivial. Four of the 16 diagrams had the perspectives offset by 90˚, and four were offset by 270˚. Since the degree of mental rotation is the same in both these categories, they are treated as one category in the analyses throughout. The last four diagrams had the perspectives offset by 180˚; these diagrams require Directors perform the greatest angular rotation in order to take the Matcher's perspective. Each diagram was printed on a separate sheet of paper, and the diagrams were arranged into separate stacks for each partner.

In addition, I also prepared a post-experimental questionnaire (shown in Appendix B), intended to discover how the task (especially the clapping conditions) affected people's stance toward each other, or if other factors, like physical comfort during the task, were interfering with the effect of the clapping rhythms. Specifically, the questionnaire asked whether participants had felt comfortable during the rhythm induction (or control) task, how difficult they had found the rhythm (or control) task, how much effort they had put towards taking the other person's perspective during the verbal task, and three social affect measures rated on a 1-9 Likert scale: how much they liked their partner, how close they felt to their partner, and how similar they felt to their partner.

These questions were chosen to explore possible influences of other factors on the speakers' behaviors. For example, if the Asynchronous clapping rhythm made participants feel uncomfortable during the experiment, it could be this discomfort that drives any difference in the spatial language they use, rather than an attention to differences between partners or a lack of developed rhythmic coordination between partners. Also, the questionnaire also asked participants whether they were known to each other before the experiment or not because previous research suggests that friends' conversations are noticeably different from strangers' conversations: strangers build rapport by using polite but verbose constructions, while friends' communications are short and to-the-point (Cassell, Gill, and Tepper, 2007), and may be more egocentric in terms of perspective-taking (Savitsky et al., 2011). The three social affect questions that asked about perceptions of Closeness, Liking, and Similarity were intended to how these dimensions of social perception might be affected by the primary conditions of interest. In particular, partners in the Synchronous condition might be expected to report higher Closeness and Similarity scores, since in this condition partners are most closely coordinated and participated in the most similar rhythm.

Procedure

Motor synchrony task. To induce motor coordination while predictably varying levels of dynamic stability, I asked pairs to clap along to an electronic metronome playing at 82 beats per minute in one of three distinct rhythms: Synchronous, Alternating, or Asynchronous. These rhythms are depicted in Figure 2.2, with one partner's motion represented by a red line and the other partner's motion by a black line.

Figure 2.2a. Angular wave representing Synchronous clapping rhythm.

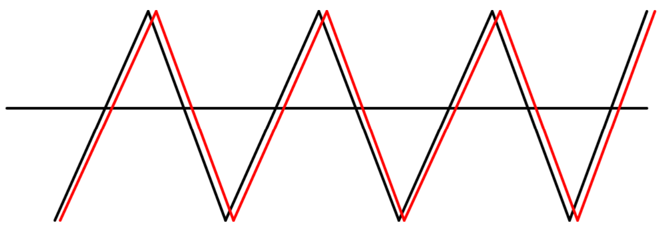


Figure 2.2b. Angular wave representing Alternating clapping rhythm.

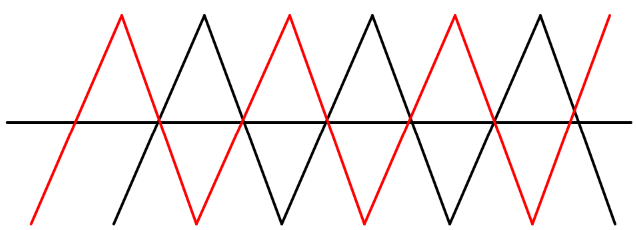
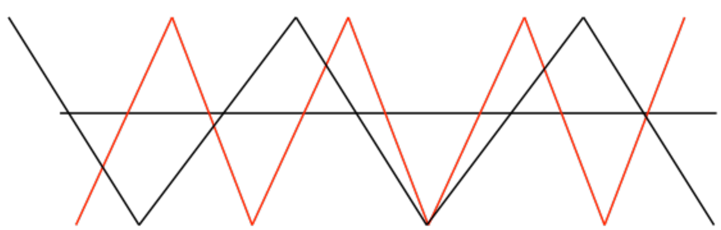


Figure 2.2c. Angular wave representing Asynchronous clapping rhythm.



These patterns were the same through all four rhythm-induction blocks of the experiment for each pair. There was also a Control condition, in which participants worked individually on problems from the Embedded Figures Task (Witkin et al., 1971) instead of the clapping task. As in the clapping conditions, the Embedded Figure problems alternated in blocks of 4 trials of the spatial perspective task.

Participants arrived in pairs and performed the motor coordination task (or control task) and conversational coordination task in a sequence of four blocks, with the clapping (or control) task always preceding the conversation task. They were told that the two tasks were unrelated. For pairs in the clapping conditions, partners sat at a table across from one another and were able to see each other as they clapped in the specified way for one minute at a time. The table used for all conditions of all four experiments in this dissertation was 36" x 48", and participants sat at the short sides of the table on non-rolling armless chairs. During the conversation task an opaque 30" x 24" foam-core barrier was placed between them as they completed the spatial location task in four 2-minute blocks, with four items per block. For pairs in the control condition, this barrier was present throughout the entire experiment. The experimenter stood at one of the long sides of the table during initial instructions and administration of the post-test questionnaire, and remained in the experiment room in order to monitor recording and timing of rounds, and movement of the barrier. The 4 blocks of clapping or the control task alternated with blocks in which pairs completed the direction-giving task used by Schober (1993) in his 'dialogue' condition. When debriefed, few participants thought the tasks were related, and none could give an explanation of how they might be related.

The timeline of the experiment is depicted in Table 1, below:

Table 2.1. Timeline of Activities in Experiment 1.

Experimental Activity	Time Required
Rhythmic Induction task (clapping)	1 minute
4 Spatial Diagrams	3 minutes
Clapping or Control	1 min
4 Spatial Diagrams	2 min
Clapping or Control	1 min

4 Spatial Diagrams	2 min
Clapping or Control	1 min
4 Spatial Diagrams	2 min
Exit Questionnaire, Debriefing	5 min

In total, participants clapped for roughly 4 minutes and completed 16 spatial diagrams in roughly 8 minutes; participants were not given instructions about speed or accuracy of completion. After all blocks were completed, participants were given the post-experimental questionnaire to complete independently. All dialogue and clapping was digitally recorded and the speech was transcribed for analysis.

2.2 Results

Coding

Pairs' speech was transcribed verbatim, and then all locative phrases spoken by directors were extracted from the directors' utterances. Each locative phrase was coded in order to determine whether directors used explicit marking of perspective, a matcher-oriented perspective, or a path-based conceptual framework to clarify their directions to the matcher. Table 2 shows examples of each of these phrase types.

Table 2.2. Examples of Locative Phrase Types.

	Present	Absent
Explicit Marking	The one on *my/your* left.	The one on *the* left.
Matcher Orientation	Up and to *your* right.	Up and to *my/our/the* right.
Path-Based Frame	The one *to/toward* your left.	The one *on* your left

Locative phrases were separated out from each utterance and their phrase type was coded independently both in order to replicate Schober's original experiment, and because in many cases, directors switch phrase types mid-utterance. Coding locative phrases independently is a more accurate alternative to coding the director's whole description of a diagram as a "hit" or "miss" for, e.g., Explicit Marking, no matter how long or how many communicative strategies directors used. Each locative phrase was coded for the presence or absence of each of these ways of marking perspective: Explicit Marking, Matcher Orientation, and Path-Based Phrasing. All three phrase types were viewed as independent of each other, for example, not all Explicitly Marked phrases were Matcher Oriented, and plenty of Matcher Oriented phrases were not Explicitly Marked. Multiple locative phrases could occur in reference to one diagram, and any locative phrase could be coded as including any or all of the effort markers.

Analysis

Analyses focused on three distinct dependent measures: the proportion of Explicit locative phrases; the proportion of Matcher-Oriented locative phrases; and the proportion of Path-Based locative phrases. Because these measures are categorical, the data from each of these measures were fit to separate logistic mixed effects regression models that included the induction task condition (Synchronous, Alternating, Asynchronous, and Control), stimulus angle (0, 90, and 180-degree), composite predictors derived from the questionnaire, and their interactions, as fixed effects. Individual speakers, speakers nested within pairs, and diagrams were included as random effects. Whenever possible, all models also included by-subject and by-item random slopes for both fixed factors and interactions. If this maximal model failed to converge, the highest-order slope associated with the smallest estimated variance was progressively removed until a model was found that successfully converged. This resulted in the random effect structure supported by the data. All models were fit using the *lmer* function in the lme4 package in R (Bates et al., 2013; lme4 v. 0.999902344-0), using maximum-likelihood estimation.

Data from a post-experiment questionnaire were also included in the logistic regression model. Questions probed on a scale from 1 to 9 how close participants felt to their partner (variable name: Close), how similar they felt to their partner (Similar), and how much they liked their partner (Like). The questionnaire also asked partners about their experience of difficulty during the experiment: how hard the verbal task felt (VerbHard), how much effort they put toward taking their partner's perspective (PerspectiveEffort), how hard the clapping manipulation felt (ManipHard; for the Control group this question referred to the control task), how much they attended to their partner during the clapping/control manipulation phase (ManipAttend), and whether they were previously acquainted with their partner (Known; binary scale). Means for these responses are shown in Table 3. Previous acquaintance was measured on a 0-1 scale but is included with the rest of the questionnaire items in all analyses and tables because communication between participants who are previously known to each other can be different from communication between strangers, and acquaintance can inform social factors such as liking, closeness, and similarity.

Answers to the questionnaire items were included in the maximal logistic regression after collapsing responses into three variables using Ward's hierarchical cluster analysis. Attempts to include all Post-Experiment Questionnaire terms independently resulted in the elimination of all random terms before convergence was reached, so I used a hierarchical agglomerative method to reduce the number of independent variables in the maximal linear model. This ensured that some random terms would remain in the models that successfully converged on a solution. Ward's hierarchical agglomerative clustering uses a minimum-variance criterion to create groups that minimize the total within-cluster variance. The clustered variables that I used in my analyses represent groups with minimal variance between responses to the items contained in the cluster. This method assumes that items that are answered in the same way share an underlying similarity. Data from each experiment was kept separate so that the clusters would reflect the response patterns of each experiment's unique population. Therefore, the clusters that emerge in each experiment will be unique to that experiment, and every effort has been made to give clusters distinctive and meaningful names that avoid confusion and facilitate later comparison.

This cluster analysis method does not depend on any external meaning that the experimenter may invest in the items, but the clusters that emerge from this process may have an obvious external interpretation. Some clusters do not have any obvious interpretation, but may instead indicate the presence of an unmeasured factor. In the analysis presented here for Experiment 1 and all other analyses, I will explain the clustered variables' meaning in terms of my theoretical assumptions. However, some interpretations may be subjective, so certain clusters' interpretations may refer to factors that are not directly measured in this experiment. Responses to all questionnaire items were converted to z-scores and summed to produce the composite variables described above. These composite variables are used as additional predictors in the linear regression.

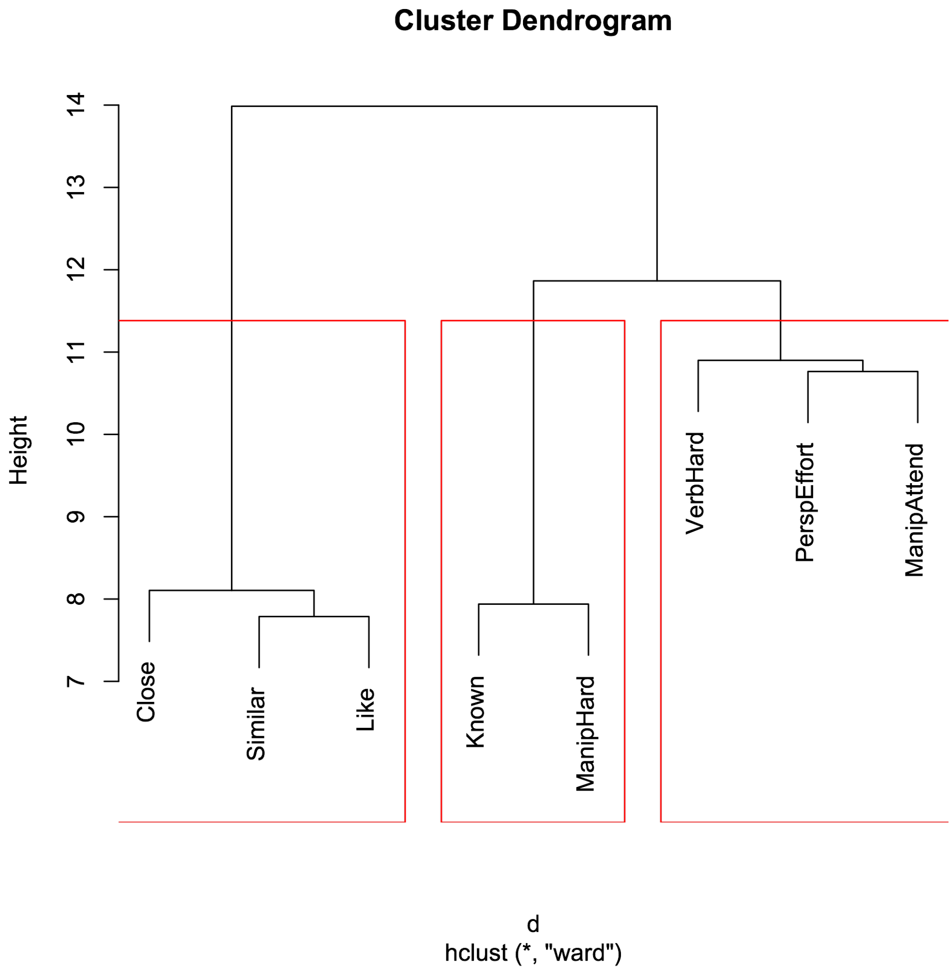
A cluster dendrogram of all questionnaire items used in Experiment 1 is shown below in Figure 3. This dendrogram shows three distinct clusters, grouped as follows:

Close + Similar + Like = Social, a composite measure that shows the generalized pro-social feeling of partners toward each other.

Known + ManipHard = Awkward, a composite measure that associates previous acquaintance with more difficulty performing the manipulation task (clapping or control; $r^2 = 0.35$). Unacquainted partners did not experience the same degree of difficulty with the manipulation task. In order to give this cluster meaning, I speculate that partners who knew each other outside of the lab may have felt the need to maintain previously-created rapport with each other, adding more effort to the rhythmic and spatial tasks involved in the experiment.

VerbHard + PerspEffort + ManipAttend = Effort, a composite measure that indicates the amount of difficulty partners associated with both the verbal task (VerbHard and PerspEffort) and the clapping/control manipulation (ManipAttend).

Figure 2.3. Cluster Dendrogram of Responses to Post-Experiment Questionnaire.



Contrast coding of the fixed effects was used to test the following hypotheses with respect to each effect:

1) Is asynchrony different from *any* kind of synchrony – either complete overlap or alternation within the same pattern? (Asynchronous vs. Synchronous & Alternating; represented in Table 2 as A[S,Alt] with contrasts in the model given values in the same order: Asynchronous = 1, Synchronous = -0.5, Alternating = -0.5)

2) Does directors' behavior in the Control condition differ from directors in any other condition? (Control vs. Asynchronous, Synchronous, & Alternating; C[A,S,Alt], contrast values 1, -1/3, -1/3, -1/3)
3) In general, do participants who are more "pro-social" toward each other use more helpful language with their partners? (greater positive score on Social cluster)
4) Does the Synchronous clapping manipulation lead to greater use of helpful language between partners? (Synchronous vs. all other conditions, interacting with reported Social composite score; S[A,C,Alt] x Social, contrast values for S[A,C,Alt] are 1, -1/3, -1/3, -1/3)
5) Are descriptions of 0˚ diagrams different from descriptions of diagrams where perspectives are offset? (0˚ vs. 90˚ & 180˚; represented in table 2 as 0[90,180] with contrasts in the model given values in the same order: 0 = 1, 90 = -0.5, 180 = -0.5)
6) Are descriptions of the two types of offset perspectives (90˚ and 180˚; represented as 90[180], contrast values 1, -1) different from each other?

The directionality (positive or negative) of the effect estimates associated with each independent variable is interpreted in the Results and Discussion sections based on the contrasts I have specified above. Positive effect estimates are aligned with "more" of the associated measure; for example, a higher value associated with the 90[180] contrast in estimating Matcher Oriented language means that there was *more* Matcher Oriented language used describing 90° diagrams than 180° diagrams.

Average proportions of Explicitly Marked, Matcher Oriented, and Path-Based locatives are presented below in Figure 3 to give a general overview of directors' language use across conditions and stimulus angles, and average responses to the post-experiment questionnaire items can be found in Table 3. Table 4 presents the results of the model fit for the main effects and first-level interactions of Condition, Angle, Social, Awkward, and Effort. Additional higher-level interactions did not have theoretically relevant interpretations and are not shown here, but are included in Appendix B.

Figure 2.4. Proportion of Locative Phrase Types Used, by Condition and Angle, Experiment 1.

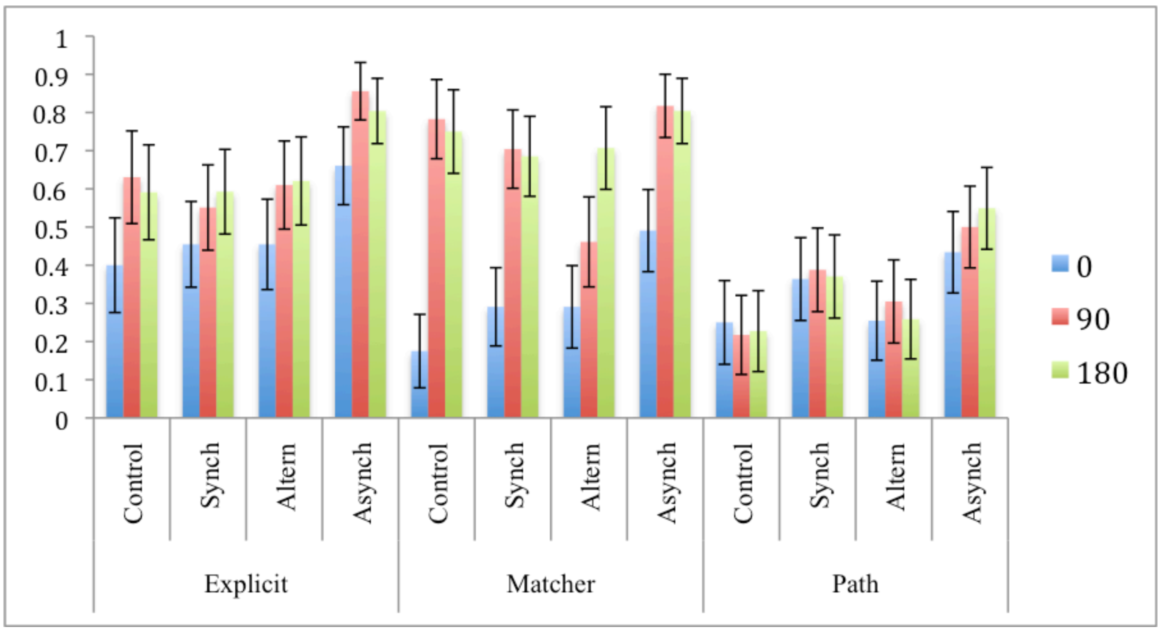


Table 2.3. Mean Scores Reported from Post-Experiment Questionnaire (7-Point Scales Except Known: 0-1).

	Synchronous	Alternating	Asynchronous
Feel Close?	3.50	2.75	2.28
Feel Similar?	5.06	3.85	4.17
Like Each Other?	6.22	5.65	5.28
Verbal Task Hard?	1.83	2.50	1.94
Perspective Effort	5.28	6.45	5.44
Clapping Task Hard?	2.56	3.30	3.28
Attend to Other's Claps?	4.72	5.90	3.22
Previously Known (Y/N)	0.33	0.10	0.06

Table 2.4. Model Estimates of Fixed Effects (with Standard Error) and *t*-scores, Experiment 1.

	Explicit Marking			Matcher Oriented			Path Based		
	Est.	SE	t	Est.	SE	t	Est.	SE	T
A[S,Alt]	0.075	0.263	0.286	0.132	0.180	0.734	0.139	0.297	0.469
C[A,S,Alt]	-0.365	0.257	-1.417	0.101	0.184	0.546	-0.396	0.269	-1.474
S[A,C,Alt]	0.084	0.255	0.330	0.021	0.180	0.117	0.030	0.290	0.105
90[180]	0.066	0.138	0.480	0.411	0.144	2.864**	-0.273	0.162	-1.692†
0[90,180]	-0.197	0.107	-1.836†	-0.003	0.095	-0.032	-0.011	0.087	-0.121
Social	-0.058	0.050	-1.172	-0.073	0.040	-1.825†	0.011	0.052	0.218
Awkward	0.066	0.087	0.759	0.088	0.080	1.097	0.110	0.094	1.169
Effort	0.077	0.069	1.110	-0.101	0.071	-1.430	-0.087	0.067	-1.296
A[S,Alt] x 90[180]	-0.258	0.262	-0.983	0.059	0.243	0.241	0.097	0.264	0.367
A[S,Alt] x 0[90,180]	0.281	0.162	1.733†	0.822	0.148	5.552**	-0.137	0.157	-0.872
A[S,Alt] x Awkward	-0.204	0.191	-1.064	-0.138	0.164	-0.841	-0.295	0.208	-1.419
A[S,Alt] x Effort	0.050	0.089	0.557	0.025	0.084	0.294	0.038	0.098	0.388
A[S,Alt] x Social	0.024	0.089	0.267	0.134	0.078	1.725†	0.071	0.103	0.684
C[A,S,Alt] x 90[180]	-0.163	0.245	-0.665	-0.308	0.231	-1.329	-0.530	0.238	-2.229*
C[A,S,Alt] x 0[90,180]	-0.663	0.154	-4.305**	-0.034	0.140	-0.240	-0.296	0.145	-2.044*
C[A,S,Alt] x Social	0.110	0.158	0.696	-0.273	0.131	-2.086*	-0.194	0.170	-1.141
C[A,S,Alt] x Awkward	0.308	0.176	1.748†	-0.179	0.176	-1.015	-0.005	0.161	-0.034
C[A,S,Alt] x Effort	-0.069	0.115	-0.602	-0.237	0.085	-2.778**	-0.121	0.114	-1.062
S[A,C,Alt] x 90[180]	-0.714	0.254	-2.807**	-0.507	0.253	-2.005*	-0.064	0.258	-0.248
S[A,C,Alt] x 0[90,180]	-0.016	0.153	-0.102	0.074	0.145	0.509	-0.550	0.148	-3.717**
S[A,C,Alt] x Social	0.289	0.174	1.660†	-0.023	0.169	-0.134	-0.290	0.197	-1.474
S[A,C,Alt] x Awkward	0.134	0.097	1.377	-0.030	0.100	-0.297	-0.073	0.106	-0.687
S[A,C,Alt] x Effort	-0.068	0.086	-0.792	-0.101	0.062	-1.634†	-0.047	0.092	-0.512
90[180] x Social	-0.006	0.105	-0.060	0.283	0.099	2.863**	0.151	0.105	1.436
90[180] x Awkward	-0.073	0.102	-0.711	0.046	0.098	0.470	0.104	0.100	1.046
90[180] x Effort	-0.064	0.081	-0.795	0.035	0.077	0.450	0.053	0.082	0.652
0[90,180] x Social	0.185	0.066	2.807**	0.134	0.061	2.202*	0.114	0.063	1.805†
0[90,180] x Awk	-0.029	0.064	-0.458	-0.047	0.059	-0.794	0.037	0.060	0.613
0[90,180] x Effort	0.007	0.042	0.156	-0.144	0.039	-3.725**	0.094	0.040	2.338*
Social x Effort	-0.063	0.038	-1.640†	0.016	0.033	0.490	0.035	0.038	0.916
Social x Awkward	-0.009	0.035	-0.256	-0.029	0.035	-0.843	0.006	0.038	0.166
Awkward x Effort	-0.054	0.046	-1.172	0.055	0.050	1.098	-0.048	0.048	-1.000

†p < 0.10; *p < 0.05; **p < 0.01

Explicit Marking

Explicit Marking indicates the director's willingness to put effort into word choice to give the matcher information about whose perspective is being used in the description of the scene. Table 4 presents the mean proportions of locative phrases that included Explicit marking of perspective, by condition and perspective angle. Collapsing across angle, these means show that directors were more likely to explicitly mark whose perspective was being taken in the Asynchronous condition (M_{asynch} = 0.79) than in either the Synchronous (M_{synch} = 0.54), Alternating (M_{altern} = 0.58), or Control ($M_{control}$ = 0.57) conditions.

Table 2.5. Mean Proportions (with Standard Deviations) of Explicitly Marked Locative Phrases, Experiment 1.

	Angle		
	0°	90°	180°
Control	0.40 *(0.50)*	0.63 *(0.49)*	0.59 *(0.50)*
Synchronous	0.45 *(0.50)*	0.55 *(0.50)*	0.59 *(0.50)*
Alternating	0.46 *(0.50)*	0.61 *(0.49)*	0.62 *(0.49)*
Asynchronous	0.66 *(0.48)*	0.86 *(0.35)*	0.80 *(0.40)*

Before accounting for the effects of the additional questionnaire-based variables, directors' behavior indicates a link between physical effort (Asynchronous clapping) and conversational effort (Explicit Marking). However, in a logistic regression model of directors' use of Explicit Marking that included clustered questionnaire responses, there was no significant difference between the Asynchronous condition and the other clapping conditions (p = 0.78), nor were the other two Condition contrasts significant. Maps that represented 0° offset between partners' perspectives were associated with less explicit marking language (p = 0.07). The clustered questionnaire variables did not produce any main effects, and were significant only in interactions with other predictors. Model estimates of the Social, Effort, and Awkward predictors show that directors who felt greater affinity toward their partner (higher Social scores) produced less Explicit Marking, while higher scores on Effort and Awkward items were associated with more Explicit Marking, albeit not significantly so. Directors in the Synchronous condition who reported more pro-social feelings toward their partner used more Explicit Marking in their descriptions ($p = 0.10$). This suggests that pro-social feelings toward a conversation partner under "easy conditions" may lead to greater use of helpful language that specifies perspectives. Asynchronous directors' Explicit Marking use was greater than other directors' only when these individuals reported low Effort and high Social feelings toward their partner, or high Effort and low Social scores (A[S,Alt] x Social x Effort, $p = 0.05$).[3] This indicates that the Social and Effort items may mediate the effect of Asynchronous clapping on Explicit Marking, although the interpretation of this effect in terms of directors' experiences and strategies is not clear.

Matcher-Oriented

Matcher Orientation indicates the director's willingness to put effort toward accommodating the matcher's perspective, regardless of whether it is explicitly marked as such in the director's description. For this measure, I conservatively coded all non-explicit utterances on 0° diagrams as Director-Oriented, since in a shared-perspective map, locative phrases that are Matcher-Oriented are no different from Director-Oriented phrases if the perspective is not explicitly marked. An example of a locative that is conservatively coded would be a director's speech about a 0° diagram that describes the target location as "On the left." Because there is no separation between partners' perspectives, it is on both the director's left and the matcher's left,

[3] Due to space constraints, this and all other three- and four-way interactions from Experiment 1 are shown in Appendix D.

and although the director may be using the matcher's perspective to structure her utterance, it is impossible to know if directors were thinking in terms of the matcher's point of view. This conservative estimate may omit some instances of Matcher-Oriented thinking. I examined each unmarked locative from 90˚ and 180˚ diagrams alongside the item to which it referred, and coded them according to whose perspective (Matcher or Director) was being taken.

Again, Directors in the Asynchronous condition were more likely to use their partner's perspective when describing locations (M_{asynch} = 0.73 (0.44)), compared to directors in the Synchronous, Alternating, or Control conditions ($M_{control}$ = 0.64 (0.48), M_{synch} = 0.59 (0.49), $M_{alternating}$ = 0.48 (0.50)). This was consistent across the angles portrayed in the diagrams; while all directors were less likely to use Matcher-Oriented language in describing 0˚ diagrams, Asynchronous directors were more likely to use this effort marker in any given diagram regardless of the angle between perspectives.

Table 2.6. Mean Proportions (with Standard Deviations) of Matcher-Oriented Locative Phrases, Experiment 1.

	Angle		
	0°	90°	180°
Control	0.18 *(0.38)*	0.78 *(0.41)*	0.75 *(0.39)*
Synchronous	0.29 *(0.46)*	0.70 *(0.46)*	0.69 *(0.39)*
Alternating	0.29 *(0.46)*	0.46 *(0.50)*	0.71 *(0.39)*
Asynchronous	0.49 *(0.50)*	0.82 *(0.39)*	0.80 *(0.39)*

Before accounting for the effects of the additional questionnaire-based variables, directors' behavior indicates that Asynchronous directors used more Matcher-Oriented language than directors in other conditions, and Alternating directors used this style less when describing 90° maps. However, in a logistic regression model of directors' use of Matcher Oriented locatives that included clustered questionnaire responses, no differences between Conditions were significant as main effects. Directors did use a different amount of matcher-oriented language depending on the angle between perspectives represented in the stimuli ($p < .005$) when looking at 90° vs 180° diagrams; this is driven by the Alternating directors' use of less Matcher Oriented phrases when describing 90° diagrams. The difference in the amount of Matcher-Oriented language used to describe 0°-offset diagrams was not significant as a main effect ($p = 0.98$). Directors who reported more positive social feelings toward their partner used less Matcher-Oriented language ($p = 0.07$). The use of different amounts of helpful language in descriptions of 0° diagrams was significant in interaction with Condition, comparing Asynchronous directors to Synchronous and Alternating ($p < 0.005$). Asynchronous directors used Matcher-Oriented language more across all angles, but this difference is especially notable for 0° diagrams. Directors in the Control condition used more Matcher-Oriented language if they reported greater pro-social feelings toward their partner ($p = 0.04$), or they put more effort toward the experiment in general ($p = 0.005$). This may indicate that there is a low baseline use of Matcher-Oriented language, but that any sense of connection or act of collaboration between partners can prompt its use.

Path-Based

Use of Path-Based descriptions indicates a director's willingness to engage in a richer representation of the map by alluding to more than one location in their description. This second location is usually one of the two perspectives represented on the map. Directors in the Asynchronous condition were also more likely to use path-based descriptions ($M_{asynch} = 0.50$ (0.50)) than those in the other three conditions ($M_{control} = 0.23$ (0.42), $M_{synch} = 0.38$ (0.49), $M_{altern} = 0.28$ (0.45)). Unlike the other two measures, Path-Based locative phrases do not seem to be dramatically affected by the angle between perspectives.

Table 2.7. Mean Proportions (with Standard Deviations) of Path-Based Locative Phrases, Experiment 1.

	Angle		
	0°	90°	180°
Control	0.25 *(0.44)*	0.22 *(0.41)*	0.23 *(0.42)*
Synchronous	0.36 *(0.49)*	0.39 *(0.49)*	0.37 *(0.49)*
Alternating	0.25 *(0.44)*	0.30 *(0.46)*	0.26 *(0.44)*
Asynchronous	0.43 *(0.50)*	0.50 *(0.50)*	0.55 *(0.50)*

Before accounting for the effects of the additional questionnaire-based variables, directors' behavior indicates that Asynchronous directors used more Path-Based locatives, and Alternating directors used the least, while Synchronous directors' Path-Based use was between these two groups. From this data, it appears that the Asynchronous rhythm is associated with enriched descriptions of the diagrams, since directors in this condition use a description style that gives more than the minimum information. However, in a logistic regression model of directors' use of Matcher Oriented locatives that included clustered questionnaire responses, directors' use of Path-Based locatives showed no main effects of Condition in any of the specified contrasts. Directors used marginally fewer Path-Based phrases when describing 90° diagrams than 180° diagrams ($p = 0.09$). Directors in the Control condition used less Path-Based language when describing 90° or 0° diagrams, based on significant interactions that involved these specified contrasts ($p = 0.03$ and $p = 0.04$, respectively). Synchronous directors use significantly less Path-Based language when describing 0° diagrams than directors in any other condition ($p < 0.001$). Reporting greater effort in the experiment is associated with greater use of Path-Based language in descriptions of 0° diagrams ($p = 0.02$) as is reporting higher pro-social feelings towards a partner ($p = 0.07$). This suggests a positive relationship between the way conversations feel (effortful, enjoyable) and the amount of helpful language used by each partner.

2.3 Discussion

In this experiment, directors who clapped in the Asynchronous pattern showed more evidence of conversational effort: they used more locative phrases that took their partner's perspective into account, marked whose perspective was being taken, and used enriched descriptions more often than directors in the other conditions. Mean proportions of directors' locative use paints a fairly consistent picture: directors who made more effort during the nonverbal task also made more effort in their descriptive task. However, the regression analysis revealed that these effects were mediated by pro-social feelings toward their partner and the degree of effort they experienced in the experiment. For example, the three-way interaction between Condition, Social, and Effort showed that the use of Explicit Marking was greater among Asynchronous directors who experienced either task difficulty in the absence of social affinity, or social affinity in the absence of task difficulty. Directors in the Synchronous and Alternating conditions were less likely to use language that deliberately aligned with their partner's perspective or provided more information about the diagram. While the addition of the clustered questionnaire variables appears to remove any main effect of condition, another perspective is possible. Taking participants' experiences into account complicates the questions I am asking in this experiment because the development of mental coordination from physical coordination may be moderated by these experiences of difficulty and positive affect.

These results also present something of a puzzle where Interactive Alignment is concerned. Pickering and Garrod (2004) proposed the idea that alignment at one level leads to alignment at other levels. The central role played by priming in the Interactive Alignment model suggests that this alignment should tend to make the behavior of one level more similar to the other, not less. Why did the best-aligned pairs on an embodied level (those who had clapped in the Synchronous and Alternating patterns) seem to be the worst at aligning on a linguistic level (or, at least not better than the control condition) – e.g. by taking their partner's spatial perspective?

If physical alignment propagates to the level of language, then those who are most closely aligned in rhythm should find it easy - or even automatic - to take their partner's perspective. Indeed, research suggests that this ease or fluency is at the root of the "perception-behavior pathway" mentioned by Bargh and colleagues (Hertwig et al., 2008) and also articulated in experiments by Alter and colleagues (Alter, Oppenheimer, Epley, & Eyre, 2007). Based on this model, motor coordination could create a sense of fluency that is misattributed as social closeness or liking. Alter and Oppenheimer's model of fluency predicts that disfluent experiences lead people to engage in abstraction to manage perceived complexity or difficulty (Alter & Oppenheimer, 2008; Alter et al., 2007). Abstracting from difficult physical actions to find a governing principle to direct those actions could lead a person to take a perspective that is more easily applied to both partners, since it is more abstract. These models can also be used to explain why disfluent conversations can produce negative results, from feelings of isolation and self-doubt (Koudenburg, Postmes, & Gordijn, 2011) to diminished executive function (Finkel, Campbell, Brunell, Dalton, Scarbeck, & Chartrand, 2006). Recent research has linked rhythmic behavior – specifically singing, drumming, and walking in step – with the promotion of pro-social cooperation in children and adults (Kirschner & Tomasello, 2009; Wiltermuth & Heath, 2009). These studies suggest a relationship between the experience of fluency in movement or conversation and behaviors that promote smooth social interactions. Why, then, does intentional rhythmic coordination lead to more evidence for cooperation (more time spent helping others in Kirschner & Tomasello, 2009; less "selfish defection" in Wiltermuth & Heath, 2009) in some studies, while more evidence for cooperation in my study was found in the language of people who were physically *less* well-coordinated?

Rather than directly influencing language planning, the subjective fluency of the rhythm coordination task may mediate a speaker's perceived need for helpful language. The obvious analogue for fluency in this experiment is the composite Effort variable, but fluency also impacts the social connection between partners. Generally, higher scores on questions clustered under

Effort were related to less Matcher Oriented language use in participants who were not experiencing any clear difficulty: either they were in the Control condition, the Synchronous clapping condition, or describing 0° diagrams. I interpret this as a feeling of effort with no obvious source, prompting directors to shift their description strategy *away from* one that centers their partner's perspective, in some cases *towards* one that provides more information about the diagram itself – a more abstract view of the problem space, one in which neither perspective is explicitly centered. This aligns with Alter and Oppenheimer's view of fluency, i.e. that disfluent experiences prompt greater cognitive abstraction in order to better identify the source of the disfluency (Alter & Oppenheimer, 2008). Abstraction may have affected conversation in two ways: experiencing disfluency, but being unable to pinpoint its source in the interaction,[4] these participants may have sensed that perspective-taking was not the source of their effort, and changed their conversational choices accordingly by shifting towards more abstract language. Additionally, if subjective disfluency prompts greater mental abstraction to enlarge the view of the problem space, directors may have taken a more "top-down" perspective where matcher-oriented language would not be as accessible. Feelings of processing fluency have been shown to influence judgments of truth (McGlone & Tofighbakhsh, 2000) and personal preference (Oppenheimer, 2008), and may be the mechanism behind the "mere exposure" effect (Bornstein & D'Agostino, 1994). Perceptual fluency may explain these results in the following way: pairs who clap in a synchronous rhythm build a feeling of perceptual fluency that carries over into the perspective-taking task. In more concrete terms, if the asynchronous clapping task produces a feeling of perceptual disfluency that is interpreted as effortful or creates social distance, directors may respond to this subjective state by enriching their descriptions: marking perspective explicitly

[4] Recall that difficulty related to the clapping or control manipulations is represented in the Awkward cluster.

and taking their partner's perspective. In this way, they might be compensating for internal discomfort or resource depletion that, in reality, is a mis-attributed feeling of motor disfluency.

No direct influence of the manipulation's difficulty (ManipHard, which clustered with Known in the composite variable Awkward) was apparent in the language measures in this experiment. It is important to reiterate here the inherent subjectivity of the clustered variables' meanings. We can easily imagine why speakers' responses to questions about closeness, liking, and similarity cluster together, but the general difficulty of the verbal task, effort put toward perspective-taking, and attention given during the nonverbal task are not so obviously related. This is a potential weakness in the present research that I will address by explaining the reasoning behind clusters as clearly as possible, but some clusters that have mathematical validity may lack semantic precision.

Chapter 3

This experiment manipulates social distance using a “minimal groups” manipulation drawn from the social psychology literature (Burger et al., 2001). This is intended to provide a test of the Compensation Hypothesis by examining whether pairs with low social similarity compensate for this by increasing their helpful contributions to the spatial location task. The prior assumption going into Experiment 1 was that differences in motor alignment would be congruent with differences in directors’ linguistic behavior – better motor alignment would produce better conversational alignment. However, “worse” motor alignment (operationalized as out-of-sync clapping patterns) actually led to more helpful behavior, as shown by the presence of more effort markers in directors’ language. Perhaps taking dissimilar actions made partners feel more distant from each other, and their helpful language was an attempt to overcome this sense of distance. However, the effect may be mediated by feelings of *social* distance, reflected in synchronous-condition participants’ higher ratings of liking and feeling close to each other (Table 3). Including questionnaire variables in the regression analysis clarified these possibilities by showing that significant movement in the language measures was not associated with the difficulty of the manipulation itself – ManipHard, represented in the Awkward cluster – but was more closely associated with directors’ social affinity for partners. Taking different actions at the same time – or performing different versions of the same task - may have produced a partner-related feeling of social dissimilarity that is unrelated to the use of rhythm or the collaborative nature of the induction task.

Previous research suggests that awareness of differences can alter perspective-taking language (Todd et al., 2011). Participants who were primed with a "difference mindset" by noticing differences (vs. similarities) between pictures were more likely to describe the location of a target object from another person's perspective in a subsequent picture-description task. This contrasts with earlier research on in-group/out-group behavior in which people who knew of differences between themselves and another person were less likely to take the other's perspective affectively, i.e. by displaying empathy towards them (Stotland, 1969). The connection between affective perspective-taking and physical perspective-taking has recently been explored in behavioral and neural research suggesting that the better someone is at mental rotation, the less they display signs of empathy towards others (Thakkar, Brugger, & Park, 2009). Thus, the jury appears to be out on the direct influence of feelings of social similarity on spatial perspective taking.

Experiment 2 addresses the question: is the presence or absence of effort toward spatial perspective-taking in Experiment 1 directly mediated by a sense of social similarity or dissimilarity brought on by the clapping task, but not directly related to rhythm or collaboration? In order to manipulate social similarity directly, I used a task developed by Burger et al. (2001) intended to produce "fleeting attraction." Participants in Burger and colleagues' study were told that they overlapped on 3 of 20 (Distant), 10 of 20 (Neutral), or 17 of 20 (Close) adjectives from a list of 50 personality-relevant descriptors (see Appendix C for this list). In Burger et al., high similarity was associated with greater rates of request compliance. This manipulation is relevant to my task because of the significance I attribute to linguistic effort: it is a sign that one partner is trying to help the other understand the difference between the two spatial representations and to successfully complete the task. The matcher in this spatial task is attempting to comply with the director's request to draw an X in the indicated circle, and the director is attempting to give the matcher clear and concise directions that help her construct an accurate mental image of the target location. Linguistic strategies that partners may use in order to increase understanding may include marking whose perspective is being taken, offering a spatial expression that represents relations between the target and other objects, rather than an objective representation of the target, and (most intuitively) phrasing locative expressions from the matcher's perspective.

This social distance manipulation will be checked using the same post-experiment questionnaire as used in Experiment 1. I expect that participants in the Close condition will report higher feelings of closeness, similarity, and liking than the Neutral and Distant groups. I also expect the Distant group to report lower feelings of closeness, similarity, and liking than the Neutral and Close groups. More importantly, however, is whether this social distance has an impact on the nature of the spatial descriptions given during the perspective-taking task.

3.1 Method

Participants

Participants were drawn from Northwestern's Psychology 110 subject pool. There was a total of 80 participants: 30 (15 women, 15 men) in the Close condition, 26 (16 women, 10 men) in the Neutral condition, and 28 (16 women, 12 men) in the Distant condition. Participants were scheduled in pairs, and all were native speakers of English.

Materials

The spatial perspective-taking task used the same diagrams as Experiment 1. The social closeness manipulation uses Burger et al.'s Adjective Checklist, which can be seen in Appendix C. This list included a variety of personality adjectives, such as adventurous, conservative, polite, and talkative.

Procedure

The Close, Neutral, and Distant conditions of the Adjective Checklist task were intended to manipulate participants' feelings of social affinity with each other, free of other potential mediators of alignment (e.g. shared embodied rhythm, varying task difficulty, investment in a collaborative goal) that may have been present in Experiment 1's clapping task. In this task, each member of the pair of participants were told to select the 20 adjectives that best described him or her from the list of 50 on the Adjective Check List. The pairs were then told that these lists would be checked against each other for overlap by the experimenter. Regardless of the actual overlap between the lists, the experimenter took the selections from each participant and arbitrarily marked 17 (for Close condition), 10 (for Neutral condition), or 3 (for Distant condition) adjectives that the participants chose as descriptors of themselves. The experimenter told the participants that the marked adjectives were those selected by both partners. List marking was performed in a separate room, and this deception was revealed during the post-experiment debriefing. The pairs then completed the full set 16 diagrams from the spatial direction-giving task following the same procedure as Experiment 1. After the spatial task, each participant then individually completed the post-test questionnaire.

3.2 Results

As in the previous experiment, counts of these locative phrase types - Explicit Marking, Matcher Orientation, and Path-Based Phrasing - were fit to logistic mixed-effects regression models that included the induction task condition (Close, Neutral, and Distant), stimulus angle (0, 90, and 180-degree), composite questionnaire responses (Social, ManipHard, and Connection) and their interaction as fixed factors. Speakers, speakers nested within pairs, and diagrams were included as random effects.

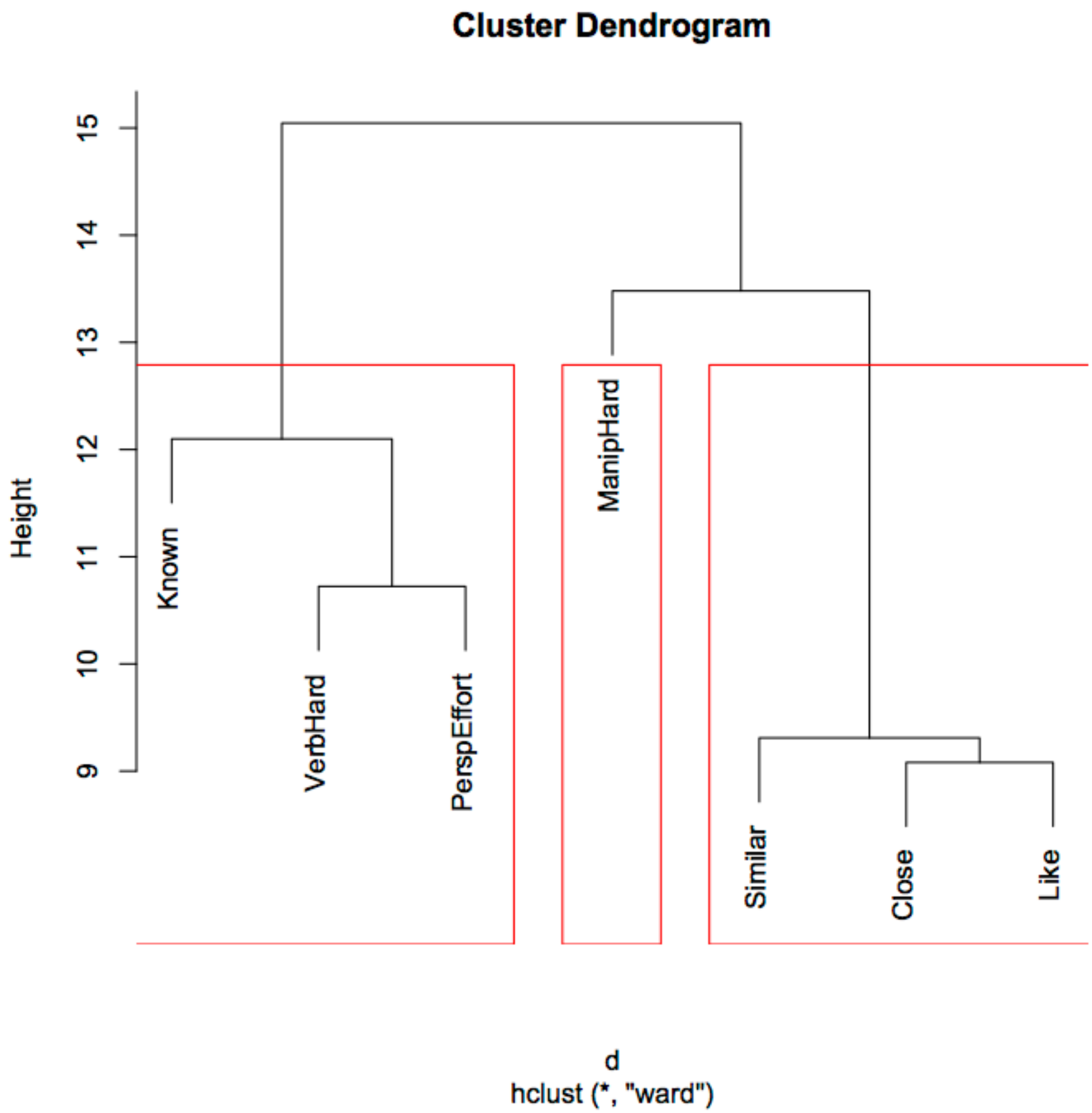
Questionnaire items probed on a scale from 1 to 9 how close participants felt to their partner (variable name: Close), how similar they felt to their partner (Similar), and how much they liked their partner (Like). The questionnaire also asked partners about their experience of difficulty during the experiment: how hard the verbal task felt (VerbHard), how much effort they put toward taking their partner's perspective (PerspectiveEffort), how hard the clapping manipulation felt (ManipHard), how much they attended to their partner during the clapping/control manipulation phase (ManipAttend), and whether they were previously acquainted with their partner (Known; binary scale). Answers to the questionnaire items were included in the maximal logistic regression after collapsing responses into three variables using Ward's hierarchical cluster analysis. A cluster dendrogram of all questionnaire items used in Experiment 2 is shown below in Figure 1. This dendrogram shows three distinct clusters, grouped as follows:

Close + Similar + Like = Social, a composite measure that shows the generalized pro-social feeling of partners toward each other. This clustered variable represents the same responses as the Social variable from Experiment 1.

ManipHard, indicating the difficulty participants associated with the adjective-picking task, did not cluster with any other items and is included as a separate predictor.

Known + PerspectiveEffort + VerbHard = Connection, a composite measure that shows the strength of the connection between partners, both outside the experiment (previous acquaintance) and inside the experiment (degree of effort towards perspective-taking, greater effort in general during the verbal task).

Figure 3.1. Cluster Dendrogram of Post-Experiment Questionnaire Items for Experiment 2.



Responses to these items were converted to z-scores and summed to produce the composite variables described above. These composite variables are used as additional predictors in the linear regression.

Contrast coding of the fixed effects was used to test the following hypotheses with respect to each effect:

1. Does perceived personality overlap make directors in the Close condition use effort markers differently than directors in the Distant condition? (represented as C[D] in Table 2, contrast values 1, -1)
2. Is behavior of directors in the Neutral condition different from either the Close or Distant conditions? (represented as N[C,D], contrast values 1, -0.5, -0.5)
3. Are descriptions of 0˚ diagrams different from descriptions of diagrams where perspectives are offset? (0˚ vs. 90˚ & 180˚; represented in table 2 as 0[90,180], contrast values 1, -0.5, -0.5)
4. Are descriptions of the two types of offset perspectives (90˚ and 180˚; represented as 90[180], contrast values 1, -1) different from each other?

The analysis was carried out the same way as in Experiment 1. The directionality (positive or negative) of the effect estimates associated with each independent variable is interpreted in the Results and Discussion sections based on the contrasts I have specified above. Positive effect estimates are aligned with "more" of the associated measure; for example, a higher value associated with the 90[180] contrast in estimating Matcher Oriented language means that there was *more* Matcher Oriented language used describing 90° diagrams than 180° diagrams.

The mean proportions of locative phrases coded for each of the three measures are presented in Figure 3, which allows us to more easily see general differences between the three conditions in terms of the amount and type of spatial descriptive language used by directors in each condition. Main effects and 2-way interactions are reported below in Table 2; most higher-level interactions did not have theoretically relevant interpretations and are not shown here, but are included in Appendix B.

Figure 3.2. Proportion of perspective effort markers used by directors across stimuli, Experiment 2.

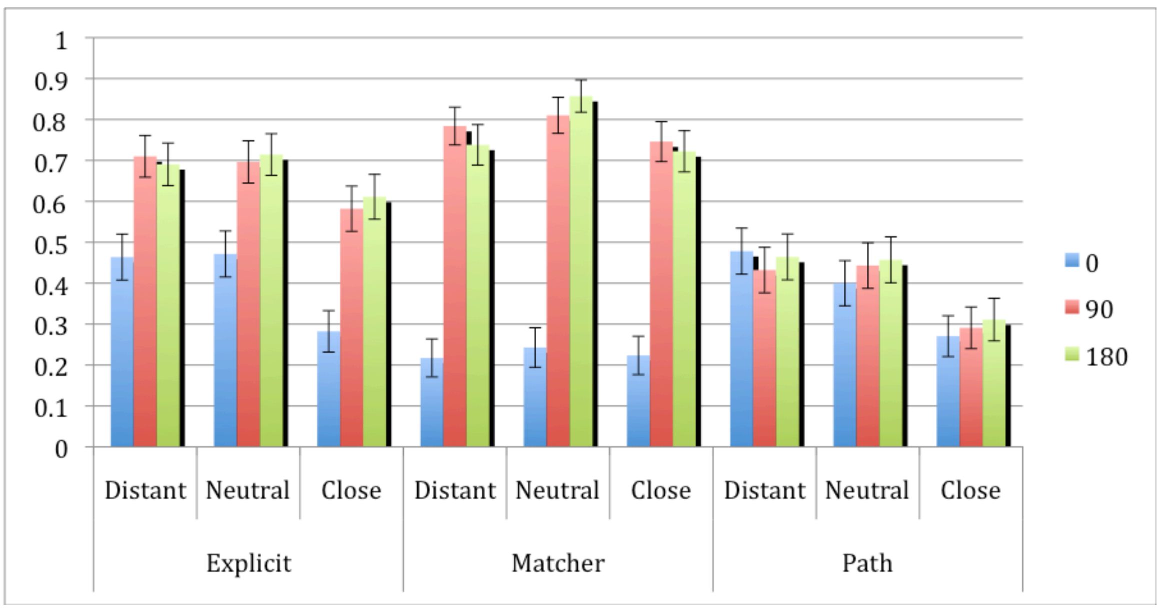


Table 3.1. Mean Scores Reported from Post-Experiment Questionnaire (7-point scales except Known: 0-1).

	Close	Neutral	Distant
Felt Close?	3.82	3.73	3.38
Felt Similar?	5.73*	5.15	3.96
Like Each Other?	5.83	6.58	5.88
Verbal task hard?	1.95	2.04	1.69
Perspective Effort	5.70	5.25	5.44
Manipulation Hard	2.50	3.08	2.62
Previously Known? (Y/N)	1.00**	0.35	0.27

*p < 0.05, **p < 0.01

Table 3.2. Model Estimates of Fixed Effects (with Standard Error) and *t*-scores, Experiment 2.

	Explicitly Marked			Matcher Oriented			Path Based		
	Est.	SE	*t*	Est.	SE	*t*	Est.	SE	*t*
Close[Distant]	-0.589	0.240	-2.452*	-0.089	0.165	-0.541	-0.393	0.271	-1.451
Neutral[Close, Distant]	0.163	0.116	1.399	0.039	0.078	0.507	0.034	0.128	0.265
90[180]	-0.168	0.094	-1.793†	0.073	0.105	0.696	0.022	0.192	0.116
0[90, 180]	-0.739	0.057	-12.921**	-1.319	0.060	-21.928**	-0.036	0.112	-0.317
Social	-0.065	0.032	-1.991*	0.011	0.023	0.496	-0.052	0.036	-1.452
Connection	0.067	0.050	1.360	0.015	0.032	0.458	0.003	0.052	0.062
ManipHard	0.098	0.089	1.097	0.044	0.060	0.721	0.113	0.093	1.217
C[D] x 90[180]	-0.626	0.254	-2.466*	0.078	0.245	0.319	0.249	0.278	0.895
C[D] x 0[90, 180]	-0.430	0.156	-2.764*	-0.556	0.150	-3.706**	-0.311	0.170	-1.829†
C[D] x Social	-0.142	0.079	-1.809†	0.011	0.057	0.191	-0.025	0.089	-0.280
C[D] x Connection	0.270	0.137	1.970*	-0.071	0.090	-0.790	0.210	0.146	1.431
C[D] x ManipHard	0.047	0.232	0.203	0.174	0.163	1.068	-0.062	0.248	-0.250
N[C, D] x 90[180]	-0.106	0.117	-0.904	-0.137	0.114	-1.203	0.037	0.127	0.294
N[C, D] x 0[90, 180]	0.100	0.071	1.413	0.151	0.069	2.196*	0.015	0.078	0.192
N[C, D] x Social	-0.119	0.046	-2.558*	-0.034	0.031	-1.101	-0.019	0.049	-0.393
N[C, D] x Connection	0.005	0.060	0.088	-0.009	0.038	-0.240	0.004	0.059	0.066
N[C, D] x ManipHard	0.272	0.117	2.326*	0.014	0.076	0.179	0.067	0.118	0.567
90[180] x Social	0.038	0.037	1.026	-0.083	0.036	-2.311*	-0.043	0.041	-1.038
90[180] x Connection	0.098	0.054	1.820†	0.006	0.052	0.122	-0.025	0.059	-0.419
90[180] x ManipHard	0.087	0.110	0.794	0.235	0.103	2.291*	-0.085	0.118	-0.719
0[90, 180] x Social	-0.017	0.022	-0.775	0.048	0.021	2.223*	0.000	0.025	0.010
0[90, 180] x Connection	0.023	0.033	0.704	0.157	0.032	4.862**	0.093	0.037	2.540*
0[90, 180] x MH	-0.098	0.065	-1.511	-0.226	0.062	-3.664**	0.006	0.071	0.080
Social x Connection	0.019	0.014	1.341	0.009	0.010	0.900	0.014	0.016	0.887
Social x MH	-0.065	0.032	-1.991*	0.011	0.023	0.496	-0.052	0.036	-1.452
Connection x MH	0.067	0.050	1.360	0.015	0.032	0.458	0.003	0.052	0.062

†$p < 0.10$; *$p < 0.05$; **$p < 0.01$

Explicit Marking

Explicit Marking indicates the director's willingness to put effort into giving the matcher more information about whose perspective is being used in the description of the scene.

Collapsing across angle, means for the proportion of Explicit Marking (Table 3) indicate that pairs in the Close condition used less explicit marking (M_{close} = 0.52) than either the Neutral or Distant conditions ($M_{neutral}$ = 0.65, $M_{distant}$ = 0.65).

Table 3.3. Mean Proportions (with Standard Deviations) of Explicitly-Marked Locatives, Experiment 2.

	Angle		
	0˚	180˚	90˚/270˚
Close	0.26 (0.44)	0.61 (0.49)	0.58 (0.49)
Neutral	0.47 (0.50)	0.71 (0.46)	0.70 (0.46)
Distant	0.46 (0.50)	0.69 (0.47)	0.71 (0.46)

Before accounting for the effects of the additional questionnaire-based variables, directors' behavior indicates that those in the Close condition use fewer conversational effort markers, and that there is no difference between Neutral and Distant directors in their use of effort markers. The descriptive statistics presented in Table 10 also show less use of effort markers to describe diagrams in which perspectives were not visually separate. A logistic regression model of directors' use of Matcher Oriented locatives that included clustered questionnaire responses confirms the effect of Condition on Explicit Marking, revealing a small but significant negative effect of social closeness on directors' tendency to explicitly mark perspective (Est. = -0.07, p = 0.05), and that a higher Social score was associated with Close directors using less explicit marking than Distant directors (Est. = -0.14, p = 0.07), and with Neutral directors using less explicit marking than Close or Distant directors (Est. = -0.12, p = 0.01). Directors did use a different amount of explicit marking depending on the angle between perspectives represented in the stimuli. However, this effect was marginally significant for both contrast cases: between offset perspectives and items in which there was no separation between the director and matcher's perspectives (0-degree-offset maps; Est. = -0.74, p = 0.06), and between the two types of offset perspectives (90 vs. 180; Est. = -0.17, p = 0.09).

Matcher-Oriented

Matcher-oriented language indicates the director's willingness to put effort into mental rotation in order to represent the matcher's perspective, regardless of whether it is explicitly marked as such in the director's description. The proportions of matcher-oriented descriptions were not significantly different by condition (M_{close} = 0.62, $M_{neutral}$ = 0.69, $M_{distant}$ = 0.65; Contrast C[N,D]: p = 0.326).

Table 3.4. Mean Proportions (with Standard Deviations) of Matcher-Oriented Locatives Used, Experiment 2.

	Angle		
	0°	180°	90°/270°
Close	0.20 (0.40)	0.72 (0.45)	0.75 (0.44)
Neutral	0.24 (0.43)	0.86 (0.35)	0.81 (0.39)
Distant	0.22 (0.42)	0.74 (0.44)	0.78 (0.41)

Before accounting for the effects of the additional questionnaire-based variables, directors' behavior indicates that matcher-oriented language did not respond to the different social closeness conditions created by the experimental manipulation. None of the questionnaire-based predictors were significant as main effects in the model of matcher-oriented language. However, directors' Social and Connection scores did influence their use of matcher-oriented language; directors who reported more pro-social feelings toward their partner used less matcher-oriented language in descriptions of 90° diagrams than 180° diagrams (Est. = -0.08, p = 0.02), and directors with higher Connection scores used more matcher-oriented language when describing 0° diagrams than other directors (Est. = 0.16, $p < 0.005$). This indicates the continued influence of social closeness as an inhibitor to helpful language use, as in the model of explicit marking. Angle emerged as a significant factor in the model of matcher-oriented language, again due to the scant appearance of matcher-oriented descriptions in directors' descriptions of the 0-degree diagrams compared to the other two angle offsets ($p < .001$). The interaction between Condition and Angle was significant, but only when considering the use of matcher-oriented language describing the 0° diagrams versus the other two angle offsets ($p < 0.05$). This indicates that directors in the Close condition were less likely to use matcher-oriented language in describing 0° diagrams than directors in the Neutral or Distant conditions. Those who reported putting more effort toward the verbal task used matcher-oriented language more evenly across diagrams; I interpret this as directors choosing matcher-oriented language as a general strategy to cope with conversational effort.

Path-Based

Use of Path-Based descriptions indicates a director's willingness to engage in a richer representation of the map by alluding to more than one location in their description. This second location is usually one of the two perspectives represented on the map. The mean proportions of Path-Based Descriptions (Table 3) indicate a difference between descriptions given by directors in the Close condition ($M_{close} = 0.29$) and those in the Neutral and Distant conditions ($M_{neutral} = 0.44$, $M_{distant} = 0.45$). Directors use Path-Based language less often in general, but they use it more consistently across all angle offsets rather than choosing only to enriching their descriptions of more "difficult" stimuli.

Table 3.5. Mean Proportions (with Standard Deviations) of Path-Based Locatives, Experiment 2.

		Angle	
	0˚	180˚	90˚/270˚
Close	0.26 (0.44)	0.31 (0.47)	0.29 (0.46)
Neutral	0.40 (0.49)	0.46 (0.50)	0.44 (0.50)
Distant	0.48 (0.50)	0.46 (0.50)	0.43 (0.50)

Before accounting for the effects of the additional questionnaire-based variables, directors' behavior indicates that path-based language was used less overall than matcher-oriented or explicitly marked phrases. As in the Explicit Marking data, directors in the Close condition use less helpful language in their descriptions. However, in a logistic regression model, there were no significant effects of Condition on directors' use of path-based descriptions and no main effect of Angle, nor were any of the questionnaire-derived predictors significant as main effects. Directors in the Close condition used less path-based language describing 0-degree diagrams than Distant directors (Est. = -0.31, p = 0.07), and directors who scored higher on measures of Connection used more path-based language describing 0-degree diagrams than other directors (Est. = 0.09, p = 0.01). Path-based language may be a less obvious choice for directors seeking to help increase listeners' understanding; thus, it may be a weaker strategy that is more likely to be impacted by differences in experiential variables like those measured by the post-experiment questionnaire.

3.3 Discussion

This experiment was intended to answer the question: how much influence does social closeness have on the alignment of spatial perspectives, independently of tasks that may vary feelings of difficulty or rhythmic alignment? The Adjective Check List induction task successfully caused participants in the Close (high adjective overlap) condition to feel more similar to their partner. However, this feeling of similarity did not lead to the increase in helpful locatives that I expected. Differences between directors' use of Explicitly Marked locatives was significant but negative, as was the relationship between Explicit Marking and higher scores on the Social items of the post-experiment questionnaire. The post-experiment questionnaire results may have more obvious relevance for this experiment than for the others in this dissertation, since the experimental manipulation was intended to change partners' social feelings about each other, and these feelings are measured by the questionnaire. In general, the results of this experiment confirm the relationship between social distance and helpful language that was suggested by the results of Experiment 1. Instead of social distance provoking greater conversational effort, here it seems that social similarity inhibits some kinds of conversational effort.

The Synchronous and Asynchronous conditions in Experiment 1 and the Close and Distant conditions in Experiment 2 have some interesting parallels: both Synchronous and Close directors gave higher social affinity ratings in the questionnaire, whereas the Asynchronous and Distant conditions are associated with lower affinity ratings. However, in Experiment 1, greater effort marker use was associated with the Asynchronous rhythm manipulation, who in general reported lower rates of closeness, liking, and similarity. By contrast, in Experiment 2 the consistent differences cluster around the Close condition – directors in this condition used consistently (but not always significantly) *lower* rates of Explicit Marking, Matcher Orientation, and Path-Based locatives than in any of the other conditions, and report *higher* rates of closeness and similarity. The Adjective Check List manipulation led to reduced effort marking in directors for whom the manipulation "worked" - those who scored higher on measures of social affinity.

In sum, the results of Experiment 2 suggest that there is a connection between feelings of social closeness or similarity and differences in the use of perspective-taking language. The use of conversational effort markers in this experiment is evidence that the Adjective Check List task motivates different language choices than the co-present clapping task from Experiment 1. If this manipulation had acted in the same way as the co-present clapping manipulation (i.e. if social affinity was indeed the most powerful moderator of helpful language use in Experiment 1), the Adjective Check List would have prompted more effort marker use by directors in the more different/difficult condition. Instead, the most interesting behavior was that of the directors who believed themselves to be more similar to their partner. Since the Adjective Check List's Close, Neutral, and Distant conditions were normed on a population of university undergraduates much like my own participants, I can assume that matching on 10 out of 20 adjectives is what the majority of pairs would do if these scores had been calculated (Burger et al., 2001).

These results echo research by Savitsky and colleagues examining differences between friends' and strangers' beliefs about the quality of their communication (Savitsky, et al., 2011). Conversations between friends contain more egocentric language and more ambiguous phrasing than conversations between strangers, yet friends believed their conversations were better comprehended. The research I present here suggests that similar effects can be recreated by artificially inducing feelings that are associated with friendship.

Chapter 4

This experiment manipulates the similarity of participants' physical coordination in the absence of social influence or co-presence. Here, I hope to directly address the Fluency Hypothesis by showing whether or not pairs who experience simple or complex physical coordination carry over this sense of physical fluency (or disfluency) over to a collaborative verbal task. The Fluency Hypothesis predicts that directors who experience difficulty with a non-conversational task will increase their conversational effort by taking their partner's perspective, making perspectives explicit, or enriching their description of the shared environment. In the previous experiments, it was impossible to cleanly separate directors' feelings of task difficulty from their feelings toward their partner, with whom they performed the entire task. The strong version of the Fluency Hypothesis would predict this carry-over effect from any type of effort, solo or collaborative, that occurred before conversation, while the Compensation Hypothesis suggests that conversational effort is related only to tasks performed collaboratively, creating a social transaction within which compensation for perceived effort is required.

In order to test these predictions, I designed a simplified version of Experiment 1 that preserves the rhythmic activity, but separates it from any social influences. Participants clapped individually, in separate locations, along with a metronome in one of two patterns: Synchronous (every other beat) and Asynchronous (every fifth beat) These conditions were meant to replicate the effect of rhythmic coordination in the Alternating and Asynchronous conditions of Experiment 1, but to provide no social task demands. In theory, they should not affect participants' feelings of similarity, liking, or closeness unless the fluency of the clapping task is mistakenly attributed to the pair's interaction.

4.1 Method

Participants

Northwestern's Psychology 110 subject pool provided participants for this experiment. I ran a total of 40 participants: 20 (13 women, 7 men) in the Synchronous clapping condition, and 20 (12 women, 8 men) in the Asynchronous clapping condition. Participants were scheduled in pairs, and all were native English speakers.

Materials

The verbal task used the same spatial diagrams as Experiment 1. The task I used to induce motor alignment/misalignment involved each partner clapping along with a metronome in isolation, in a soundproof booth following written instructions displayed on a computer. Participants used headphones to listen to metronome beats at 82bpm via the computer in each booth. In each pair, both participants were assigned to either the Synchronous clapping condition (every other beat) or the Asynchronous clapping condition (every fifth beat).

Procedure

Participants performed the clapping task and the verbal task in alternating blocks: 1 minute of clapping followed by 4 spatial diagrams, until all 16 diagrams had been discussed. The clapping task was always performed by each participant in isolation; following each block of clapping, both participants came together as a pair to complete the next block of spatial diagrams. In the Synchronous clapping condition, participants were instructed to clap along with a metronome at 82 beats per minute, clapping on every other beat for 1 minute, while the digital metronome emphasized every other beat, after which they were instructed to exit the booth and switch to the verbal task. In the Asynchronous clapping condition, participants were instructed to clap along with a metronome at 82 beats per minute, on every 5^{th} beat for 1 minute, while the digital metronome emphasized every 3rd beat, after which they were instructed to exit the booth and switch to the verbal task. Partners could not see or hear each other during the clapping segments of the experiment.

As in the previous experiments, participants were prevented from seeing each other during the spatial perspective-taking task by an opaque barrier. Pairs sat across from each other at a table adjacent to the soundproof booths for ease of movement between tasks.

A brief questionnaire was administered after all the blocks were completed, prior to debriefing. The questionnaire asked whether participants had felt comfortable during the rhythm induction task, how difficult they had found the rhythm task, how much effort they had put towards taking the other person's perspective during the verbal task, and social affect ratings of liking, closeness, and similarity.

4.2 Results

Pairs' speech was transcribed verbatim, and all locative phrases spoken by directors were extracted from the directors' utterances. The locative phrases were coded in order to determine whether directors used explicit marking of perspective, a matcher-oriented perspective, or a path-based conceptual framework to clarify their directions to the matcher. A general overview of means for each measure across Condition and Angle are presented in Figure 1. Means are presented for each measure and basic patterns are discussed before the results of a logistic regression model for each measure. Each measure is treated separately as converging evidence for the effect of the motor fluency task on increased effort among directors. For each measure, I present a logistic regression model representing the likelihood of a director using one of these methods in their speech.

Contrast coding of the fixed effects was used to test the following hypotheses with respect to each effect:

1. Do the two different clapping patterns produce different levels of conversational effort? (Asynchronous vs. Synchronous; represented in Table 2 as A[S], contrast values given in the model Synchronous = 1, Asynchronous = -1)
2. Are descriptions of 0˚ diagrams different from descriptions of diagrams where perspectives are offset? (0˚ vs. 90˚ & 180˚; represented in Table 2 as 0[90,180], contrast values 1, -0.5, -0.5)
3. Are descriptions of the two types of offset perspectives (90˚ and 180˚; represented as 90[180], contrast values 1, -1) different from each other?

The directionality (positive or negative) of the effect estimates associated with each independent variable is interpreted in the Results and Discussion sections based on the contrasts I have specified above. Positive effect estimates are aligned with "more" of the associated measure; for example, a higher value associated with the 90[180] contrast in estimating Matcher Oriented language means that there was *more* Matcher Oriented language used describing 90° diagrams than 180° diagrams.

As in the previous experiments, a post-experiment questionnaire was given to participants after they completed all rounds of experimental tasks. Questionnaire items probed on a scale from 1 to 9 how close participants felt to their partner (variable name: Close), how similar they felt to their partner (Similar), and how much they liked their partner (Like). In order to examine the degree of perceived effort participants spent on the verbal task, I asked one general question and one specific question: how hard the verbal task was (VerbHard), and how much effort they made to take their partner's point of view (PerspEffort). In order to check that the Synchronous and Asynchronous conditions of the clapping task were in fact perceived as hard or easy, I asked participants how hard they found the clapping task (ClapHard), and how comfortable they were with the clapping task (ClapComfort). In order to explore the degree of attention given to the computer during the non-verbal task, I asked participants to report much attention they paid to the audible ticks that accompanied the clapping task (ClapAttend). I also asked participants how well they knew each other before the experiment commenced (Known). Means for these items are presented in Table 1 below. Answers to the questionnaire items were included in the maximal logistic regression after collapsing responses into four variables using Ward's hierarchical cluster analysis. A cluster dendrogram of all questionnaire items used in Experiment 3 is shown below in Figure 1. This dendrogram shows four distinct clusters, grouped as follows:

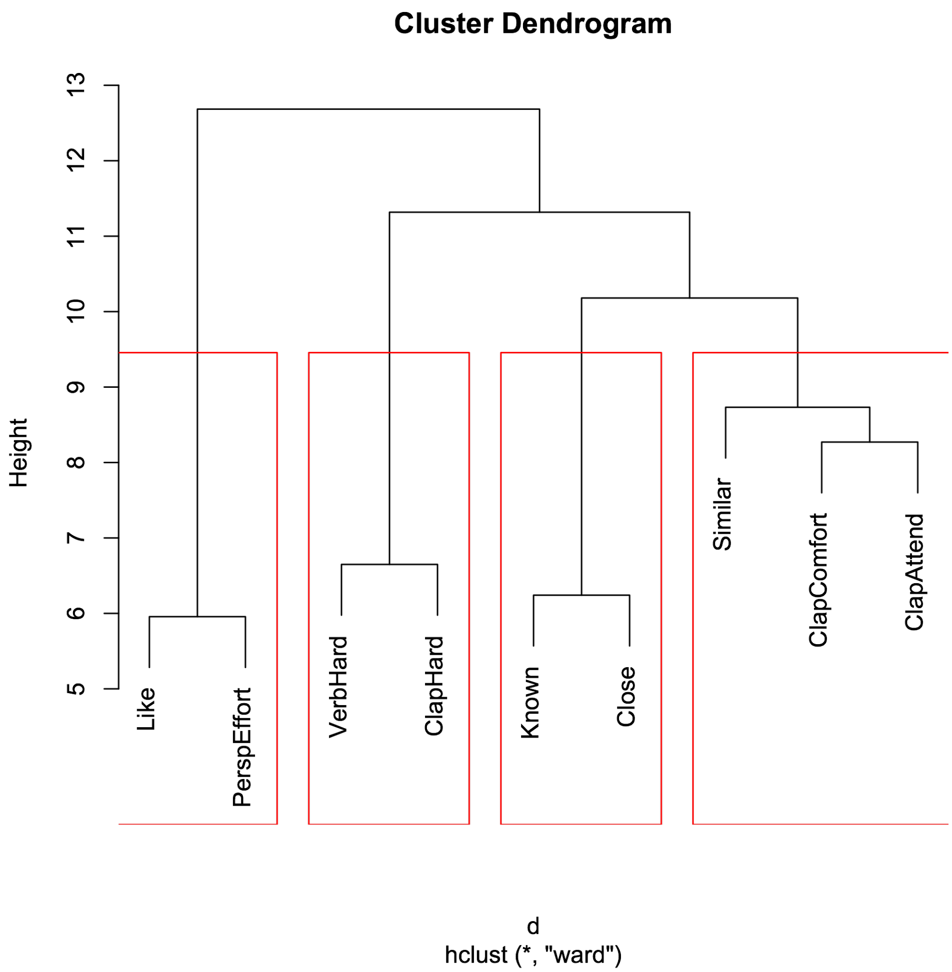
Like + PerspEffort = Impress, a composite measure indicating that participants who like their partner put more effort toward taking their partner's perspective. Subjectively, it seems that if directors scored high on both components of this cluster, they would be trying to make a good impression on a partner they liked by helpfully taking their partner's perspective in conversation. However, it is wise to avoid overinterpretation of this cluster.

VerbHard + ClapHard = Difficulty, a composite measure indicating the general level of difficulty participants associated with both parts of the experiment (verbal task and manipulation). These items also served as a manipulation check on the true difficulty of the Asynchronous clapping task.

Known + Close = Friends, a composite measure indicating the presence of closeness and previous acquaintance generally associated with friendship.

Similar + ClapComfort + ClapAttend = Comfort, a composite measure indicating that directors who are more comfortable performing the clapping task with the computer are more likely to pay attention to their part in the clapping pattern, and that this general feeling of comfort with the solo task rises and falls in tandem with their feeling of similarity to their partner. In short, those who feel more similar to each other are more likely to feel comfortable with the solo clapping task and devote more of their attention to doing it well. Comfort (as defined here) combines one kind of social affinity – similarity – with felt experience from both the clapping task and the conversation task.

Figure 4.1. Cluster Dendrogram of Post-Experiment Questionnaire Items for Experiment 3.



The analysis was carried out the same way as in Experiment 1. Beta weights (with standard errors) from the logistic regression model are presented below for all main effects, 2- and 3-way interactions; 3-way interactions are included below due to the higher total number of predictors in this model (6, as opposed to 5 in the previous experiments). Higher-order interactions are included in Appendix C.

Table 4.1. Mean Scores Reported from Post-Experiment Questionnaire (7-Point Scales Except Known: 0-1), Experiment 3.

	Asynchronous	Synchronous
Feel close?	3.95 *(1.76)*	3.95 *(2.16)*
Feel similar?	5.05 *(1.99)*	5.40 *(1.43)*
Like each other?	3.80 *(2.48)*	4.20 *(2.19)*
Verbal task hard?	4.70 *(3.54)*	2.95 *(2.54)*
Clapping task hard?	5.95 *(1.85)*	2.60 *(0.85)*
Effort towards perspective?	4.50 *(2.95)*	3.95 *(3.38)*
Previously known?	0.20 *(0.41)*	0.20 *(0.41)*

Figure 4.2. Proportion of Conversational Effort Markers Used by Directors Across Stimuli in Experiment 3.

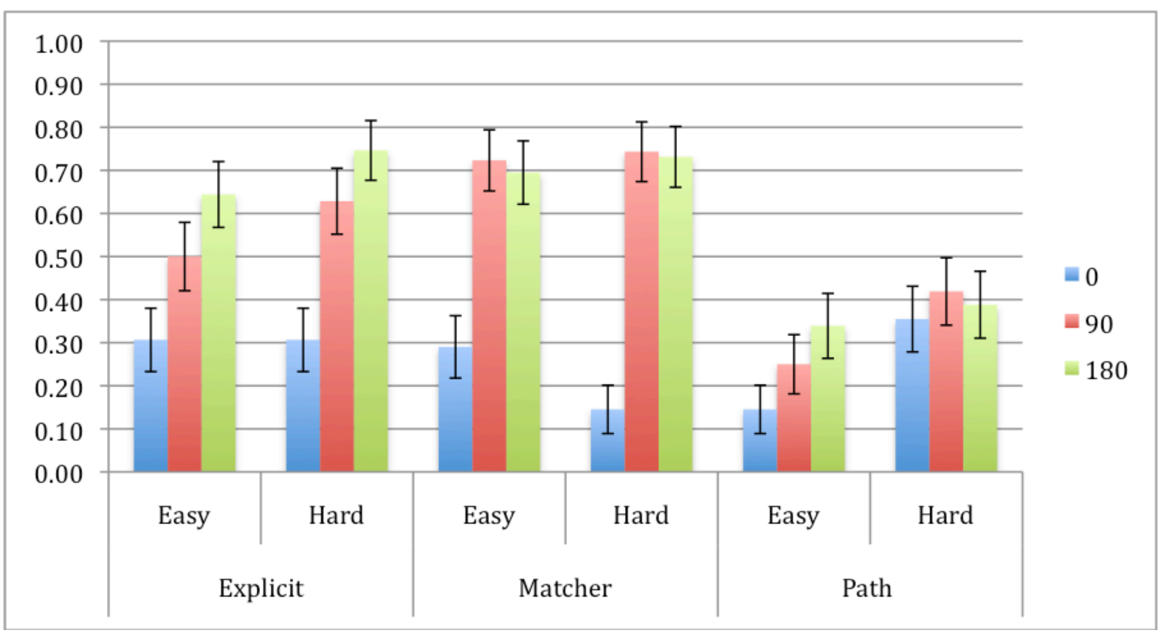


Table 4.2. Model Estimates of Fixed Effects (with Standard Error), and *t*-scores, Experiment 3.

	Explicit Marking			Matcher Oriented			Path-Based		
	Est	SE	*t*	Est	SE	*t*	Est	SE	*t*
Asynchronous[Synchronous]	1.898	0.556	3.417**	-0.118	0.375	-0.315	-0.374	1.353	-0.277
90[180]	0.100	0.499	0.200	1.227	0.465	2.639*	0.725	0.451	1.605
0[90,180]	-0.284	0.314	-0.905	-0.140	0.262	-0.536	-0.402	0.252	-1.594
Impress	0.295	0.109	2.706*	-0.142	0.066	-2.165*	-0.015	0.282	-0.053
Difficulty	0.578	0.220	2.632*	-0.166	0.147	-1.131	-0.378	0.499	-0.757
Friends	0.589	0.258	2.285*	-0.455	0.168	-2.711*	-0.770	0.637	-1.209
Comfort	0.992	0.410	2.421*	-0.991	0.278	-3.559**	-1.285	0.974	-1.320
A[S] x 90[180]	1.889	0.985	1.918†	2.412	0.930	2.594*	2.162	0.900	2.401*
A[S] x 0[90,180]	0.281	0.618	0.456	0.993	0.523	1.898†	-0.013	0.502	-0.026
A[S] x Difficulty	1.095	0.439	2.495*	-0.384	0.294	-1.304	-1.123	0.998	-1.125
A[S] x Friends	1.843	0.515	3.581**	-0.447	0.335	-1.334	-1.060	1.274	-0.832
A[S] x Impress	0.477	0.218	2.187*	-0.155	0.131	-1.180	-0.538	0.565	-0.953
A[S] x Comfort	2.962	0.818	3.622**	-0.960	0.557	-1.723†	-2.014	1.947	-1.034
90[180] x Difficulty	0.574	0.395	1.454	0.854	0.365	2.340*	0.901	0.365	2.471*
90[180] x Friends	0.525	0.439	1.195	1.118	0.411	2.722*	0.978	0.405	2.413*
90[180] x Impress	0.383	0.180	2.127*	0.043	0.156	0.275	0.285	0.155	1.836†
90[180] x Comfort	0.151	0.723	0.209	2.206	0.692	3.189**	1.308	0.664	1.969*
0[90,180] x Difficulty	0.403	0.265	1.522	0.663	0.206	3.224**	-0.007	0.202	-0.036
0[90,180] x Friends	0.481	0.283	1.699†	0.860	0.237	3.629**	-0.112	0.233	-0.481
0[90,180] x Impress	0.120	0.143	0.842	0.230	0.096	2.407*	-0.187	0.096	-1.957*
0[90,180] x Comfort	1.008	0.447	2.253*	1.751	0.388	4.512**	-0.294	0.371	-0.794
Difficulty x Friends	0.665	0.211	3.148**	-0.357	0.138	-2.588*	-0.615	0.538	-1.142
Difficulty x Comfort	1.215	0.423	2.872**	-0.713	0.291	-2.449*	-1.272	0.984	-1.293
Friends x Comfort	0.833	0.380	2.196*	-0.844	0.251	-3.361**	-0.891	0.910	-0.978
Impress x Difficulty	0.000	0.102	0.002	-0.290	0.064	-4.524**	-0.339	0.203	-1.673†
Impress x Friends	0.239	0.084	2.856**	-0.089	0.057	-1.552	-0.379	0.167	-2.276*
Impress x Comfort	0.246	0.126	1.953*	-0.157	0.086	-1.826†	-0.230	0.283	-0.810
A[S] x 90[180] x Difficulty	1.176	0.792	1.485	0.677	0.730	0.928	1.671	0.730	2.289*
A[S] x 90[180] x Friends	1.481	0.873	1.697†	1.583	0.822	1.926*	1.735	0.810	2.142*
A[S] x 90[180] x Impress	0.763	0.359	2.125*	0.802	0.312	2.572*	0.384	0.311	1.236
A[S] x 90[180] x Comfort	0.490	1.441	0.340	3.795	1.384	2.743*	2.100	1.327	1.582
A[S] x 0[90,180] x Difficulty	1.214	0.527	2.305*	1.363	0.411	3.316**	-0.076	0.402	-0.188
A[S] x 0[90,180] x Friends	0.835	0.565	1.477	1.584	0.474	3.342**	-0.693	0.466	-1.486
A[S] x 0[90,180] x Impress	-0.044	0.286	-0.153	0.395	0.192	2.061*	-0.288	0.192	-1.504
A[S] x 0[90,180] x Comfort	0.908	0.893	1.017	2.233	0.776	2.877**	-1.292	0.740	-1.746†
A[S] x Difficulty x Friends	1.277	0.421	3.031**	-0.342	0.276	-1.240	-1.493	1.077	-1.387
A[S] x Difficulty x Comfort	2.442	0.845	2.889**	-1.452	0.582	-2.494*	-2.427	1.967	-1.233

A[S] x Friends x Comfort	2.660	0.757	3.514**	-0.523	0.502	-1.041	-1.633	1.821	-0.897
A[S] x Impress x Difficulty	0.556	0.202	2.752*	0.173	0.128	1.349	-0.300	0.405	-0.739
A[S] x Impress x Friends	0.389	0.168	2.313*	-0.366	0.114	-3.194**	-0.577	0.333	-1.731†
A[S] x Impress x Comfort	0.726	0.253	2.875**	-0.257	0.172	-1.494	-0.430	0.567	-0.758
90[180] x Difficulty x Friends	0.402	0.358	1.123	0.705	0.339	2.078*	0.833	0.330	2.523*
90[180] x Difficulty x Comfort	0.385	0.764	0.504	1.788	0.729	2.454*	1.323	0.706	1.875†
90[180] x Friends x Comfort	0.506	0.666	0.759	1.711	0.620	2.758*	1.037	0.611	1.696†
90[180] x Impress x Difficulty	0.362	0.173	2.097*	0.438	0.151	2.896**	0.377	0.155	2.428*
90[180] x Impress x Friends	0.278	0.150	1.858†	0.477	0.140	3.404**	0.311	0.139	2.227*
90[180] x Impress x Comfort	0.347	0.226	1.539	0.387	0.211	1.837†	0.541	0.213	2.535*
0[90,180] x Difficulty x Friends	0.521	0.243	2.146*	0.935	0.194	4.821**	-0.162	0.188	-0.863
0[90,180] x Difficulty x Comfort	0.968	0.447	2.165*	1.534	0.402	3.813**	-0.233	0.382	-0.612
0[90,180] x Friends x Comfort	0.841	0.410	2.050*	1.347	0.352	3.829**	-0.250	0.344	-0.728
0[90,180] x Impress x Difficulty	0.072	0.158	0.453	0.243	0.094	2.581*	0.073	0.097	0.752
0[90,180] x Impress x Friends	0.134	0.108	1.238	0.235	0.081	2.901**	-0.016	0.081	-0.196
0[90,180] x Impress x Comfort	0.098	0.144	0.678	0.222	0.121	1.830†	-0.125	0.122	-1.029
Difficulty x Friends x Comfort	1.032	0.406	2.543*	-0.601	0.273	-2.206*	-1.066	0.966	-1.103
Impress x Difficulty x Friends	-0.107	0.097	-1.099	-0.288	0.061	-4.716**	-0.105	0.164	-0.641
Impress x Difficulty x Comfort	-0.022	0.067	-0.330	0.026	0.046	0.560	-0.201	0.117	-1.728†
Impress x Friends x Comfort	0.342	0.146	2.340*	-0.147	0.097	-1.505	-0.164	0.351	-0.469

†$p < 0.10$, *$p < 0.05$, **$p < 0.01$

Explicit Marking

Explicit Marking indicates the director's willingness to put effort into word choice in order to give the matcher more information about whose perspective is being used in the description of the scene. Means for the proportion of Explicit Marking indicate that directors in the Asynchronous condition used more Explicitly Marked locative phrases (M_{asynch} = 0.58 (SD = 0.50)) than directors in the Synchronous condition (M_{synch} = 0.48 (SD = 0.49)). This was driven by instances in which perspectives were clearly different; when describing diagrams with 0° separation between them, directors were less likely to explicitly mark whose perspective was being taken, regardless of the clapping task condition.

Table 4.3. Mean Proportions (with Standard Deviations) of Explicitly Marked Locative Phrases, Experiment 3.

	Angle		
	0˚	180˚	90˚/270˚
Synchronous	0.31 (0.46)	0.50 (0.50)	0.64 (0.48)
Asynchronous	0.31 (0.46)	0.63 (0.48)	0.75 (0.44)

Before accounting for the effects of the additional questionnaire-based variables, directors' behavior indicates that the use of explicit marking increased with the angle of separation between perspectives, and that the Asynchronous clapping task prompted more frequent explicit marking of perspective. In a linear regression model that included questionnaire responses as composite predictors, the relationship between clapping rhythm and Explicit Marking was positive, large (judging by the model estimate, Est. = 1.90), and significant ($p < 0.005$), suggesting that the clapping manipulation changed directors' expressions even when accounting for social feelings toward the matcher. However, in this model, directors did not use different amounts of Explicit Marking to describe different diagrams (90[180], $p = 0.84$; 0[90,180], $p = 0.37$). Angle did interact with Condition (Est. = 1.89, $p = 0.06$), indicating that directors in the Asynchronous condition used more Explicit Marking when describing 90˚ diagrams than 180˚ diagrams. When social factors were accounted for, different diagrams merited different descriptions from directors in more difficult conditions. All four post-experiment questionnaire composite predictors (Impress, Difficulty, Friends, and Comfort) were positive and significant as main effects on the amount of Explicit Marking used, as well as in interactions with Condition. This is interesting because the conditions of this experiment were arguably the least interactive, although the questionnaire variables Difficulty and Comfort included questions about the solo clapping condition. Partners did not perform any non-linguistic tasks together, but the difficulty of the solo clapping task influenced directors' use of Explicitly Marked descriptions regardless of the diagram being described.

Matcher Orientation

Matcher Orientation indicates the director's willingness to put effort into mental rotation in order to represent the matcher's perspective, regardless of whether it is explicitly marked as such in the director's description. Means for the proportion of Matcher-Oriented locatives suggest that directors in both conditions used Matcher-Oriented locatives in similar proportions (M_{synch} = 0.61 (SD = 0.49), M_{asynch} = 0.60 (SD = 0.49)). A more detailed examination suggests that they may also be using the same strategy to improve comprehension with the least effort: directions were given from the matcher's perspective roughly 70% of the time when describing the 180˚ and 90˚/270˚ diagrams, and less than 30% of the time when describing diagrams where both perspectives were from the same location.

Table 4.4. Mean Proportions (with Standard Deviations) of Matcher-Oriented Locative Phrases, Experiment 3.

	Angle		
	0°	90°	180°
Synchronous	0.29 *(0.46)*	0.72 *(0.45)*	0.69 *(0.46)*
Asynchronous	0.15 *(0.36)*	0.74 *(0.44)*	0.73 *(0.45)*

Before accounting for the effects of the additional questionnaire-based variables, the mean proportions reported above in Table 16 indicate that Synchronous and Asynchronous directors' behavior is mostly similar except when describing 0˚ diagrams, when Synchronous directors use twice as many Matcher-Oriented phrases. In a logistic regression model that included questionnaire-based variables, the main effect of clapping rhythm on Matcher-Oriented language was not significant (p = 0.75), suggesting that Matcher-Oriented phrases may emerge in response to social factors, but not those directly related to clapping difficulty. The main effect of Angle was positive, but significant only for the 90° / 180° contrast (p = 0.008), and the interaction between Condition and Angle was positive and significant for the 90° / 180° contrast (p = 0.009) and only marginally significant for the 0° vs. 90° / 180° contrast (p = 0.06). Given the difference between 0° descriptions and all other descriptions reported in Table 16, this is an unexpected result. As with Explicit Marking, the additional predictors Impress, Friends, and Comfort were significant, although all (including Difficulty, n.s.) were negative, indicating that higher scores on these items in the post-experiment questionnaire was associated with less Matcher Oriented language use. Most of the two- and three-way interactions involving clustered predictors and Angle contrasts were significant predictors of greater Matcher Oriented Language use: 24 of the 28 interactions of clustered predictors with Angle contrasts reported in Table 14 were significant at p =0.05 or less. Rather than having a direct impact on directors' overall use of Matcher Oriented language, social affinities and subjective experiences of difficulty appear to affect the distribution of Matcher Oriented language use between different diagrams

Path-Based

Use of Path-Based descriptions indicates a director's willingness to engage in a richer representation of the map by alluding to more than one location in their description. This second location is usually one of the two perspectives represented on the map. The proportions of Path-Based Descriptions indicate that participants in the Asynchronous group (M_{asynch} = 0.40) generally used more Path-Based descriptions than participants in the Synchronous group (M_{synch} = 0.24).

Table 4.5. Mean Proportions (with Standard Deviations) of Path-Based Locative Phrases, Experiment 3.

	Angle		
	0°	90°	180°
Synchronous	0.15 *(0.36)*	0.25 *(0.43)*	0.34 *(0.48)*
Asynchronous	0.35 *(0.48)*	0.42 *(0.50)*	0.39 *(0.49)*

Before accounting for the effects of the additional questionnaire-based variables, directors' behavior indicates greater use of Path-Based language with the Asynchronous manipulation, except when describing 180° diagrams. However, including questionnaire-based variables in a logistic regression model revealed that overall, Condition did not predict greater use of Path-Based language ($p = 0.78$). The main effect of Angle was not significant ($p = 0.11$), but there was a significant interaction between Condition and the 90 vs. 180 angle contrast condition. In the Synchronous condition, more Path-Based phrases are used to describe 180˚ diagrams, while in the Asynchronous condition, roughly equal amounts of Path-Based language are used ($p = 0.02$). In the Synchronous condition there is a graduated pattern of Path-Based language use, keeping pace with the degree of separation between perspectives, as seen in Figure 2.[5] There were no significant main effects of the questionnaire-based predictors, although all were involved in significant (Difficulty, Friends, Comfort) or marginally significant (Impress) interactions with Angle. This indicates that directors whose questionnaire scores were higher used comparatively more Path-Based language in their descriptions of 90˚ diagrams than 180˚ diagrams. A significant interaction between Impress and Angle using the 0[90, 180] contrast reveals that

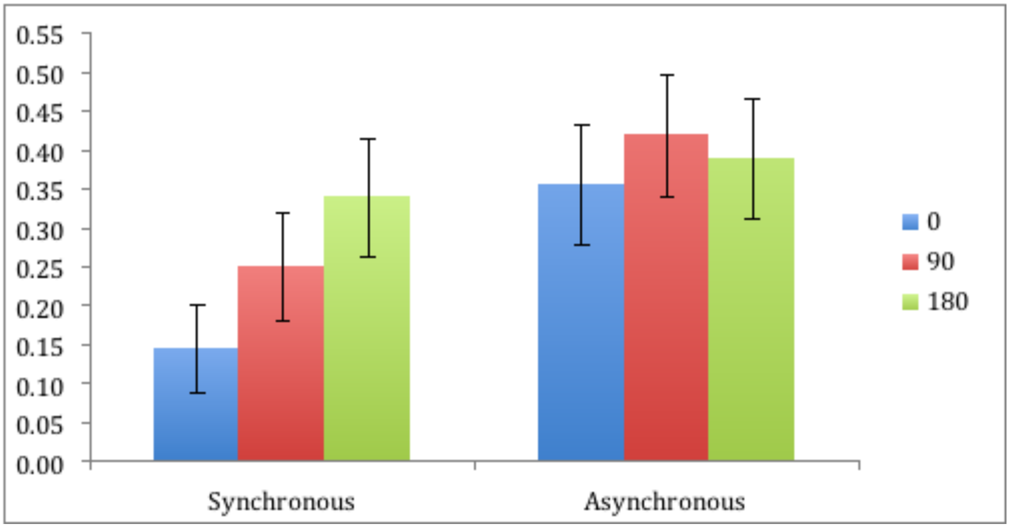
[5] The contrast between angled and 0˚ diagrams did not reveal a significant difference. The significance of this interaction for only the 90˚ vs. 180˚ angle contrast may be due to the lower rate of Path-Based language use compared to Explicit Marking or Matcher-Oriented phrases. The smaller number of Path-Based phrases makes this measure noisier than the other measures I used in these studies.

directors who scored higher on the Impress items (Like + PerspEffort) used less Path-Based language in descriptions of 0° diagrams than directors who did not score as high on Impress items. Although there is no theory-driven reason for this relationship, Path-Based language may require more cognitive resources to construct more detailed mental spaces; directors who are devoting these resources to taking their partner's perspective may have less available to keep track of multiple spatial locations in their description of the diagram.

4.3 Discussion

This experiment showed that motor disfluency can carry over into directors' use of Explicit Marking, and marginally into their use of Matcher Oriented locatives when directors feel similar to their partner and pay attention during the motor task. Directors in both conditions responded to differences in the visual location of perspectives by changing the language they used to describe the diagrams. Directors in the Asynchronous condition tended to use effort markers at the same rate across all diagrams, compared to their Synchronous counterparts. This pattern can be seen in the Path-Based marker use shown in Figure 3, an extract from Figure 2 focusing solely on Path-Based language.

Figure 4.3. Proportion of Utterances Using Path-Based Locatives to Describe Stimuli, By Angle and Clapping Condition.



Although the regression analysis indicated that Asynchronous directors actually used *less* Matcher Oriented and Path-Based language than Synchronous directors overall, the interaction between Condition and Angle (90˚ vs. 180˚) shows a positive relationship between the Asynchronous clapping condition and helpful language in 90˚ diagrams. This pattern of use suggests that Synchronous directors use more helpful language in proportion to the degree of separation between perspectives. As illustrated by the data in Figure 3, directors in the Synchronous condition appear to be using Path-Based language more strategically, while Asynchronous directors may be taking a more promiscuous approach to disambiguating locations.

The post-experiment questionnaire items in this experiment clustered differently from the previous two experiments. All four of the composite variables (Impress, Difficulty, Friends, and Comfort) were related to increased use of Explicit Marking, but with the exception of Difficulty, they all indicated reduced use of Matcher-Oriented locatives. The negative relationship between the Friends composite variable (Known + Close) and Matcher-Oriented language can be compared to the effect of the High Overlap condition on Explicit Marking in Experiment 2: in general, feelings of social affinity can reduce helpful language. The negative relationship between Matcher-Oriented language and the Impress variable is especially interesting because this variable comprises responses to "How much do you like your partner?" and "How much effort did you put toward taking your partner's perspective?" This interaction shows that those who reported taking their partner's perspective more often used language that was *less likely* to reflect an effort to do so. However, while the clusters of questionnaire variables were determined quantitatively, the interpretation of which responses "go together" is necessarily subjective. In order to respect this subjectivity, I have tried not to over-interpret the influence of questionnaire variables on my results.

In sum, it appears that physical disfluency does have carry-over effects to verbal behavior even after accounting for moderating social influences, and effort in a solo physical task may be misinterpreted as conversational effort, even absent an increase in the type of helpful language that would be a logical outcome of this effort. These results continue to confirm the relationship between disfluency, discomfort, or disconnection, and less helpful language that was suggested in Experiments 1 and 2.

Chapter 5

In the previous two experiments, I treated social closeness and rhythmic motor activity as exerting separate influences on other-oriented language. The original experimental task included rhythmic motor activity in a quasi-social context in pursuit of a shared goal - successfully keeping to the assigned rhythm. If we view the clapping task as goal-oriented, we can see that the different conditions of the task also correspond to different degrees of attention to the partner in the pursuit of the goal:

1. Alternating pairs have the most collaborative goal, since the timing of one partner's contribution depends on the previous contribution of the other partner.
2. Asynchronous pairs have the least collaborative goal, since the asynchronous rhythms do not depend on each other. One partner's behavior cannot be easily used to predict the other's behavior, and may even be distracting; thus, attending to the partner in this condition probably hinders performance.
3. Synchronous pairs may or may not be attending to their partner's contribution - it is not necessary to do so, but only to attend to the metronome.

When partners in the Alternating condition reported a high degree of attention to the other person's clapping, why was this attention necessary? A simple view of this task in terms of the relationship between human rhythm and metronome rhythm would not differentiate between the Alternating and Synchronous conditions except for the amount of kinetic energy expended by the human (half as much motion in the Alternating condition as in the Synchronous condition). However, partners in the Alternating condition of Experiment 1 did report that they attended more to their partner's actions than in either the Synchronous or the Asynchronous conditions (Experiment 1 Directors: M_{Alt} = 5.90, M_{Synch} = 4.72, M_{Asynch} = 3.22).

A plausible reason for this increase in reported attention is that the participants were trying to use what they could hear (and perhaps see) to improve the alignment of their claps with the appropriate metronome ticks. This effort towards improvement or maintenance of an accurate rhythm implies that participants had a goal in mind - the goal articulated by the experimenter in her directions to "clap on alternate beats" (or "on every beat," "on every third beat," "on every fifth beat" etc.). Participants in the Alternating (and to some extent the Synchronous) condition had a goal that was best supported by attending to what their partner was doing. Participants in the Asynchronous condition, by contrast, had a goal that was best supported by ignoring their partner's claps and trying to keep their own rhythm going without being distracted by their partner's concurrent noises and movements. Instead of the difficulty or stability of the rhythmic movements, or the degree of social closeness induced by them, perhaps participants' other-oriented spatial language was being modulated by attentional orientation carried over from a task that demanded greater or less focus on their partner in order to achieve the goal of maintaining a prescribed rhythm. The conditions that provoked more matcher-oriented language were more "collaborative" or other-oriented than the conditions that provoked less matcher-oriented language.

In the original induction task used in Experiment 1, the Synchronous and Alternating conditions may be viewed as joint efforts, although the Alternating task potentially involved more "jointness," indicated by the higher rating given to 'Attending to partner's claps' in the post-experiment questionnaire. The Asynchronous condition may have involved the most effort, but it was the least collaborative. Because task difficulty in Experiment 1 was inversely related to partner-directed attention, it is difficult to draw conclusions about effort separately from conclusions about collaboration. Thus, the fourth and last experiment that I present here focuses on the importance of collaboration (or joint effort) in a goal-oriented task, separately from feelings that may have been produced by the social context of the task, and the rhythmic quality of the task itself. Instead, the induction task used in this experiment is a motor task that can be performed either jointly or alone, and can be modified to either require a high level of task attention or a low level of task attention.

To examine the effect of joint effort, I designed a task that did not explicitly involve rhythmic movement, nor was it designed to promote social closeness between partners. The task allowed me to vary co-presence independently of the fluency of the task itself. Previous studies showed that making an "easy" grasping motion difficult was powerful enough to shift deeply-seated semantic associations between right and left (Casasanto & Chrysikou, 2011). In Casasanto and Chrysikou's task, the fluency of participants' dominant hands was disrupted by using bulky ski gloves to make picking up small objects difficult. For my purposes, a similar task was needed that would allow me to vary motor fluency, and could be performed either alone or by pairs in either an "easy" or "difficult" condition. Also, the paired version of the task should not be so socially awkward that the level of social closeness was more affected by this awkwardness than by the act of collaboration. I wanted to separate collaboration from physical effort in this task in order to test the hypothesis that they have separate effects that were potentially confounded in Experiment 1.

Given these considerations, Experiment 4 asks participants to engage in a task that is physical, but not necessarily rhythmic. The constraints and affordances of the experiment space allowed me to develop a task in which participants moved plastic cups from one location to another on a vertical metal surface. Each cup had a small magnet glued to the underside. Moving these objects by hand was a simple physical exercise; the Difficult condition was created by asking half the pairs to move the cups using chopsticks. A more detailed illustration of this task is given below.

Based on the results of Experiment 1, I expected directors in the Together/Difficult condition to display the most helpful spatial language, and directors in the Solo/Easy condition to use the most Director-centered phrases and fewest Explicitly Marked or Path-Based locatives. If joint action affects partner-directed attention differently than the general increased effort brought on by experiencing disfluency, then the fluency and co-presence of the manipulation task should have distinct effects on directors' language.

5.1 Method

Participants

Northwestern's Psychology 110 subject pool provided participants for this experiment. I ran a total of 78 participants: 20 (13 women, 7 men) in the Solo+Easy condition, 20 (12 women, 8 men) in the Solo+Hard condition, 20 (11 women, 9 men) in the Together+Easy condition, and 18 (15 women, 5 men) in the Together+Hard condition. Participants were scheduled in pairs, and all were native speakers of English.

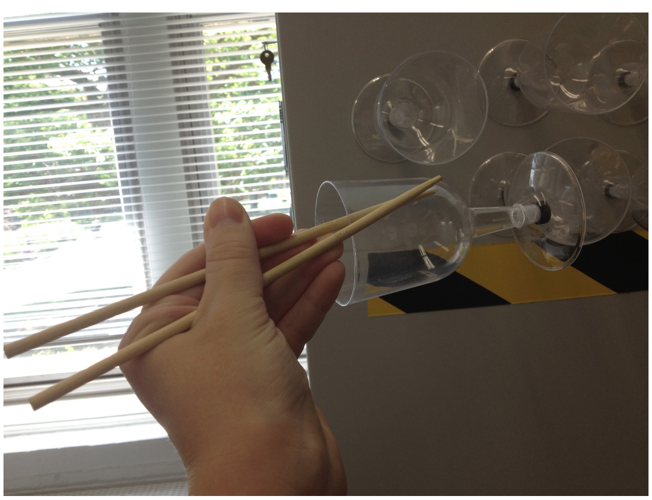
Materials

The verbal task used the same spatial diagrams as Experiment 1. The task I used to induce non-linguistic alignment/misalignment involved moving objects either by hand (Easy condition) or with chopsticks (Difficult condition), either working solo (Solo condition) or passing the objects back and forth between partners (Together condition). The objects were plastic cups (12 per participant) that had been magnetically mounted on a vertical metal surface. See Figure

1a and 1b for depictions of how the cups were manipulated in Easy and Difficult conditions. Partners in the Together condition stood side by side and passed the cups to each other in order to move all of the cups across an 80cm-wide separation on the metal surface. Partners in the Solo condition also had the task of moving the plastic cups from place to place on a vertical metal surface, but each participant completed this task independently while separated by an opaque black curtain. Participant pairs were randomly assigned to either the Easy (use hands) or Difficult (use chopsticks) manipulation conditions.

Figure 5.1a. Manipulation of Object in Easy Condition.

Figure 5.1b. Manipulation of Object in Difficult Condition.



Procedure

Participants in the Solo condition were asked to move ten of these magnetized cups from one section of the metal surface (marked by yellow and black emergency tape above) to another section 1 meter below. Participants in the Together condition were asked to pass each cup to their partner, who then placed it on the lower section of the metal surface. Participants in the Difficult condition used chopsticks to manipulate the cups, including passing them between partners when working together. In all conditions, each partner handled ten cups. Partners were instructed not to speak to each other during the object manipulation task, and if a cup fell, to merely pick it up with chopsticks or their hands (depending on condition) and continue with the task.

This object manipulation task was interleaved with the verbal task used in the previous experiments. Participants completed one block of the object-moving task, completed four diagrams in the verbal task, then alternated between the object-moving task and blocks of four diagrams in the verbal task until all 16 diagrams had been discussed. The same object-moving constraints (Solo; Together and Easy; Difficult) were used for all four iterations of the object-moving task for a given pair (i.e., these factors were manipulated between-pairs).

A brief questionnaire was administered after all the blocks were completed, prior to debriefing. The questionnaire asked whether participants had felt comfortable during the object-moving task, how difficult they had found the object-moving task, how much effort they had put towards taking the other person's perspective during the verbal task, and social affect ratings of liking, closeness, and similarity.

5.2 Results

The measures of linguistic effort that I examined previously are examined again here:

Explicit Marking, Matcher-Orientation, and Path-Based Framing. Means are presented for each measure and basic patterns are discussed before presenting a multiple regression model comparison for each measure. Each measure is treated separately as converging evidence for the effect of the physical collaboration manipulation task on increased effort among directors. For each measure, I present a logistic regression model representing the likelihood of a director using one of these methods in a direction-giving utterance.

Contrast coding of the fixed effects was used to test the following hypotheses with respect to each effect:

1. Do the two different co-presence conditions produce different levels of conversational effort? (Co-Presence, Together vs. Solo; represented in Table 4 as Tog[Solo], contrast values given in the model Together = 1, Solo = -1)
2. Do the two different difficulty conditions produce different levels of conversational effort? (Difficulty, Easy vs. Hard; represented in Table 4 as Easy[Hard], contrast values 1, -1)
3. Are descriptions of 0˚ diagrams different from descriptions of diagrams where perspectives are offset? (Angle, 0˚ vs. 90˚ & 180˚; represented in Table 2 as 0[90,180], contrast values 1, -0.5, -0.5)
4. Are descriptions of the two types of offset perspectives (90˚ and 180˚; represented as 90[180], contrast values 1, -1) different from each other?

The directionality (positive or negative) of the effect estimates associated with each independent variable is interpreted in the Results and Discussion sections based on the contrasts I have specified above. Positive effect estimates are aligned with "more" of the associated measure; for example, a higher value associated with the 90[180] contrast in estimating Matcher Oriented language means that there was *more* Matcher Oriented language used describing 90° diagrams than 180° diagrams.

Questionnaire items probed on a scale from 1 to 9 how close participants felt to their partner (variable name: Close), how similar they felt to their partner (Similar), and how much they liked their partner (Like). In order to examine the degree of perceived effort participants spent on the verbal task, I asked one general question and one specific question: how hard the verbal task was (VerbHard), and how much effort they made to take their partner's point of view (PerspEffort). In order to check that the Hard and Easy conditions of the object-moving task were in fact perceived as hard or easy, I asked participants how hard they found the object-moving task (ManipHard). Because this task is unusual enough that it might provoke some social awkwardness or have unforeseen social effects, I asked participants how silly they felt while performing the object-moving task (ManipSilly). In order to explore the degree of attention given to the partner during the non-verbal task, I asked participants to report how aware they were of their partner's presence (ManipAttend). I also asked participants how well they knew each other before the experiment commenced (Known). Means for these items are presented in Table 3 below. Answers to the questionnaire items were included in the maximal logistic regression after collapsing responses into two variables using Ward's hierarchical cluster analysis. A cluster dendrogram of all questionnaire items used in Experiment 4 is shown below in Figure 3. While these clusters may not have an obvious interpretation, they may indicate an underlying variable not captured by the questionnaire. The dendrogram for Experiment 4 shows two distinct clusters, grouped as follows:

VerbHard + ManipHard + ManipSilly + ManipAttend = External, a composite measure indicating the perceived effect of external factors (the experimental manipulation and the verbal task) on participants.

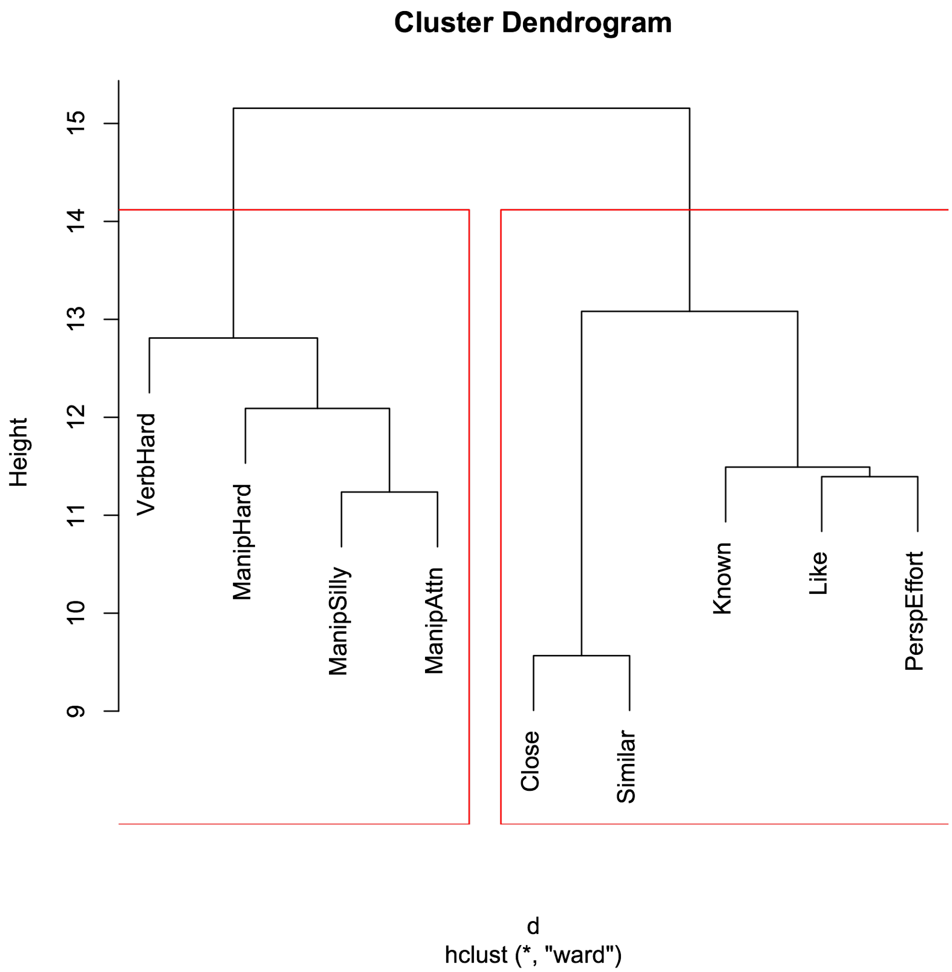
Close + Similar + Known + Like + PerspEffort = Connection, a composite measure indicating a connection between partners that went beyond mere pro-social feelings. Although this cluster may appear to contain two sub-clusters, I preferred to keep the "social affinity" items (Close, Similar, and Like) together in the same cluster when it makes sense to do so. In this case, the interpretation of these results is no more meaningful or interpretable if Close and Similar are viewed as a separate cluster from Known, Like, and PerspEffort.

Table 5.1. Mean Scores Reported from Post-Experiment Questionnaire (7-Point Scales Except Known: 0-1), Experiment 4.

	Solo-Easy	Solo-Hard	Together-Easy	Together-Hard
Feel close?	2.600	2.500	2.955	3.938*
Feel similar?	4.000	3.900	3.818	5.563*
Like each other?	6.050	5.800	5.364	6.438
Perspective effort?	5.400	5.775	6.955	6.563
Verbal task hard?	1.700	1.450	1.682	1.563
Object-moving task hard?	1.400	3.575**	1.909	3.375**
Object-moving task silly?	5.789	5.750	5.955	5.813
Aware of partner's presence?	4.579	5.100	6.955**	6.125*
Know each other before experiment?	1.000	1.000	1.136	1.813**

* $p < 0.05$; ** $p < 0.01$

Figure 5.2. Cluster Dendrogram of Post-Experiment Questionnaire, Experiment 4.



In the analyses below, the Co-Presence and Difficulty conditions are between-pairs, and the within-pairs stimulus angle contrasts are as specified in the previous three experiments. The effect estimates for all fixed effects are presented in Table 5.2. Pairs' dialogue was transcribed verbatim and the locative phrases uttered by each participant as a director were coded according to the three measures used in Experiment 1.

To compare directors' performance on all three measures and across all three diagram types (0, 180, and 90/270-degree perspective offset), means for each measure averaged across conditions are presented below in Figure 5.3.

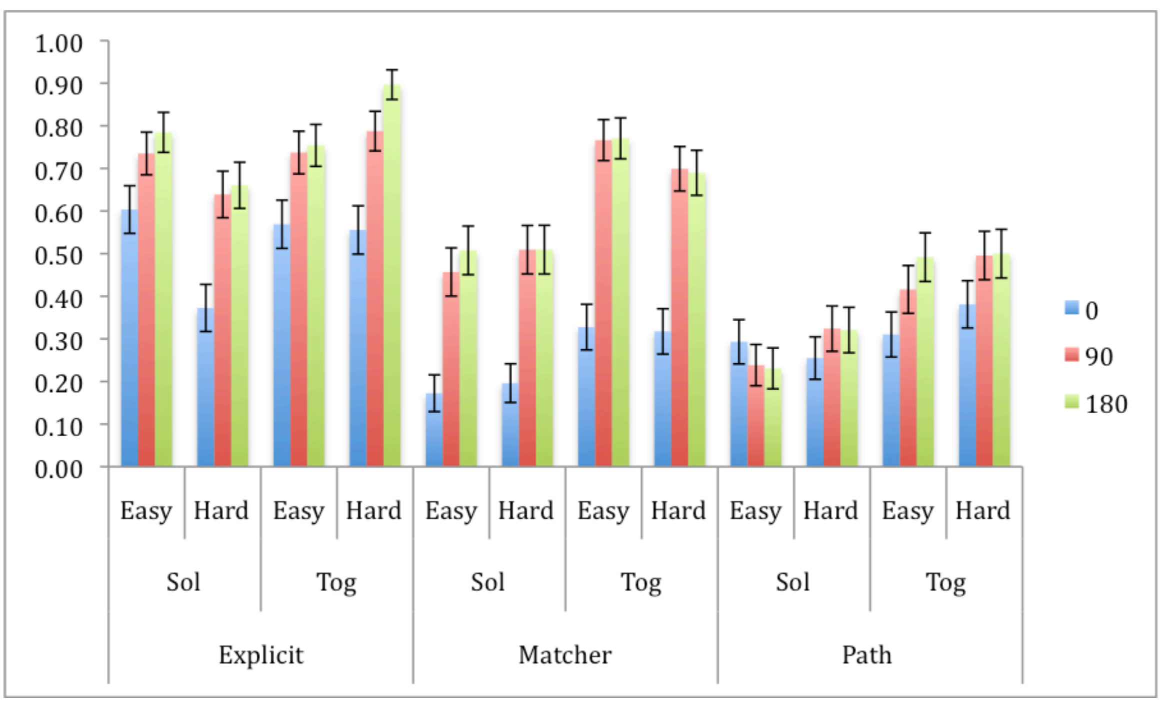
Table 5.2. Model Estimates of Fixed Effects with Standard Error and *t*-scores, Experiment 4.

	Explicit Marking			Matcher Oriented			Path-Based		
	Est.	SE	*T*	Est.	SE	*t*	Est.	SE	*t*
Tog[Solo]	-0.020	0.050	-0.407	0.314	0.071	4.428**	0.272	0.141	1.933*
Easy[Hard]	-0.195	0.067	-2.900**	0.008	0.090	0.088	0.116	0.163	0.707
90[180]	0.058	0.033	1.785†	0.039	0.054	0.722	0.183	0.092	1.991*
0[90,180]	-0.087	0.026	-3.321**	-0.294	0.049	-6.038**	-0.048	0.054	-0.889
Effort	-0.019	0.010	-1.808†	-0.039	0.017	-2.257*	-0.015	0.028	-0.516
Connection	0.038	0.009	4.053**	0.004	0.015	0.240	0.007	0.015	0.505
Tog[Solo] x Easy[Hard]	0.267	0.073	3.646**	-0.071	0.101	-0.705	-0.052	0.209	-0.247
Tog[Solo] x 90[180]	-0.010	0.044	-0.228	-0.025	0.063	-0.396	-0.162	0.099	-1.629
Tog[Solo] x 0[90,180]	0.020	0.035	0.589	0.097	0.058	1.675†	-0.057	0.065	-0.883
Easy[Hard] x 90[180]	-0.031	0.048	-0.655	0.036	0.074	0.485	-0.261	0.105	-2.481*
Easy[Hard] x 0[90,180]	-0.113	0.041	-2.735*	0.035	0.068	0.514	-0.038	0.077	-0.490
Tog[Solo] x Effort	0.013	0.014	0.976	0.059	0.021	2.818**	-0.003	0.037	-0.086
Easy[Hard] x Effort	-0.004	0.017	-0.234	0.020	0.024	0.821	-0.006	0.046	-0.137
90[180] x Effort	0.004	0.013	0.335	0.003	0.027	0.103	0.070	0.049	1.447
0[90,180] x Effort	0.006	0.010	0.603	-0.019	0.021	-0.899	-0.059	0.028	-2.126*
Tog[Solo] x Connection	-0.051	0.013	-3.938**	-0.003	0.019	-0.172	0.051	0.034	1.528
Easy[Hard] x Connection	-0.062	0.014	-4.288**	-0.054	0.020	-2.706*	-0.041	0.032	-1.266
90[180] x Connection	-0.029	0.012	-2.358*	0.003	0.018	0.192	0.014	0.025	0.552
0[90,180] x Connection	0.014	0.013	1.072	0.023	0.024	0.970	-0.036	0.016	-2.300*
Effort x Connection	0.016	0.005	3.294**	0.010	0.008	1.159	-0.002	0.010	-0.203
T[S] x Easy[Hard] x 90[180]	-0.058	0.065	-0.892	-0.076	0.088	-0.865	0.206	0.128	1.603
T[S] x Easy[Hard] x 0[90,180]	0.157	0.053	2.941**	-0.062	0.083	-0.745	0.049	0.096	0.507
T[S] x Easy[Hard] x Effort	0.037	0.021	1.802†	-0.036	0.029	-1.225	-0.003	0.061	-0.048
T[S]x 90[180] x Effort	-0.019	0.019	-1.012	-0.001	0.031	-0.040	-0.083	0.054	-1.554
T[S] x 0[90,180] x Effort	0.005	0.015	0.340	0.068	0.026	2.563*	0.007	0.040	0.178
Easy[Hard] x 90[180] x Effort	0.025	0.024	1.079	0.008	0.035	0.226	-0.074	0.059	-1.241
Easy[Hard] x 0[90,180] x Effort	-0.030	0.019	-1.636	0.027	0.028	0.960	0.064	0.036	1.758†
T[S]x Easy[Hard] x Connex	0.079	0.018	4.402**	0.067	0.025	2.708*	-0.031	0.050	-0.614
T[S] x 90[180] x Connex	-0.018	0.019	-0.979	-0.007	0.023	-0.311	-0.028	0.031	-0.905

	Explicit Marking			Matcher Oriented			Path-Based		
	Est.	SE	*T*	Est.	SE	*t*	Est.	SE	*t*
T[S] x 0[90,180] x Connex	-0.022	0.017	-1.254	-0.030	0.027	-1.119	0.040	0.022	1.852†
Easy[Hard] x 90[180] x Connex	0.059	0.020	3.019**	0.008	0.026	0.321	-0.018	0.037	-0.483
Easy[Hard] x 0[90,180] x Connex	-0.048	0.019	-2.484*	-0.073	0.029	-2.504*	-0.010	0.029	-0.345
Tog[Solo] x Effort x Connex	-0.011	0.008	-1.384	-0.003	0.012	-0.250	-0.055	0.022	-2.437*
Easy[Hard] x Effort x Connex	-0.021	0.006	-3.755**	-0.012	0.009	-1.251	0.009	0.015	0.574
90[180] x Effort x Connex	-0.014	0.007	-1.974*	-0.022	0.011	-1.969*	0.007	0.018	0.416
0[90,180] x Effort x Connex	0.013	0.007	1.844†	0.019	0.013	1.445	-0.020	0.011	-1.865†

†$p < 0.10$; *$p < 0.05$; **$p < 0.01$

Figure 5.3. Proportion of Conversational Effort Markers Used by Directors Across Stimuli in Experiment 4.



Explicit Marking

Explicit Marking indicates the director's willingness to put effort into word choice in order to give the matcher more information about whose perspective is being used in the description of the scene. Directors in the Solo condition who performed the Hard version of the motor task tended to use the least explicit marking of all four conditions (M_{SEasy} = 0.719 (0.450), M_{SHard} = 0.580 (0.495), M_{TEasy} = 0.703 (0.458), M_{THard} = 0.752 (0.433)). This effect seems to be driven by the zero-degree condition, as indicated in Table 20. Directors in the other three conditions tended to explicitly mark whose perspective was being taken about half the time in the zero-degree diagrams where both perspectives were visually aligned, while Solo-Hard Condition directors reserved explicit marking for descriptions of the 90˚ and 180˚ diagrams. Directors in the Together-Hard condition used explicit marking like other directors in addressing the 0˚ and 90˚ diagrams, but when describing the 180˚ diagrams they used explicitly marked locatives nearly 90% of the time.

Table 5.3. Mean Proportions (with Standard Deviations) of Explicitly Marked Locative Phrases, Experiment 4.

	Angle		
	0°	90°	180°
Solo-Easy	0.60 *(0.49)*	0.74 *(0.44)*	0.79 *(0.41)*
Solo-Hard	0.37 *(0.49)*	0.64 *(0.48)*	0.66 *(0.48)*
Together-Easy	0.57 *(0.50)*	0.74 *(0.44)*	0.75 *(0.43)*
Together-Hard	0.56 *(0.50)*	0.79 *(0.41)*	0.90 *(0.31)*

Before accounting for the effects of the additional questionnaire-based variables, directors' behavior indicates that difficulty and co-presence have opposite effects on the use of Explicitly Marked phrases: completing difficult tasks alone is associated with less Explicit Marking, while completing difficult tasks together is associated with more Explicit Marking, especially as the angle between perspectives increases. However, results from the logistic model revealed that the main effect of Co-Presence was not significant in this analysis ($p = 0.68$), but the interaction of Co-Presence with Difficulty was (Est. = 0.267, $p < 0.001$). Directors in the Easy condition used significantly less Explicit Marking to denote perspective than their counterparts in the Difficult condition (Est. = -0.195, p = 0.004). The effect of Angle was also significant (p = 0.001) although as in the previous experiments this was the result of directors treating the 0-degree diagrams much differently than the 90-degree and 180-degree diagrams. This is also evident in the 3-way interaction between Co-Presence, Difficulty, and Angle: directors in the Together/Hard condition used more Explicit Marking in descriptions of 0-degree diagrams than other directors (Est. = 0.16, p = 0.02). Directors in the Solo condition who scored lower on measures of Connection used significantly less Explicit Marking than other directors (Est. = -0.05, p < 0.001), as did directors in the Hard condition who scored lower on Connection (Est. = -0.062, p < 0.001). No interactions between Angle and External were significant, but directors who scored higher on Connection measures used less Explicit Marking in descriptions of 90-degree diagrams than 180-degree diagrams (Est. = -0.029, p = 0.02).

Matcher Orientation

Matcher Oriented language indicates the director's willingness to put effort into mental rotation in order to represent the matcher's perspective to themselves before planning an utterance, regardless of whether it is explicitly marked as such in the director's description. Directors in the Together condition tended to use more matcher-oriented language than those in the Solo condition, across all three stimulus angles (M_{Tog} = 0.63 (0.48), M_{Solo} = 0.42 (0.49)).

Table 5.4. Mean Proportions (with Standard Deviations) of Matcher-Oriented Locative Phrases, Experiment 4.

	Angle		
	0°	90°	180°
Solo-Easy	0.17 *(0.38)*	0.46 *(0.50)*	0.51 *(0.50)*
Solo-Hard	0.20 *(0.40)*	0.51 *(0.50)*	0.51 *(0.51)*
Together-Easy	0.33 *(0.47)*	0.77 *(0.43)*	0.77 *(0.42)*
Together-Hard	0.32 *(0.47)*	0.70 *(0.46)*	0.69 *(0.47)*

Before accounting for the effects of the additional questionnaire-based variables, directors' behavior indicates that Matcher Oriented phrasing is more easily affected by co-presence than by task difficulty. Directors in the Together conditions used significantly more Matcher-Oriented descriptions than directors in the Solo conditions ($p < .001$). Directors' use of Matcher-Oriented language did not appear to differ based on the Difficulty of the induction task ($p = 0.93$). Directors used significantly less Matcher-Oriented language when describing diagrams where perspective was shared compared to diagrams in which perspectives were offset from each other (0˚ vs. 90/180: $p < .001$; 90˚ vs. 180˚: $p = 0.47$). However, results from the logistic regression model revealed that higher scores on the External variable cluster were associated with more Matcher Oriented language ($p = 0.024$), but higher scores on the Connection variable cluster were not ($p = 0.81$). Directors did not appear to use Matcher-Oriented language to mitigate effort related to external factors in the Difficult condition (Difficulty x External, $p = 0.41$), but when that effort was related to a collaborative task, as in the Together condition, directors who reported higher External scores did use more Matcher-Oriented phrases ($p = 0.005$).

Path-Based

Use of Path-Based descriptions indicates a director's willingness to engage in a richer representation of the map by alluding to more than one location in their description. This second location is usually one of the two perspectives represented on the map. Directors in the Together conditions tend to use more Path-Based descriptions than directors in the Solo conditions, and in general, more Path-Based descriptions in the Hard fluency conditions than in the Easy conditions (M_{SEasy} = 0.248 (0.433), M_{SHard} = 0.307 (0.462), M_{TEasy} = 0.410 (0.493), M_{THard} = 0.466 (0.500)).

Table 5.5. Mean Proportions (with Standard Deviations) of Path-Based Locative Phrases,

Experiment 4.

	Angle		
	0°	90°	180°
Solo-Easy	0.29 *(0.46)*	0.24 *(0.43)*	0.23 *(0.43)*
Solo-Hard	0.26 *(0.44)*	0.32 *(0.47)*	0.32 *(0.47)*
Together-Easy	0.31 *(0.50)*	0.42 *(0.50)*	0.49 *(0.50)*
Together-Hard	0.38 *(0.49)*	0.50 *(0.50)*	0.50 *(0.50)*

Before accounting for the effects of the additional questionnaire-based variables, directors' behavior indicates that co-presence is a greater influence on Path-Based language than fluency. Indeed, in the logistic regression model, the difference in use of Path-Based language between the two Co-Presence conditions was significant ($p = 0.05$), while the difficulty of the motor task was not associated with more Path-Based locatives ($p = 0.48$). However, the amount of Path-Based language used by directors differed significantly between 90˚ and 180˚ diagrams ($p = 0.05$), although Path-Based language was not used significantly less in descriptions of 0˚ diagrams ($p = 0.37$). Neither questionnaire-based measure (External or Connection) was significant as a main effect, but both were significant in interactions with Angle, indicating that directors used less Path-Based language when describing 0˚ diagrams if they scored higher on External ($p = 0.03$) or Connection ($p = 0.02$). This suggests that both external task demands and feelings of interpersonal affinity are associated with more "strategic" use of Path-Based phrases. Directors who experienced the manipulation and language tasks as disfluent appear to use Path-Based phrases more often when it matters, i.e. when their perspective differed from their partner's.

5.3 Discussion

This experiment separates two factors in Experiment 1 whose overlap obscured the search for a mechanistic explanation of that study's results: physical task difficulty and deliberate co-ordination with another person. In Experiment 1, the task that participants performed before talking about spatial diagrams was both co-present and had varying degrees of physical difficulty. In Experiment 4, the two orthogonal condition groups (Difficulty: Hard vs. Easy and Co-Presence: Solo vs. Together) allow me to see the influence of co-presence on a non-rhythmic and, crucially, goal-oriented task. In my interpretation of the results of Experiment 4, I assume that the Together conditions have a similar effect on partners' language use that the clapping task – especially the Alternating and Asynchronous varieties – had on partners in Experiment 1. In both cases, partners were trying to deliberately create or maintain a pattern of movement collaboratively: one person's actions depended on the other person's actions for successful execution. In the Alternating condition of Experiment 1, the movement was only successful if both partners attended to their own clapping rhythm and ensured that their own claps did not occur at the same time as their partner's claps. In the Asynchronous condition partners had to focus on their own clapping pattern in order to maintain it, but were also able to hear their partner's clapping pattern and passively monitor its accuracy. In the Together conditions of the present experiment, the object-moving task could not be successful unless one partner was ready to accept an object when the other partner was ready to pass her the object, requiring attention and coordination. In both cases, partners needed to attend to each other's actions and anticipate or monitor them as they unfolded over time. It is this attention that led to greater use of effortful language in their description of the spatial diagrams.

The general trend in this experiment was toward greater use of effort markers in the Together conditions and less frequent use in the Solo conditions, although the effects of Co-Presence are not significant across all effort markers. Directors in the two Co-Presence conditions followed this trend in two out of three measures of linguistic effort that I tracked: Matcher Orientation and Path-Based Locative use. Directors who performed the Solo tasks tended to use fewer Matcher-Oriented and Path-Based locatives than those in the Together conditions, although differences in Explicit Marking were driven mostly by task difficulty. In the object-moving task, directors either became used to working alone and ignoring their partner's presence (in the Solo conditions), or working together, anticipating their partner's movements, and adjusting to accommodate their partner's actions in order to successfully complete the task. Figure 4 shows that the Together condition encouraged partners to attend to each other's perspective in order to accomplish a collaborative goal across both Easy and Hard variants of the manipulation task.

While the impact of Co-Presence affected Matcher Oriented and Path-Based locatives, the effect of Difficulty was concentrated in directors' use of Explicit Marking. Experiencing greater motor fluency in this goal-oriented, non-rhythmic task results in less use of Explicit Marking, which parallels the behavior of directors in Experiment 3 who also used less Explicit Marking in the Easy clapping condition. A sense of Connection between partners also tended to decrease helpful language in concert with Co-Presence and Difficulty conditions. While greater reported Connection increased the use of Explicit Marking across all conditions, higher Connection scores seemed to decrease helpful language use for collaborating directors or those who performed the easier motor task. Increased social affinity and previous acquaintance lowers the likelihood of helpful language use, aligning with the "close-communication bias" research presented by Savitsky and colleagues that shows more egocentric language use between friends (Savitsky et al., 2011). Adding the grouped questionnaire variables to the regression analysis complicated the interpretation of Experiment 4, since the experimental manipulations were designed to vary the degree of externally-imposed difficulty (some of which may have been captured by the External cluster) and interpersonal connection (some of which was captured by the Connection cluster). These two variable clusters were not fully correlated with the Difficulty and Co-Presence manipulations, but represent internal states that, when present, predicted helpful language use better than Difficulty and Co-Presence alone. Although grouping the Connection and External clusters was somewhat subjective, they may reflect an underlying unknown variable that was not captured by the questionnaire or universally produced by the experimental manipulations. The clustered variables show the importance of participants' subjective experience to mediate between the physical facts of a task and the communication choices people make in order to manage that task.

The Solo condition forced partners to switch back and forth between focusing on their own hand-eye coordination in the object-moving task, and focusing on their partner's visual perspective in the spatial description task. In the Together condition, partners continued to focus on the other person throughout the experiment. However, in the Easy Fluency condition, this attention-switching does not appear to have any cost in terms of conversational effort. In the Hard condition, we see that the cost of switching attention from a genuinely difficult hand-eye coordination task performed alone, to a conversation with another person, is a reduction in the effort spent on that conversation.

The tasks in the Together-Hard condition effectively made partners feel closer and more similar to each other, as they reported in the questionnaire. This suggests, unsurprisingly, that real-life collaborative acts induce stronger pro-social feelings than having an authority figure tell you that you are similar to someone else (as in Experiment 2). The evidence from conversations between people in the Together-Hard condition shows that closeness and similarity go hand in hand with helpful language and improved perspective-taking. The focused attention required by the Together-Hard task, similarly to the Asynchronous clapping task in Experiment 1, carried over to pairs' conversations, in which some perspective-taking language was required. The amount of this perspective-taking language was regulated by the pairs' *joint effort* in the previous task, reflected both by directors' language in the Easy vs. Hard conditions and by self-reported manipulation effort in the post-experiment questionnaire.

In the next and final chapter, I will discuss how these results shed light on previous studies in the literature, discuss general implications for spatial language in interactions, the role of joint effort in verbal and non-verbal tasks, and address any open questions with suggestions for future research in this vein.

Chapter 6

These experiments were intended to discover possible connections between our physical coordination with each other and our cognitive connection with each other through language, and how types of coordination might modulate and influence each other. The initial experiment that motivated this series of studies grew out of an intuition expressed in Pickering & Garrod's (2004) Interactive Alignment account of conversation: "alignment at one level leads to alignment at another level." This statement can be taken to mean that the growth of one kind of linguistic alignment can lead to another kind of linguistic alignment. For example, the growth of syntactic alignment between speakers may go hand in hand with the alignment of their pronunciation of certain words. However, I was interested in taking this further, examining whether linguistic alignment developed during conversation could be linked to non-linguistic alignment, especially of physical motions. Work in the dynamical systems tradition had already suggested that alignment of unconscious body movements can influenced by the alignment of language patterns (Shockley, Santana, & Fowler, 2003). And experiments on group behavior suggested that the direction of causality could also be reversed: aligning body movements deliberately - especially using rhythm - could align people cognitively in ways that emerged as conversational helpfulness or displays of trust (Kirschner & Tomasello, 2010; Wiltermuth & Heath, 2009).

In Experiment 1, I attempted to reproduce this connection between deliberately-aligned body movements and helpful behavior in conversation. I was also interested in exploring different types or degrees of alignment, and operationalized this in the experimental context as different rhythmic coordination patterns. Dynamic stability in the oscillating patterns of human movement is an important cue that researchers have used to study connections between people, as in Shockley, Santana, and Fowler's work (2003). Combined with Pickering and Garrod's notion of alignment at one level leading to alignment at another level, I reasoned that controlling dynamic stability could give us insight into alignment at any level in which oscillating behavior occurred.

Pickering and Garrod's intuition was simple, although it has been further explored and strengthened by recent work (Pickering & Garrod 2009; 2013). On its face, it seemed that alignment at one level should lead to alignment at other levels in a linear fashion: better alignment on level A = better alignment on level B, given a clear connection between A and B. However, in this case "clear" connections do not necessarily take a linear path. In Experiment 1, I discovered that the connection between clapping in rhythm and using more effort to explain a spatial perspective did not reflect the simple prediction that types of alignment should mutually benefit one another. I expected that people who had a more stable physical alignment (the Synchronous pairs) would have an experience like the participants in Wiltermuth and Heath's (2009) study, who deliberately walked in step with each other and found that they displayed more trust in a later game. I reasoned that evidence of helpfulness - explicitly marking whose perspective is being taken, for example, or using the addressee's perspective - would be associated with those who were better aligned physically.

This was not the case in Experiment 1. On the surface, it appeared that directors in the most well physically synchronized condition produced the least helpful language, and more effort toward linguistic coordination was displayed by directors who had the more effortful task of aligning to two opposing rhythms. The worst-aligned pairs on an embodied level seemed to be the best at aligning with their partners' spatial representations. This effect was moderated by both perceived task effort and social affinity. The 3-versus-5 "Asynchronous" rhythm should have been difficult to produce without a great deal of focus on the internal mechanics of correct rhythm production. Yet it seemed that Asynchronous directors who reported this difficulty (and felt some affinity for their partner) put more effort toward perspective taking in the spatial description task. The clapping task did not appear to use up resources that were needed later in conversation, but instead seemed to set expectations for the amount of resources required, as reflected by directors' use of effort markers. These results led me to take a more direct approach to physical coordination, social affinity, and joint action in the subsequent three experiments, in the hopes of teasing these factors apart.

The three experiments that followed tested two possible explanations for the results of Experiment 1: the Fluency hypothesis and the Compensation hypothesis. The Fluency hypothesis proposed that the surprising results of Experiment 1 were due to the subjective physical difficulty of the clapping patterns as experienced by the partners. This sense of disfluency carried over to the verbal task, and influenced the alignment of their own perspective with their partner's perspective. Partners who completed the Synchronous clapping task performed a fluent action that was trivially easy for them. This level of physical ease set their initial expectation for the verbal task, which translated into lower levels of effort markers in their descriptions. Since the maps were designed to require a special type of effort (perspective-taking), different levels of task difficulty should produce different levels of perspective-taking language. This lines up with Pickering and Garrod's (2004) intuition about "alignment at one level leading to alignment at other levels." The Fluency hypothesis proposed that these levels were connected by a general feeling of fluency or ease that affected partners' behavior in all tasks performed.

The Compensation hypothesis, however, attributed the results of Experiment 1 to a different mechanism. On this account, partners in the Asynchronous condition may have felt more distant and dissimilar from each other after performing the clapping task. Their increased use of effort markers in conversation was an attempt to make up the social distance that they felt. In order to overcome the social discomfort caused by performing the difficult or unnatural-feeling clapping pattern, they put extra effort towards smoothing the social connection during the conversation task.

With these hypotheses in mind, the three subsequent experiments tested several likely candidates for the mediator of this effect.

1. *Social Closeness*: participants who performed the Synchronous clapping task felt closer to each other, so they were less likely to use helpful language because there was less need to build rapport or make effort towards taking the other person's perspective. In Experiment 2, I examined this possible mediator by artificially inducing social closeness using a list of adjectives that were doctored to present partners as similar or dissimilar in personality. This manipulation did make partners feel more or less similar to each other based on condition, but it did not result in significantly more helpful/effortful language in either the Close or Distant conditions. Across experiments, the relationship between the social affinity subscale (Similarity, Liking, and Closeness) of the post-experiment questionnaire was inconsistent as a predictor of helpful language. In Experiments 3 and 4, the social affinity subscale clustered with other items in the post-experiment questionnaire, including whether partners were previously acquainted and whether the direction-giving task was effortful, making it

impossible to suggest a causal relationship between social closeness and conversational performance.

2. *Rhythmic Stability*: participants who performed the Asynchronous clapping task reported that it was more difficult and that they tried to concentrate mostly on their own clapping rather than the other person's clapping. Asynchronous directors used more Explicitly Marked and Matcher-Oriented language than either Synchronous or Alternating directors. I hypothesized that this could be because the rhythm they maintained during the clapping task was much less dynamically stable and inherently more difficult or less "natural." In Experiment 3, I attempted to remove the social or collaborative component from the equation and examined the situation of participants who independently clapped along with a computer metronome, either an "easy" dynamically stable and natural rhythm (every other beat), or a "hard" and unstable or unnatural rhythm (every 5th beat), before coming together to do the spatial description task. Partners in the Hard condition did in fact find the 5-rhythm harder to maintain successfully for the brief 60-second periods in which they were isolated from their partners, but linked this difficulty to the joint action of conversation in a limited way (only increasing Explicit Marking).

3. *Collaboration and Motor Difficulty*: combining both the social component examined in Experiment 2 and the difficulty component examined in Experiment 3, I explored the influence of collaboration on spatial language use in Experiment 4. In Experiment 1, participants were asked to successfully maintain a rhythm together in three different ways: in the Synchronous condition, they maintained a rhythm that either one could have easily maintained alone, and which required no especial attentiveness to the

partner's actions. In the Alternating condition, the rhythm itself was not difficult, but the successful maintenance of the rhythm required both partners to pay close attention to timing and turn-taking. In the Asynchronous condition, partners knew that their rhythms were distinct from each other, so they could not rely on the other person's rhythm to accurately predict their own as they could in the Alternating task. However, the rhythms themselves were also difficult enough that they required significant internal attention to coordinate with the metronome and with their own pattern, e.g. by counting the number of beats since their last clap. Even so, they were involved in a collaborative and goal-oriented task in which each partner had to "pull their weight" by keeping the two disparate rhythms going for a full minute. Viewing these tasks not merely as experiences but as goals to be achieved could mean a goal that is intensely collaborative but easily accomplished (Alternating condition) may influence the use of spatial language differently than a goal that requires more internal attention than external attention, and which is difficult to accomplish. In order to tease apart these two factors (collaboration and task difficulty) I used the task described in Experiment 4. Partners who performed tasks together, regardless of their difficulty, tended to use a higher proportion of Matcher-Oriented and Path-Based descriptions. The influence of task difficulty only emerged as unique in Explicit Marking, where pairs in the Solo Hard condition consistently used a *lower* proportion of explicitly marked locative phrases. Overall, the results of Experiment 4 suggest that collaboration or co-presence has a greater influence than the difficulty of an activity on the use of effort markers. Task difficulty was not a consistent predictor of helpful language across experiments in the regression analysis, although it clustered together with the post-experiment questionnaire item about conversational difficulty in Experiments 3 and 4, suggesting that partners felt similar levels of difficulty in the induction task and the conversation task. Since the conversation task was the same across all four experiments, this is one indication that the experience of nonverbal effort can carry over to later verbal tasks, even if the verbal task is not itself difficult.

At the beginning of this dissertation, I articulated a list of questions that I intended to explore in the experiments I designed. In order to get a general overview of how these questions were addressed, I list them here as they align with the purpose and scope of the four experiments. If a question is not addressed by a particular experiment, that cell is left blank.

Table 6.1. Checklist of Queries and Evidence Across All Experiments.

Question	Exp. 1	Exp. 2	Exp. 3	Exp. 4
What is the role of intentionality in "automatic" alignment?	Unclear	Possible		Important
Does intentional or unintentional alignment exert the most influence across levels?	Unclear			Intentional
How do we distinguish between intrinsic and collaborative actions?	Unclear			Visual co-presence
What is the relationship between "helpful" conversational effort towards the alignment of perspective, and non-isochronous embodied rhythms?	Some rhythms increase helpful language		*Some* rhythms increase *some* helpful language types	
Do feelings of social closeness mediate the relationship between rhythmic behavior and conversational effort?	Yes	Yes		
Does motor coordination outside of co-presence influence conversational effort?			No	
Does subjective motor disfluency carry over into later conversational effort (effort breeds effort)?	In some cases		Yes	Yes
Does subjective motor disfluency carry over into later conversational effort *in the absence of rhythmic alignment*?				Yes
Are degrees of dynamic stability important in determining the strength of alignment that crosses levels?	No			
Which has more power to align our representations: dynamically stable rhythms, or goal-directed collaboration?	Unclear			Collaboration

Experiments 1 and 4 provided the most evidence for my initial questions. However, in Experiment 1, as many questions were created as were answered, and several items remained unclear. Some rhythmic behavior (Asynchronous clapping) seemed to increase helpful language, but a more detailed analysis revealed that this effect depended on greater pro-social feelings and experiencing the tasks as effortful. Experiment 1 showed that subjective motor disfluency was carried over into later conversational effort to some degree, but only when participants *felt* they had put more effort toward the motor and verbal tasks. In Experiment 2, I tested whether social closeness could be artificially aligned, and whether this would affect conversational effort. Participants did not align their personalities with each other out of choice - they were told whether or not they were well-aligned based on random assignment. This suggests that a belief in greater social alignment – even a false belief – will produce greater helpful language use between partners. The results of Experiment 4 showed two distinct patterns in the relationship between motor effort and conversational effort. Subjective motor disfluency, measured in the post-experiment questionnaire as ManipHard and represented in the Effort variable cluster, predicted less conversational effort in the form of Matcher Oriented and Explicitly Marked phrases. However, greater motor disfluency as part of a collaborative task (the Hard-Together condition in Experiment 4) produced increases in all three measures of helpful language, compared to the non-collaborative condition. Even without rhythmic alignment, joint task-oriented movements influenced later conversations. This interaction between fluency and co-presence leads me to conclude that goal-directed collaboration, not dynamically stable rhythms, strongly influences shared spatial representations in conversation.

6.1 Overview of Measures

Overall, the three effort markers I examined in my analyses can be said to reflect different conversational strategies, each of which could contribute a different amount of effort to the conversation. On the principle of Least Collaborative Effort (Clark, 1996), we can assume that the use of particular markers of perspective implies that the speaker believes some degree of effort is necessary in order to achieve mutual understanding. Explicit Marking (such as saying "on my left") seems to be the least effortful of the three marker types, since it does not require any mental rotation on the part of the director, and can be used to describe an egocentric perspective just as easily as it can describe a Matcher-Oriented perspective. Even so, Explicit Marking also serves to decrease ambiguity. Matcher-Oriented effort markers show that the Director is willing to perform the necessary amount of mental rotation to align their description with the Matcher's perspective on the diagram. This effort marker is the most important one for the verbal task I used across all four experiments, since accurate use of the Matcher's perspective can eliminate any need for Matcher queries or confusion. However, the mental rotation involved in describing the 90˚ and 180˚ diagrams from the Matcher's perspective is not insignificant, and many Directors opted not to put that degree of effort into their descriptions. Path-Based descriptions also involve more effort up front, since they require Directors to think of the diagram in terms of the relationship between objects, rather than merely setting the objects in an implied coordinate system of Left/Right and Up/Down. However, they also use more than one object in describing a location, so they also require the Matcher to think of the map in these enriched terms. Path-Based descriptions may not decrease the effort required by the Matcher to think about the objects in the diagram, but they do decrease ambiguity by anchoring the description of the target to another known, distinguishable object.

There were some commonalities across all four experiments in how the different types of conversational effort were used. Directors used effort markers much less when describing the 0˚ diagrams (just as Schober (1993) found in his original study), probably because no effort was required in order to mentally rotate the diagram and take the Matcher's perspective - both partners saw the objects from the same perspective. However, Directors never completely abandoned the use of effort markers in the 0˚ diagrams. Most likely, this is due to the routinization of descriptions that included effort markers, boosting their presence in the construction of all descriptions, including the 0° diagrams. These routine constructions were also consistent across experiments: Directors often used the "my left, your right" format in order to decrease ambiguity; in this construction, both perspectives are marked, the Matcher's perspective is used, and it is set in relation to the Director's perspective. In this short phrase, Directors are arguably able to convey as much information as is available from the diagram without being verbose. However, multiple effort markers per description were common, reflecting the general 'low cost' of each. Directors were not asked to make their descriptions concise, merely accurate, and effort markers are not mutually exclusive - all can be present or absent from a phrase independently of each other. The use of specific effort markers was remarkably consistent across experiments, suggesting that these measures were employed in a similar way, or for similar reasons, by all speakers regardless of what happened outside of the direction-giving conversation. These proportions (% of all locative phrases in which the specific effort marker occurred) were presented separately in the chapter devoted to each respective experiment, and are presented again here in Table 1 in order to show the commonalities and differences that emerged.

Table 6.2. Proportion of Effort Markers Used, by Experiment.

	Explicit	Matcher	Path
Experiment 1	0.63	0.59	0.38
Experiment 2	0.60	0.65	0.39
Experiment 3	0.54	0.60	0.33
Experiment 4	0.69	0.53	0.36

Explicit Marking was generally the most common way that directors put more effort into their descriptions of diagrams. Across all four experiments, Directors used Explicitly Marked locatives around 60% of the time. Locative phrases explicitly marked for perspective were also more likely to be used in the 0˚ diagrams than phrases containing the other two effort markers. Since marking whose perspective is being taken does not require mental rotation or representation of more than one object in the diagram, it is unsurprising that this is the most frequently used effort marker. It is also likely that more Explicit Marking was used across all angles due to routinized sentence frames. Partners often established a consistent sentence frame, such as "The X is on [my/your/our] [left/right]," that they settled into after an initial negotiation period. Since these sentence frames can contain explicitly marked perspectives, they may have inflated the number of Explicitly Marked locatives used overall.

Matcher-Oriented locatives were also very common in descriptions of the map stimuli; just under 60% of locatives across all four experiments were Matcher-Oriented. Speakers used this effort marker more strategically with respect to angle, using it less when describing the 0˚ diagrams than they used Explicit Marking. This should not be surprising, since the descriptions of 0˚ diagrams were conservatively coded – I assumed that non-explicit descriptions were given from the Director's perspective. Since these perspectives were not separated on the diagram, I could not assume that Directors were separating them cognitively. Still, there was not a single condition across all four experiments in which Matcher-Oriented locatives for the 0˚ diagrams made up less than 10% of phrases. Again, this may be due to the prevalence of routine sentence frames that used a Matcher-Oriented pronoun; when all other diagrams are conventionally described as "to your [left/right]," it may be easiest to continue with this pattern even when a more accurate phrase would be "to our [left/right]." Indeed, in scattered cases Directors corrected themselves when describing 0˚ diagrams, offering a repaired phrase aligned with "our" shared perspective. If some pairs had described only 0˚ diagrams, it is possible that they would never have fallen into the pattern of using Matcher-Oriented locatives, but it is also possible that

Matcher-Oriented descriptions are preferred as a matter of politeness, even when they are not necessary.

Path-Based locatives followed a similar pattern to Explicit Marking and Matcher Orientation, but there are some interesting differences that distinguish this effort marker from the other two. Path-Based locatives were not just the least popular effort marker, they were used in a minority of utterances, comprising only 36% of locatives overall. Path-Based locatives are distinguished by the prepositions used in their construction: *to*, *toward*, *closer*, and *further* denote Path-Based phrasing. Also, there were fewer effects of Angle on the use of these effort markers. Diagrams with different angles between perspectives may be best described with different prepositions - for example, in the 180˚ diagram many descriptions used the "closer to/farther from" construction. However, in subsequent 90˚ or 0˚ diagrams, the objects may both have been equidistant from both partners' locations, so neither object could be described as "closer" or "farther." Since Path-Based locatives are coded based on the preposition used, breaking the lexical pattern of preposition use every few diagrams would have reduced the likelihood that a Path-Based structure would persist over time. It is also possible that the use of Path-Based locatives is lower because they simply take more effort and are harder to construct than either Explicitly Marked or Matcher-Oriented phrases. Cognitively, they require the speaker to represent more than one object in the field of view, and to make a connection between those two objects explicit to the listener. However, while the use of Explicitly Marked and Matcher-Oriented phrases tended to decrease over the four blocks of diagrams in favor of unmarked Director-Oriented phrases, proportions of Path-Based phrases tended to remain low but steady over the course of the experiment.

6.2 Diagrams and Perspective

Across all four experiments, directors and matchers alike adjusted their conversational effort to match the amount of mental rotation required to align the perspectives represented in each map. The table below summarizes, across all four experiments, the proportion of effort markers used grouped by the angle between perspectives. These proportions (% of all locative phrases in which the specific effort marker occurred) were presented separately in the chapter devoted to each respective experiment, and are collected here in order to discuss commonalities and differences that emerged.

Table 6.3. Proportion of Effort Markers Used Across All Experiments, by Angle.

	0°	90°	180°
Explicitly Marked	0.45	0.67	0.70
Matcher-Oriented	0.26	0.69	0.71
Path-Based	0.31	0.35	0.37

In the 0° maps, directors made the least effort toward taking the Matcher's perspective or providing them with an enriched description. It should not be surprising that directors in all experiments used the least effort in diagrams where both partners' perspectives were in the same location. In the 90° and 270° maps, directors dramatically increased their use of Matcher-Oriented language across experiments, with some interesting exceptions. In Experiment 1, Directors in the Alternating condition did not use significantly more Matcher-Oriented language than they did to describe 0° diagrams. In Experiment 4, Directors in the Solo conditions used more, but not significantly more Matcher-Oriented locatives when describing 90° and 180° diagrams than when describing 0° diagrams. While there is no clear reason for the Experiment 1 result, the behavior of Directors in Experiment 4 suggests that those in the Solo conditions were generally less sensitive to differences between perspectives. In the 180° maps, directors tended to use the highest proportion of effort markers in all three categories. Since these diagrams involved the most mental rotation, increased effort towards creating understanding seems an appropriate strategy.

6.3 Spatial Language in Embodied Interactions

My research informs the current joint action approach to studying conversation, as opposed to language in isolation. Spatial language, in particular, has sometimes been studied as a phenomenon that occurs in the "ideal speaker/hearer" and not in response to another person's presence. However, that has changed in recent years (Schober, 1993; Keysar, Barr, Balin, & Brauner, 2000; Steels & Loetzsch, 2007; Hasegawa, Cassell, & Araki, 2010; Ma, Raux, Ramachandran, & Gupta, 2013). Speakers take their listeners into account when giving directions or using spatial language, but we have previously assumed that these calculations were based on a speaker's model of their listener's knowledge. The studies presented here suggest that embodied actions, especially joint actions, also provide relevant information for coordinating one's perspective with an interlocutor. In the present studies, Directors in Experiment 1's Asynchronous clapping condition or Experiment 4's Together-Hard object moving condition could have used the sense of being out-of-synch, or of their collaboration being difficult, as a heuristic to figure out how much help their partner would need in the verbal task. Alternatively, this sense of synchrony may not have emerged at a conscious level but influenced cross-modal alignment in a more automatic way. It is still an open question whether speakers are being strategic in their deployment of effort. The character of the interactions - verbal or nonverbal - between speakers can greatly affect their use of spatial language when it is a form of helpful behavior.

Based on these studies, I cannot conclude that increased nonverbal alignment leads seamlessly to increased alignment of representations, as might be predicted by the most straightforward interpretation of Pickering and Garrod's (2004) interactive alignment account. However, Directors who performed tasks in which nonverbal alignment was easiest were also those who used the lowest proportion of conversational effort markers, implying that they may have believed (either implicitly or not) that their representations were already better aligned. When nonverbal alignment was easy, Directors may have assumed that the Matcher's perspective was closer to their own (Savitsky et al., 2011). This assumption would predict less use of effort markers by Directors who found the induction task easy and more effort markers when the induction task was more difficult. Across all four experiments, the composite variable containing the ManipHard item (the best analogue for effort in the induction task) was not consistently associated with increased effort markers; in Experiment 3, this variable was a significant predictor of more Explicit Marking, but in Experiment 4 it was a significant predictor of less Explicit Marking and less Matcher-Oriented language. Since the post-experiment questionnaire was always administered after the entire experiment was completed, it is possible that participants had trouble pulling apart the subjective difficulty of the manipulation from the difficulty of the verbal task. They did not merge these two feelings of difficulty, since this would have led to ManipHard consistently clustering with VerbHard across experiments, which it did not. The behavior of ManipHard relative to verbal effort markers suggests that there is not a linear relationship between embodied, nonverbal difficulty and the use of spatial language between partners.

6.4 Co-Presence, Effort, and Fluency

One motivating question behind my research is: what makes speakers likely to put more work into a conversation sometimes, but not other times? Outside of a laboratory setting, this work could be regulated by external factors like distractions, inherent interest in the topic or in one's conversation partner, or internal factors like fatigue. The studies I present here show that one important factor could be the degree of effort involved in any prior nonverbal joint action with one's conversation partner. In my studies, the rhythmic coherence of the clapping patterns used in Experiments 1 and 3 is a proxy for degree of effort. Previous studies in this vein have not approached conversation from the perspective of effort, although Kirschner and Tomasello's (2009) developmental study contains some interesting parallels. In their study, children who performed a song-and-movement task with a set pattern were later more helpful than children who performed a speech-only, self-directed version of the same task. The goal of the task in both conditions was to "wake up" a toy frog. The condition that produced the most helpful language and behavior involved collective movements, while the other condition was more individually-focused. It is possible that trying to keep in time with the group's movements and rhythm required more attention to others, and that this focus outside the self carried over to increased collaborative behavior in later free play. Coordinated joint action can focus our attention on others, and this other-focus may make it easier to keep our conversation partner's perspective in mind, or lead to verbal choices that make things easier for them. In both Experiments 1 and 4, the most helpful language was used by pairs who performed a task that involved joint movement and/or rhythm to accomplish a goal. These pairs also developed significant feelings of similarity and closeness. The results of Experiment 4 show a contrast in language use between directors who make an effort to coordinate verbally with their partner, even in the Easy physical-movement condition, and those who do not. It is possible that collaborative actions, or the feelings of similarity and social affinity that such actions engender, are common influences on the degree of helpful language that speakers use.

The results of the studies presented here cohere with Clark's (1996) theory that conversations involve collaborative effort, and that this effort is dynamically assessed by speakers as the conversation unfolds. However, these data suggest the amount of effort that we contribute to a conversation is informed not only by what happens within that conversation, but also by effortful activities that happen outside conversation. I previously suggested that the relationship between nonverbal joint actions and conversational effort may also be regulated by the subjective fluency of nonverbal activities. When an action is easy to perform, it is perceived as fluent; when an action is difficult to perform, it is perceived as disfluent. This applies to coordination as well: if it is difficult to coordinate with someone else, either because the coordinating action itself is complex or unfamiliar, or because our partner's actions are irregular or difficult to match, we will experience the action as disfluent. In Experiments 1, 3, and 4, I asked participants to coordinate nonverbally using either a fluent (natural, easy, intuitive) action or a disfluent action, allowing me to observe the effect of physical fluency or disfluency on subsequent conversation. The results of Experiment 3 in particular suggest that the collaborative effort of conversation can be impacted by nonverbal behavior that is irrelevant to the conversation. Even in the absence of a partner to coordinate with, disfluent coordination with an electronic beat led directors to use more explicit marking in their descriptions. Experiment 4 showed that the use of helpful language is produced more reliably by disfluent coordination with another than with mere physical disfluency. Directors in the Together/Hard condition used all of the conversational effort markers more than directors in the Solo/Hard condition, suggesting that interactive difficulty has a greater impact on language use than generalized difficulty. "Mere disfluency," while it does lead to some increase in helpful language, is not as great a factor as collaborative disfluency.

Across all four experiments, levels of verbal and physical effort reported by speakers impacted their use of helpful language. However, this impact does not present a linear picture of the consequences of effort. In some cases, greater effort was linked with less use of Matcher-Oriented descriptions and more use of Explicit Marking; in other cases, it was linked with more Matcher-Oriented descriptions, but only when the effort could be attributed outside the conversation - to the difficulty of a motor task, as in Experiments 3 and 4. These experiments were designed both to deliberately manipulate levels of perceived effort and to require different kinds of effort from participants, but since the results do not link different conversational features clearly to different sources of effort, it would be dangerous to assume that all effort is the same.

If collaborative activities change our expectations of effort in ways that carry over to later conversation, how do they do so? Even activities that don't seem very collaborative, like the Asynchronous clapping task in Experiments 1 and 3, can change the way conversations are carried out. The obvious difference between solo tasks and collaborative tasks is the presence of another person, who provides a focus for attention and emotion when partners work together. Using the affinity- and effort-related questionnaire items as predictors in my analyses revealed an unexpected negative relationship between pro-social feelings and helpful language use in Experiments 2, 3, and 4. However, the root of this negative relationship may be the use of social affinity as a heuristic – a cue to assume someone's perspective is similar to our own. In Savitsky and colleagues' study of pair communication between pairs of friends or spouses and stranger pairs, they found that friends and spouses were slower to correct their default assumption that their partner shared their perspective (Savitsky et al., 2011). This egocentric default may be helpful most of the time, facilitating quick and effortless communication between friends. In the same set of studies, friends and spouses also overestimated their effectiveness at conveying meaning through ambiguous phrases, suggesting that people expect those close to them to understand them better than people from whom they feel distant or dissimilar. It is not surprising that we assume that we share our perspective with our friends, but what would it mean for this phenomenon to be responsible for the behavior of participants in the current work? Even relatively low levels of reported closeness, similarity, liking, and previous acquaintance can lead to lower rates of helpful language, most consistently the use of Explicit Marking and Matcher-Oriented phrases. These effort markers disambiguate which perspective is being taken (even if it is the speaker's egocentric perspective), and adjust the speaker's perspective to match the listener's (even if tacitly). It is possible that these beginning signs of friendship shown by participants in my studies - feelings of closeness, similarity, and liking - are connected to the two signs of friendship noted by Savitsky et al.: assumption of a default egocentric perspective, and less accurate disambiguation, as shown by Directors' more egoistic and ambiguous direction-giving. The role of physical coordination in rapport can also inform an interpretation of these results, one in which social affinity and motor fluency interact to cue the director that the least amount of effort is necessary. Tickle-Degnen and Rosenthal's (1990) model of the nonverbal development of rapport in a relationship stresses the high importance of positivity in early interactions and lower importance of positivity in later interactions, and the contrasting levels of importance over time for coordination, in building and maintaining rapport. Several of the experiments I present here required pairs to perform coordinated actions, or deliberately difficult-to-coordinate actions, within minutes of meeting each other. The appearance of unusually good (or poor) physical coordination early in a pair's interaction may have led the process of rapport-building to skip some developmental steps: if helpful spatial language is seen as contributing to positivity between partners, rather than as a goal-directed information exchange prompted by the difficulty of a spatial task, then experiencing better coordination could miscue directors that increasing positivity was no longer needed.

6.5 Remaining Questions and Future Research Possibilities

Although these studies were originally inspired in part by Dynamical Systems approaches to language and interpersonal coordination (Shockley et al., 2003; Richardson, Dale, & Shockley, 2004), these experiments suggest that dynamical stability does not inevitably affect interpersonal interactions (at least as I have measured them here) as strongly as goal orientation and a collaborative mindset. While Experiment 3 demonstrated that the difficulty of a solitary rhythmic task can affect the use of helpful language during conversation, difficulty in Experiment 4 had similar effects on Solo directors. Both experiments showed that increased motor difficulty is linked with increased Explicit Marking in descriptions, suggesting that directors turn to this type of helpful language when they have just experienced a cognitively difficult motor task. What part of directors' experience of motor effort causes them to compensate by increasing the explicit marking of perspective in spatial descriptions? If we believe that "effort breeds effort," is Explicit Marking just the kind of conversational effort that motor coordination breeds? One way to explore this issue would be to further test the influence of qualitatively different types of effort at a finer granularity than I was able to in this thesis, including both rhythmic coordination with a non-human source and collaborative goal-oriented motor movements with variants that were effortful but required higher or lower degrees of motor involvement, cognitive resources, and collaboration. It may be that any of these effortful actions will lead to more Explicit Marking; if that is the case, then it would lend support to the Fluency Hypothesis, and specify that subjective disfluency emerges as explicit marking of perspective in spatial conversations.

Collapsing linguistic behavior over the four rounds of these experiments allowed me to generalize participants' use of effort markers based on their response to the manipulation used in each separate experiment. However, expanding this data to examine the progressive decrease in Explicit Marking and Matcher Orientation over time may provide insight into why speakers use (or omit) certain effort markers in speech to friends versus strangers. It would be interesting to see whether previously acquainted participants, or participants who scored higher on social measures, decreased their use of effort markers more quickly than pairs that had a "stranger-like" affective profile. This prediction would align both with Tickle-Degnen and Rosenthal's rapport framework (Tickle-Degnen & Rosenthal, 1990) and with behavioral evidence from Savitsky and colleagues' investigation of egocentrism in speech between close friends (Savitsky et al., 2011).

For the sake of simplicity, I treated dynamic rhythmic stability with very coarse distinctions in these studies. However, the reality of any dynamical system is that it is continuous in many aspects (Kelso & Engstrøm, 2010). The partners in Experiment 1's clapping patterns were meant to produce Stable, Less-Stable, and Unstable rhythms. But aside from anecdotal confirmation that all pairs did, in fact, maintain the assigned rhythm, there are no gradations between these categories. In reality, some pairs were likely more rhythmically gifted than others. Some pairs found the Asynchronous rhythm challenging but doable, while a few had false starts or appeared distracted by the other partner's rhythm. A close analysis of the actual clapping patterns in Experiment 1 may reveal differences in rhythmic alignment that correlate with differences in conversational effort patterns. Pairs with more accurate clapping rhythms whose claps most closely match the metronome's beat, regardless of their dynamic stability, may be those who put the most effort into the nonverbal task.

In all four experiments of this dissertation, I included the results of a post-experiment questionnaire that asked participants about their social feelings toward each other, their experience of different parts of the experiment, and whether they were previously acquainted. The raw items in the questionnaire were collapsed using Ward's hierarchical clustering method in order to reduce the complexity of the maximal linear model. The behavior of these collapsed variables in my models had a significant impact on my understanding of conversational effort and how different manipulation tasks changed the social connection between participants.

In general, the questionnaire items clustered into two or three distinct groups. Social feelings almost always clustered together (Close, Similar, and Like). Responses in Experiment 3 were markedly different in this respect, perhaps because participants completed the manipulation task in different rooms, while even in Experiment 4's Solo condition, participants stayed in the same room but were visually separated by an opaque cloth barrier. Self-reported effort measures (VerbHard, PerspEffort, ManipHard) sometimes clustered together, though not consistently, and never all three in the same cluster. Previous acquaintance (Known) did not have a consistent clustering pattern either - sometimes it was grouped with social feelings, as in Experiments 3 and 4, while in other experiments it was grouped with verbal effort (Experiment 2) or manipulation effort (Experiment 1). This single-item probe is too simple to capture variation in partners' knowledge of each other – were they classmates? Had they seen each other around campus? Did they live together? Had they met even before their undergraduate years began? Previous acquaintance, as shown by studies of the social behavior of friends versus strangers, has noticeable effects on collaboration and conversation (Savitsky et al., 2011). Due to the constraints of the participant recruitment system, it was impossible to eliminate pairs that were previously acquainted, and the Known item was meant only to control for all the different ways in which people who know each other behave differently from true strangers. In Experiments 1 and 2, verbal effort items grouped separately from manipulation effort items, while in Experiments 3 and 4, verbal and non-verbal effort items clustered together. Movement between locations in Experiments 3 and 4, even if within the same room, required more task-switching effort than experiments that were performed entirely while seated, which may have made both verbal and non-verbal tasks feel more effortful.

Further analyses of the post-experiment questionnaire items should investigate the similarity of items within conditions - for example, do the responses of directors in Experiment 4's Together condition group in the same way as directors in the Solo condition? These analyses are not presently possible due to the small sample size within each group, but they could inform the interpretation of interactions between conditions and collapsed questionnaire variables. A replication of Experiment 4 that fully separated participants in the Solo condition would also allow me to see whether the unusual clustering of questionnaire variables in Experiment 3 was due to full sensory separation in that experiment.

Additionally, other markers of conversational effort could also be explored, beyond the three types I have examined in these studies. Word count, of course, is a classic measure of conversational effort, and could be applied to these data as a gross measure of work expended. I did not include an analysis of word count in order to focus on the use of specific, strategic phrases instead of gross measures of effort. However, I believe a more fine-grained approach to effort markers would be more interesting and informative. Examining the way locative use unfolds over time could test hypotheses about effortful language, since presumably the beginning of a conversation is more effortful, and as common ground is negotiated, effort decreases. The routine use of phrases like "my left, your right" in tasks like these should be investigated, since they are effectively neutral where Matcher Orientation is concerned, but count as two Explicitly Marked statements. Other measures of effort that could apply here include changes in the speed of speech that may correspond to greater cognitive effort, tendency toward overlap between partners or other turn-taking mechanics, and a closer examination of confusion or error points, to see what disambiguation strategies are tried, and which ultimately succeed.

6.6 Conclusion

Perhaps the most important contribution that the current research makes is as a partial answer to assertions about rhythmic alignment motivating helpful language, as in Wiltermuth and Heath (2009): "[A]rmies still train by marching in step. Similarly, religions around the world incorporate synchronous singing and chanting into their rituals." My research affirms the common intuition that this synchronization must occur with others - marching alone may be great exercise, but it will never increase patriotic fervor. This has specific implications for the Interactive Alignment account in terms of cross-modal alignment and conversation. Alignment that crosses modalities is enhanced in physically co-present pairs when they are working toward a common goal. This lines up well with more recent articulations of the Interactive Alignment account that focus on the importance of prediction (Pickering & Garrod, 2009; 2013). However, predicting others' behavior may not be a universal goal, even for partners in conversation with each other. Collaborating on a physical task can force people to try to anticipate another person's behavior, especially if the task is somewhat difficult or unfamiliar.

While the collaborative tasks I used in my research are not exactly the tasks that conversation partners would encounter in everyday life, they are similar enough to real-life tasks that I am confident that my results have some external validity. Experiment 1's motor task recalls what an ensemble of musicians do when they are playing a piece by sight for the first time, and Experiment 4's motor task parallels industrial assembly work or even putting away groceries with a partner. The common element in these tasks is the way that attention patterns during physical action carry over to attention patterns during conversation, and how these patterns are mediated - through feelings of social affinity and a fluency "gestalt." In these experiments, cross-modal alignment towards spatial perspectives emerges when speakers are focused on a difficult physical task that depends either implicitly (as in Experiment 1) or explicitly (as in Experiment 4) on how well we coordinate our movements with another's. If cross-modal alignment depends on this pattern of collaborative attending under disfluent circumstances, then perhaps predicting others during conversation is not as automatic as the current Interactive Alignment account suggests. Being oriented toward a collaborator on any level (physical, linguistic) enhances alignment at that level by making a certain amount of attention available to us to carry out the collaborative action. Perhaps orienting toward a collaborator on multiple levels allows us to use all attention that has been made available (i.e. for both the physical task and the linguistic task) at our discretion, for whichever task we focus on. This could explain why more other-focused physical behavior was associated with more other-focused language in Experiment 4.

It also suggests that the Interactive Alignment account may benefit from a top-down guidance mechanism that determines how important predicting another person is for our current task. In my initial review I stated that adding intentionality-triggered emulation to the Interactive Alignment account strayed from the account's initial reliance on bottom-up processes. The current research suggests that this addition is warranted, and that the details of the emulation we construct matter. If we emulate another's linguistic behavior in order to predict the direction a conversation will go, we may not be able to predict their physical behavior based on this same emulation. However, if our emulation of another is intended to help us predict their physical behavior, it may also be useful in predicting their thoughts about physical locations.

This research also offers a detailed exploration of what, exactly, 'helpful language' means. By simplifying the conversational task and focusing on spatial expressions, I was able to show that different effort markers are used differently, suggesting that speakers have an array of choices available to them depending on how much effort they wish to put in. Some helpful language is relatively low-effort; for example, explicitly marking whose perspective is being given in a description. Depending on the difference between partners' perspectives, mentally rotating the scene in order to take one's partner's perspective can be cognitively low-effort or high-effort, although there is an upper limit at 180°. And perhaps most effortful, speakers can choose to represent more than just the target object in a scene in order to decrease ambiguity and create a mental path from a known location to the target location, unknown by the listener. This perspective on conversational effort will lead to a more nuanced view of the language used in informative conversations, especially about spatial information.

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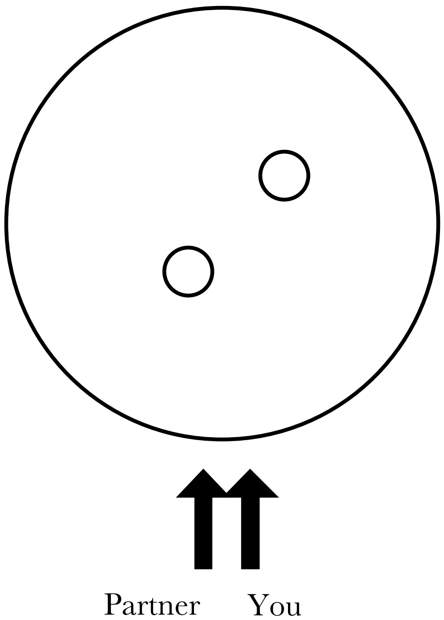
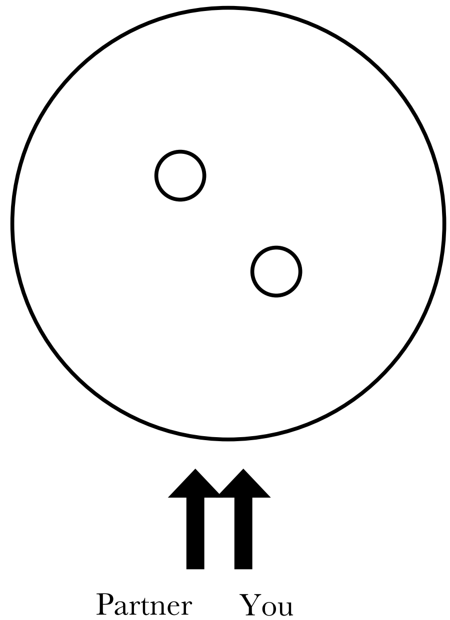
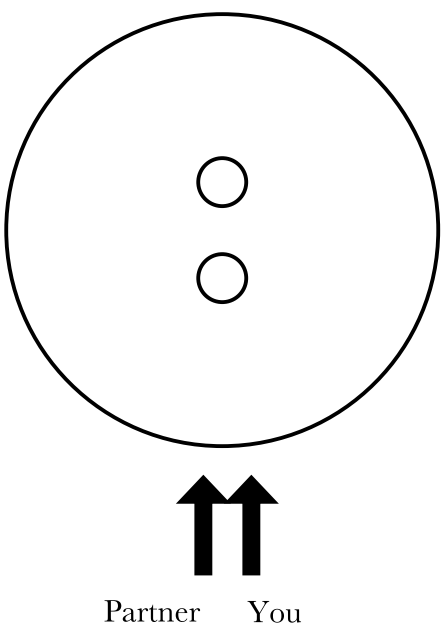
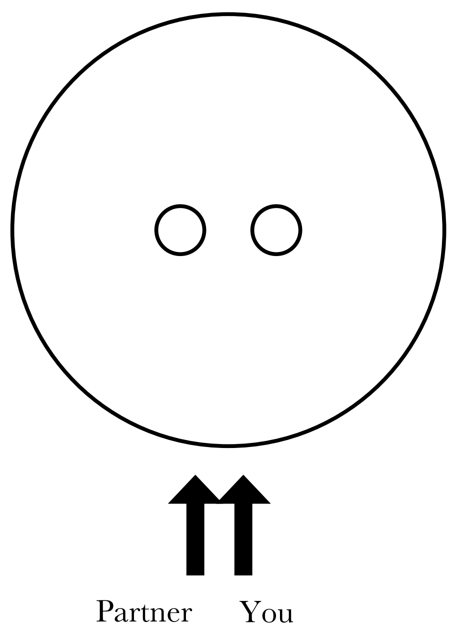
Appendix A. Stimuli Used in All Experiments.

(0˚ Diagrams)

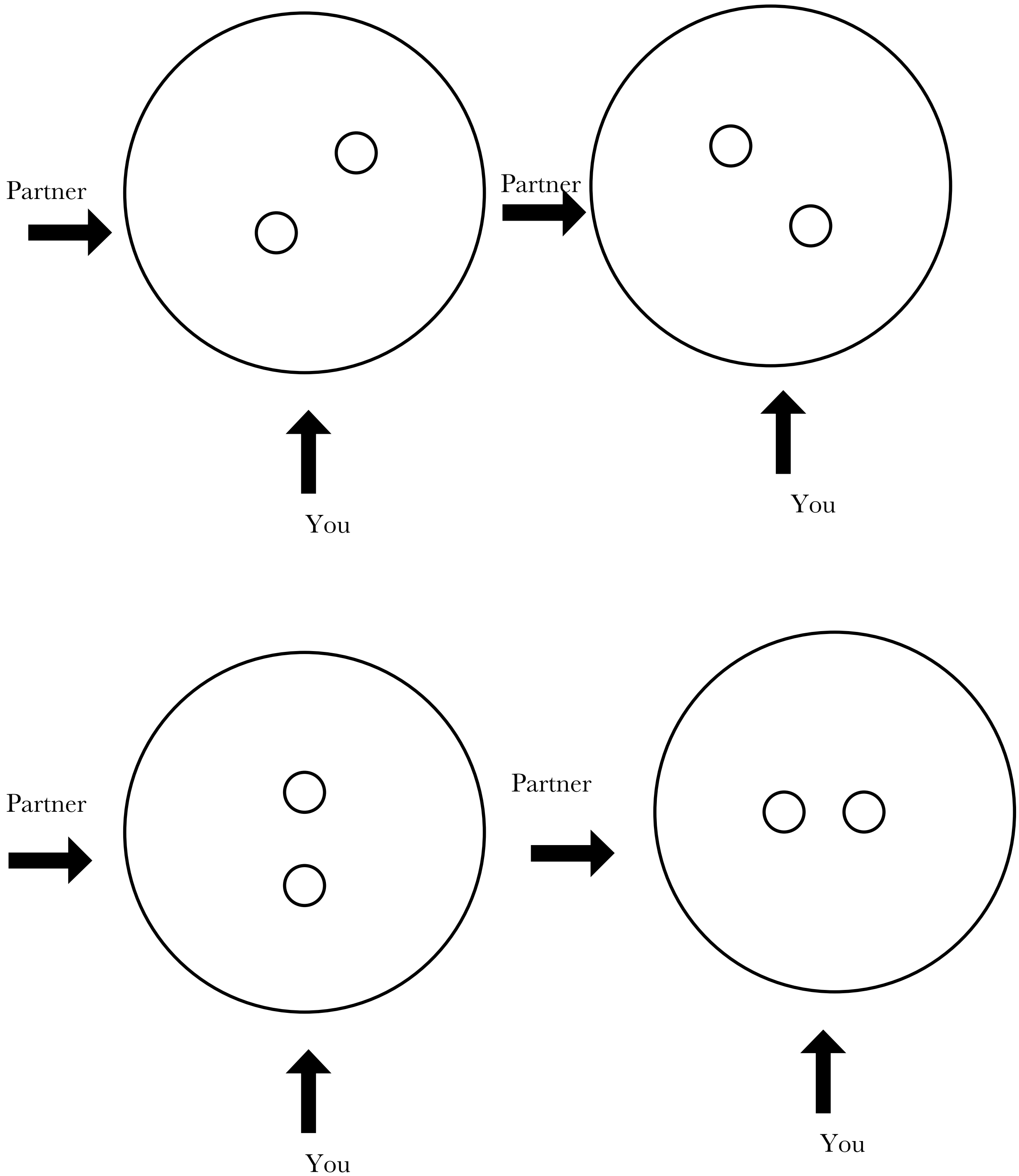




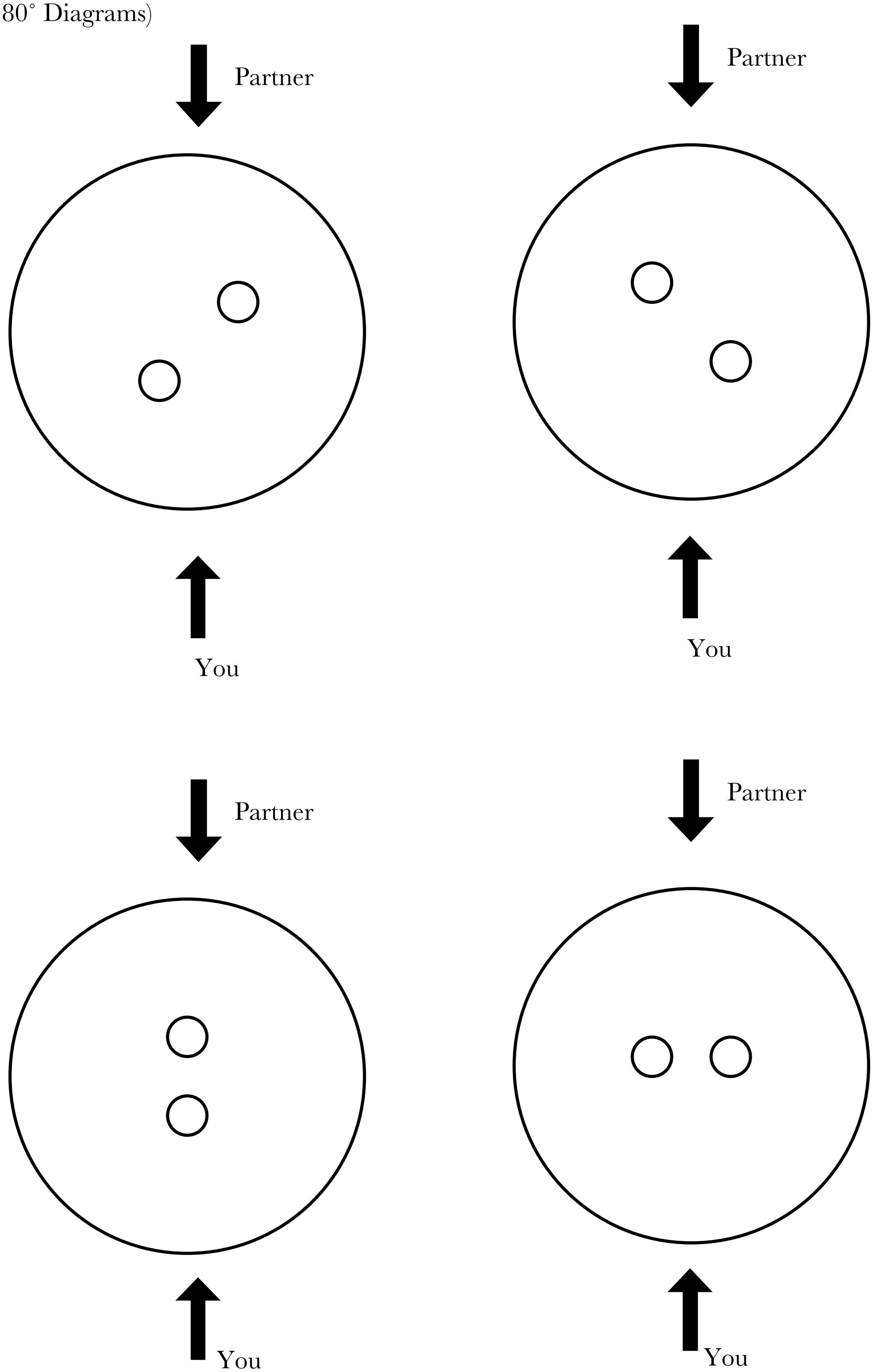




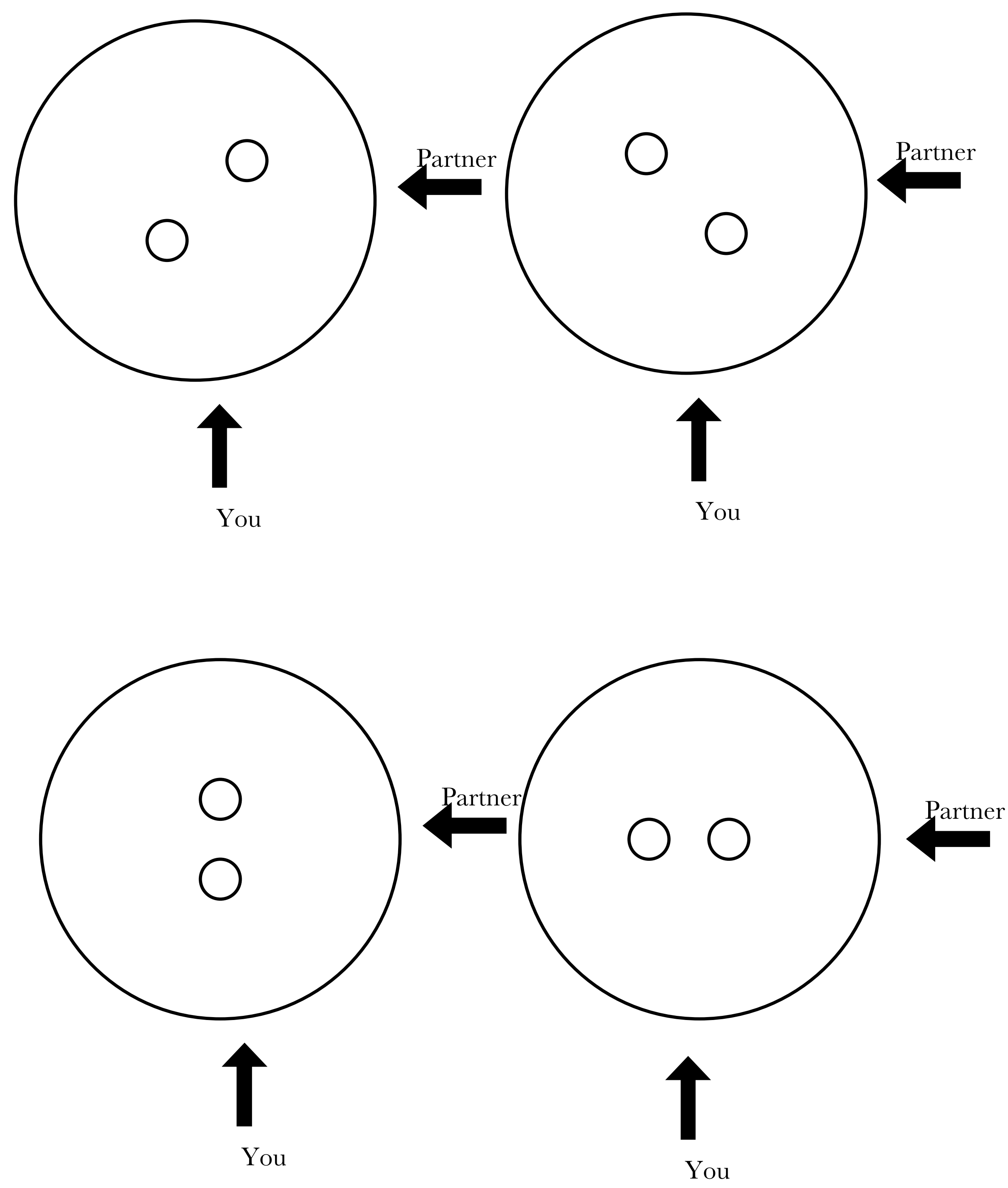
(90˚ Diagrams)



(180˚ Diagrams)



(270° Diagrams)



Appendix B. Post-Experiment Questionnaire.

Post-Experiment Questionnaire

We are interested in your reactions to the task that you just completed. Your answers will NOT be shared with your partner, so please be as straightforward as possible.

For the following questions, answer YES or NO.

1) Did you feel relatively comfortable during the clapping task? YES NO

2) Were you acquainted with your partner before the experiment? YES NO

3) Did you feel that not seeing your partner affected how you did the verbal task? YES NO

4) Did you think that the clapping task made a difference in the verbal task? YES NO

For the following questions, give a numerical answer based on the following 9-point scale:

1 2 3 4 5 6 7 8 9

A) How close do you feel to the individual with whom you are working on this study?
(1 = not close at all; 9 = very close) ________

B) How similar do you feel to the participant with whom you are working on this study?
(1 = not similar at all; 9 = very similar) ________

C) How much do you like the individual with whom you are working on this study?
(1 = not at all; 9 = very much) ________

D) How hard did you find the verbal task? *(1 = easy; 9 = very hard)* ________

E) How much effort did you make during the verbal task to take the other person's point of view?
(1 = no effort; 9 = a large effort) ________

F) How hard did you find the clapping task? (*1 = easy; 9 = very hard)* ________

Participant ___ Pair ___ Date __________

Appendix C. Adjective Check List Used in Experiment 2

Please read through the following list of 50 adjectives and put an X next to 20 that you feel describe your personality. Your selections are confidential and will NOT be shared with your partner. There are no "right" or "wrong" answers, and this task will not impact other tasks you may be asked to do as part of this experiment. When you have finished, please notify the experimenter.

___	Antagonistic	___	High-strung	___	Self-centered
___	Anxious	___	Idealistic	___	Sentimental
___	Artistic	___	Independent	___	Shallow
___	Boisterous	___	Industrious	___	Sincere
___	Cheerful	___	Insecure	___	Spontaneous
___	Conceited	___	Intolerant	___	Superstitious
___	Conservative	___	Kind	___	Tactful
___	Cool	___	Loyal	___	Timid
___	Dependable	___	Mischievous	___	Unconventional
___	Devious	___	Neat	___	Uncritical
___	Domineering	___	Opinionated	___	Uninhibited
___	Eccentric	___	Passive	___	Unrealistic
___	Ethical	___	Pleasant	___	Volatile
___	Foolhardy	___	Predictable	___	Whiny
___	Forgetful	___	Quiet	___	Worldly
___	Generous	___	Relaxed	___	Zany
___	Gullible	___	Respectful		

Appendix D. Full Results of Maximal Linear Model of Experiment 1.

	Explicit Marking			Matcher Oriented			Path Based		
	Est.	SE	t	Est.	SE	t	Est.	SE	t
A[S,Alt]	0.075	0.263	0.286	0.132	0.180	0.734	0.139	0.297	0.469
C[A,S,Alt]	-0.365	0.257	-1.417	0.101	0.184	0.546	-0.396	0.269	-1.474
S[A,C,Alt]	0.084	0.255	0.330	0.021	0.180	0.117	0.030	0.290	0.105
90[180]	0.066	0.138	0.480	0.411	0.144	2.864**	-0.273	0.162	-1.692†
0[90,180]	-0.197	0.107	-1.836†	-0.003	0.095	-0.032	-0.011	0.087	-0.121
Social	-0.058	0.050	-1.172	-0.073	0.040	-1.825†	0.011	0.052	0.218
Awkward	0.066	0.087	0.759	0.088	0.080	1.097	0.110	0.094	1.169
Effort	0.077	0.069	1.110	-0.101	0.071	-1.430	-0.087	0.067	-1.296
A[S,Alt] x 90[180]	-0.258	0.262	-0.983	0.059	0.243	0.241	0.097	0.264	0.367
A[S,Alt] x 0[90,180]	0.281	0.162	1.733†	0.822	0.148	5.552**	-0.137	0.157	-0.872
A[S,Alt] x Awkward	-0.204	0.191	-1.064	-0.138	0.164	-0.841	-0.295	0.208	-1.419
A[S,Alt] x Effort	0.050	0.089	0.557	0.025	0.084	0.294	0.038	0.098	0.388
A[S,Alt] x Social	0.024	0.089	0.267	0.134	0.078	1.725†	0.071	0.103	0.684
C[A,S,Alt] x 90[180]	-0.163	0.245	-0.665	-0.308	0.231	-1.329	-0.530	0.238	-2.229*
C[A,S,Alt] x 0[90,180]	-0.663	0.154	-4.305**	-0.034	0.140	-0.240	-0.296	0.145	-2.044*
C[A,S,Alt] x Social	0.110	0.158	0.696	-0.273	0.131	-2.086*	-0.194	0.170	-1.141
C[A,S,Alt] x Awkward	0.308	0.176	1.748†	-0.179	0.176	-1.015	-0.005	0.161	-0.034
C[A,S,Alt] x Effort	-0.069	0.115	-0.602	-0.237	0.085	-2.778**	-0.121	0.114	-1.062
S[A,C,Alt] x 90[180]	-0.714	0.254	-2.807**	-0.507	0.253	-2.005*	-0.064	0.258	-0.248
S[A,C,Alt] x 0[90,180]	-0.016	0.153	-0.102	0.074	0.145	0.509	-0.550	0.148	-3.717**
S[A,C,Alt] x Social	0.289	0.174	1.660†	-0.023	0.169	-0.134	-0.290	0.197	-1.474
S[A,C,Alt] x Awkward	0.134	0.097	1.377	-0.030	0.100	-0.297	-0.073	0.106	-0.687
S[A,C,Alt] x Effort	-0.068	0.086	-0.792	-0.101	0.062	-1.634†	-0.047	0.092	-0.512
90[180] x Social	-0.006	0.105	-0.060	0.283	0.099	2.863**	0.151	0.105	1.436
90[180] x Awkward	-0.073	0.102	-0.711	0.046	0.098	0.470	0.104	0.100	1.046
90[180] x Effort	-0.064	0.081	-0.795	0.035	0.077	0.450	0.053	0.082	0.652
0[90,180] x Social	0.185	0.066	2.807**	0.134	0.061	2.202*	0.114	0.063	1.805†
0[90,180] x Awk	-0.029	0.064	-0.458	-0.047	0.059	-0.794	0.037	0.060	0.613
0[90,180] x Effort	0.007	0.042	0.156	-0.144	0.039	-3.725**	0.094	0.040	2.338*
Social x Effort	-0.063	0.038	-1.640†	0.016	0.033	0.490	0.035	0.038	0.916
Social x Awkward	-0.009	0.035	-0.256	-0.029	0.035	-0.843	0.006	0.038	0.166
Awkward x Effort	-0.054	0.046	-1.172	0.055	0.050	1.098	-0.048	0.048	-1.000

A[S,Alt] x 90[180] x Social	-0.389	0.218	-1.787†	-0.216	0.203	-1.063	-0.314	0.218	-1.437
A[S,Alt] x 90[180] x Awkward	0.078	0.121	0.647	0.271	0.112	2.427*	-0.070	0.120	-0.579
A[S,Alt] x 90[180] x Effort	-0.247	0.169	-1.461	-0.261	0.161	-1.628†	-0.147	0.177	-0.835
A[S,Alt] x 0[90,180] x Social	0.110	0.140	0.783	0.529	0.128	4.141**	-0.052	0.135	-0.383
A[S,Alt] x 0[90,180] x Awkward	0.165	0.077	2.129*	0.249	0.070	3.541**	0.059	0.074	0.801
A[S,Alt] x 0[90,180] x Effort	0.014	0.077	0.189	0.181	0.071	2.544*	0.003	0.077	0.038
A[S,Alt] x Social x Effort	-0.169	0.085	-1.995*	-0.061	0.084	-0.726	-0.012	0.090	-0.136
A[S,Alt] x Social x Awkward	-0.020	0.071	-0.282	0.181	0.076	2.392*	0.010	0.084	0.117
A[S,Alt] x Awkward x Effort	-0.006	0.038	-0.163	0.076	0.042	1.810†	0.067	0.046	1.457
C[A,S,Alt] x 90[180] x Social	-0.158	0.167	-0.951	-0.525	0.157	-3.345**	0.068	0.161	0.421
C[A,S,Alt] x 90[180] x Awkward	-0.359	0.256	-1.402	0.239	0.243	0.984	0.321	0.244	1.316
C[A,S,Alt] x 90[180] x Effort	-0.159	0.158	-1.004	-0.194	0.152	-1.275	0.412	0.154	2.681*
C[A,S,Alt] x 0[90,180] x Social	0.194	0.106	1.821†	-0.451	0.095	-4.766**	-0.165	0.098	-1.682†
C[A,S,Alt] x 0[90,180] x Awkward	-0.307	0.162	-1.896†	-0.403	0.147	-2.733*	0.224	0.150	1.491
C[A,S,Alt] x 0[90,180] x Effort	-0.068	0.097	-0.700	-0.465	0.087	-5.355**	0.050	0.088	0.571
C[A,S,Alt] x Social x Effort	-0.137	0.094	-1.453	0.101	0.105	0.967	-0.029	0.094	-0.311
C[A,S,Alt] x Social x Awkward	0.031	0.071	0.440	0.131	0.059	2.233*	-0.043	0.068	-0.635
C[A,S,Alt] x Awkward x Effort	-0.151	0.107	-1.418	0.047	0.085	0.554	0.037	0.103	0.364
S[A,C,Alt] x 90[180] x Social	-0.821	0.211	-3.897**	-0.722	0.205	-3.515**	-0.468	0.209	-2.238*
S[A,C,Alt] x 90[180] x Awkward	0.224	0.136	1.646†	0.172	0.137	1.263	-0.263	0.141	-1.860†
S[A,C,Alt] x 90[180] x Effort	0.035	0.087	0.404	-0.178	0.084	-2.117*	0.151	0.087	1.723†
S[A,C,Alt] x 0[90,180] x Social	-0.153	0.123	-1.242	0.203	0.115	1.757†	-0.384	0.119	-3.227**
S[A,C,Alt] x 0[90,180] x Awkward	0.072	0.080	0.903	-0.250	0.077	-3.235**	-0.052	0.078	-0.672
S[A,C,Alt] x 0[90,180] x Effort	0.028	0.056	0.505	0.145	0.052	2.800**	0.044	0.053	0.835
S[A,C,Alt] x Social x Effort	-0.006	0.076	-0.074	0.031	0.088	0.353	0.029	0.082	0.358
S[A,C,Alt] x Social x	-0.094	0.057	-1.656†	0.010	0.054	0.182	-0.053	0.062	-0.848

Awkward									
S[A,C,Alt] x Awkward x Effort	-0.018	0.034	-0.518	0.065	0.038	1.689†	0.106	0.040	2.675*
90[180] x Social x Effort	0.064	0.071	0.897	-0.063	0.067	-0.935	-0.040	0.069	-0.575
90[180] x Social x Awkward	0.036	0.063	0.563	0.068	0.061	1.110	-0.100	0.065	-1.529
90[180] x Awkward x Effort	-0.051	0.054	-0.942	-0.043	0.052	-0.833	-0.155	0.053	-2.946**
0[90,180] x Social x Effort	0.146	0.047	3.088**	0.101	0.043	2.337*	-0.016	0.044	-0.369
0[90,180] x Social x Awkward	0.019	0.034	0.571	0.150	0.031	4.782**	0.044	0.032	1.358
0[90,180] x Awkward x Effort	-0.117	0.032	-3.639**	0.103	0.029	3.517**	-0.034	0.030	-1.135
Social x Awkward x Effort	0.008	0.028	0.285	0.005	0.028	0.168	0.014	0.030	0.478
A[S,Alt] x 90[180] x Social x Effort	0.040	0.118	0.343	0.287	0.108	2.656*	0.116	0.115	1.001
A[S,Alt] x 90[180] x Social x Awk	-0.183	0.141	-1.293	-0.063	0.134	-0.475	-0.147	0.148	-0.995
A[S,Alt] x 90[180] x Awk x Effort	0.004	0.074	0.056	0.096	0.071	1.345	-0.044	0.077	-0.569
A[S,Alt] x 0[90,180] x Social x Effort	-0.008	0.083	-0.093	0.194	0.076	2.558*	0.143	0.079	1.800†
A[S,Alt] x 0[90,180] x Social x Awk	0.017	0.067	0.248	0.040	0.061	0.654	0.089	0.067	1.334
A[S,Alt] x 0[90,180] x Awk x Effort	0.030	0.040	0.754	-0.006	0.037	-0.157	0.043	0.039	1.112
A[S,Alt] x Social x Awk x Effort	-0.027	0.045	-0.617	-0.009	0.052	-0.182	0.008	0.053	0.141
C[A,S,Alt] x 90[180] x Social x Effort	0.115	0.145	0.789	0.031	0.138	0.222	-0.190	0.140	-1.360
C[A,S,Alt] x 90[180] x Social x Awk	0.121	0.105	1.147	0.100	0.105	0.952	0.027	0.102	0.268
C[A,S,Alt] x 90[180] x Awk x Effort	0.043	0.139	0.308	0.022	0.132	0.164	-0.258	0.132	-1.948*
C[A,S,Alt] x 0[90,180] x Social x Effort	0.111	0.095	1.168	0.117	0.088	1.336	-0.122	0.088	-1.382
C[A,S,Alt] x 0[90,180] x Social x Awk	0.009	0.062	0.149	0.240	0.057	4.249**	-0.071	0.057	-1.242
C[A,S,Alt] x 0[90,180] x Awk x Effort	-0.264	0.086	-3.078**	0.171	0.077	2.217*	-0.045	0.079	-0.573
C[A,S,Alt] x Social x Awk x Effort	0.115	0.067	1.710†	-0.038	0.059	-0.640	0.001	0.067	0.012
S[A,C,Alt] x 90[180] x Soc x Effort	0.124	0.127	0.978	0.144	0.120	1.198	-0.037	0.126	-0.290
S[A,C,Alt] x 90[180] x Social x Awk	0.095	0.079	1.215	0.020	0.076	0.263	0.092	0.078	1.186
S[A,C,Alt] x 90[180] x Awk x Effort	0.092	0.054	1.711†	0.086	0.053	1.620	0.111	0.054	2.043*

S[A,C,Alt] x 0[90,180] x Soc x Eff	-0.100	0.081	-1.234	-0.189	0.076	-2.487*	0.021	0.077	0.274
S[A,C,Alt] x 0[90,180] x Soc x Awk	0.066	0.047	1.400	-0.002	0.044	-0.047	0.030	0.045	0.668
S[A,C,Alt] x 0[90,180] x Awk x Eff	0.016	0.033	0.495	0.027	0.031	0.859	0.061	0.032	1.919†
S[A,C,Alt] x Social x Awk x Effort	0.020	0.031	0.632	0.012	0.037	0.325	0.066	0.035	1.857†
90[180] x Social x Awk x Effort	0.013	0.041	0.325	0.015	0.039	0.395	0.076	0.040	1.884†
0[90,180] x Social x Awk x Effort	0.087	0.025	3.438**	0.030	0.023	1.313	0.033	0.024	1.369
A[S,Alt] x 90[180] x Soc x Awk x Eff	-0.014	0.076	-0.183	0.068	0.071	0.961	-0.079	0.077	-1.035
A[S,Alt] x 0[90,180] x Soc x Awk x Eff	0.010	0.046	0.210	0.058	0.043	1.357	0.091	0.045	2.036*
C[A,S,Alt] x 90[180] x Soc x Awk x Eff	0.141	0.089	1.585	0.070	0.085	0.825	0.152	0.085	1.787†
C[A,S,Alt] x 0[90,180] x Soc x Awk x Eff	0.142	0.055	2.567*	-0.129	0.051	-2.543*	0.053	0.051	1.023
S[A,C,Alt] x 90[180] x Soc x Awk x Eff	0.091	0.051	1.807†	0.017	0.048	0.360	-0.008	0.050	-0.152
S[A,C,Alt] x 0[90,180] x Soc x Awk x Eff	-0.032	0.032	-1.012	-0.005	0.030	-0.176	0.038	0.030	1.254

†$p < 0.10$, *$p < 0.05$, **$p < 0.005$

Appendix E. Full Results of Maximal Linear Model of Experiment 2.

	Explicitly Marked			Matcher Oriented			Path Based		
	Est.	SE	t	Est.	SE	t	Est.	SE	t
Close[Distant]	-0.589	0.240	-2.452*	-0.089	0.165	-0.541	-0.393	0.271	-1.451
Neutral[Close, Distant]	0.163	0.116	1.399	0.039	0.078	0.507	0.034	0.128	0.265
90[180]	-0.168	0.094	-1.793†	0.073	0.105	0.696	0.022	0.192	0.116
0[90, 180]	-0.739	0.057	-12.921**	-1.319	0.060	-21.928**	-0.036	0.112	-0.317
Social	-0.065	0.032	-1.991*	0.011	0.023	0.496	-0.052	0.036	-1.452
Connection	0.067	0.050	1.360	0.015	0.032	0.458	0.003	0.052	0.062
ManipHard	0.098	0.089	1.097	0.044	0.060	0.721	0.113	0.093	1.217
C[D] x 90[180]	-0.626	0.254	-2.466*	0.078	0.245	0.319	0.249	0.278	0.895
C[D] x 0[90, 180]	-0.430	0.156	-2.764*	-0.556	0.150	-3.706**	-0.311	0.170	-1.829†
C[D] x Social	-0.142	0.079	-1.809†	0.011	0.057	0.191	-0.025	0.089	-0.280
C[D] x Connection	0.270	0.137	1.970*	-0.071	0.090	-0.790	0.210	0.146	1.431
C[D] x ManipHard	0.047	0.232	0.203	0.174	0.163	1.068	-0.062	0.248	-0.250
N[C, D] x 90[180]	-0.106	0.117	-0.904	-0.137	0.114	-1.203	0.037	0.127	0.294
N[C, D] x 0[90, 180]	0.100	0.071	1.413	0.151	0.069	2.196*	0.015	0.078	0.192
N[C, D] x Social	-0.119	0.046	-2.558*	-0.034	0.031	-1.101	-0.019	0.049	-0.393
N[C, D] x Connection	0.005	0.060	0.088	-0.009	0.038	-0.240	0.004	0.059	0.066
N[C, D] x ManipHard	0.272	0.117	2.326*	0.014	0.076	0.179	0.067	0.118	0.567
90[180] x Social	0.038	0.037	1.026	-0.083	0.036	-2.311*	-0.043	0.041	-1.038
90[180] x Connection	0.098	0.054	1.820†	0.006	0.052	0.122	-0.025	0.059	-0.419
90[180] x ManipHard	0.087	0.110	0.794	0.235	0.103	2.291*	-0.085	0.118	-0.719
0[90, 180] x Social	-0.017	0.022	-0.775	0.048	0.021	2.223*	0.000	0.025	0.010
0[90, 180] x Connection	0.023	0.033	0.704	0.157	0.032	4.862**	0.093	0.037	2.540*
0[90, 180] x ManipHard	-0.098	0.065	-1.511	-0.226	0.062	-3.664**	0.006	0.071	0.080
Social x Connection	0.019	0.014	1.341	0.009	0.010	0.900	0.014	0.016	0.887
Social x ManipHard	-0.065	0.032	-1.991*	0.011	0.023	0.496	-0.052	0.036	-1.452
Connection x ManipHard	0.067	0.050	1.360	0.015	0.032	0.458	0.003	0.052	0.062
C[D] x 90[180] x Social	0.027	0.097	0.281	-0.131	0.093	-1.404	-0.040	0.107	-0.374
C[D] x 90[180] x Connection	0.166	0.147	1.133	-0.068	0.141	-0.480	-0.214	0.161	-1.328
C[D] x 90[180] x ManipHard	0.063	0.293	0.215	1.078	0.278	3.877**	0.023	0.319	0.072

C[D] x 0[90,180] x Social	0.003	0.057	0.058	-0.077	0.055	-1.401	0.185	0.063	2.919**
C[D] x 0[90,180] x Connection	0.419	0.093	4.518**	0.712	0.090	7.952**	0.001	0.102	0.010
C[D] x 0[90,180] x ManipHard	-0.278	0.174	-1.598	-0.666	0.167	-3.988**	-0.269	0.190	-1.415
C[D] x Social x Connection	0.043	0.039	1.097	-0.010	0.028	-0.360	0.036	0.043	0.837
C[D] x Social x ManipHard	-0.057	0.092	-0.626	0.080	0.065	1.234	-0.083	0.100	-0.829
C[D] x Connection x ManipHard	0.045	0.145	0.307	-0.154	0.096	-1.615	0.067	0.153	0.436
N[C,D] x 90[180] x Social	-0.033	0.050	-0.657	0.075	0.048	1.562	0.038	0.055	0.683
N[C,D] x 90[180] x Connection	-0.140	0.066	-2.134*	0.023	0.064	0.355	0.114	0.072	1.595
N[C,D] x 90[180] x ManipHard	0.077	0.139	0.553	-0.096	0.128	-0.752	0.024	0.147	0.163
N[C,D] x 0[90,180] x Social	-0.146	0.030	-4.930**	-0.040	0.029	-1.388	-0.103	0.033	-3.119**
N[C,D] x 0[90,180] x Connection	-0.021	0.040	-0.524	-0.081	0.039	-2.097*	0.003	0.044	0.077
N[C,D] x 0[90,180] x ManipHard	0.290	0.082	3.530**	0.194	0.077	2.511*	-0.091	0.090	-1.003
N[C,D] x Social x Connection	0.009	0.018	0.513	-0.003	0.012	-0.238	0.018	0.018	0.998
N[C,D] x Social x ManipHard	-0.018	0.049	-0.372	-0.001	0.032	-0.023	0.103	0.048	2.135*
N[C,D] x Connection x ManipHard	-0.022	0.076	-0.285	-0.064	0.046	-1.401	-0.136	0.071	-1.914†
90[180] x Social x Connection	-0.003	0.018	-0.187	0.039	0.017	2.261*	-0.005	0.020	-0.264
90[180] x Social x ManipHard	-0.047	0.049	-0.979	0.025	0.045	0.552	-0.124	0.053	-2.349*
90[180] x Connection x ManipHard	-0.102	0.068	-1.502	-0.140	0.063	-2.210*	-0.011	0.073	-0.147
0[90,180] x Social x Connection	0.001	0.011	0.060	-0.029	0.011	-2.734*	-0.023	0.012	-1.898†
0[90,180] x Social x ManipHard	0.045	0.028	1.627	0.063	0.026	2.372*	0.015	0.031	0.484
0[90,180] x Connection x ManipHard	-0.032	0.041	-0.780	0.106	0.039	2.721*	0.066	0.046	1.442
Social x Connection x ManipHard	0.022	0.016	1.380	0.008	0.011	0.710	-0.012	0.018	-0.671
C[D] x 90[180] x Social x Connection	-0.038	0.049	-0.779	0.032	0.047	0.690	-0.013	0.055	-0.240
C[D] x 90[180] x Social x ManipHard	-0.168	0.125	-1.343	0.098	0.120	0.820	-0.150	0.142	-1.055
C[D] x 90[180] x Connection x ManipHard	-0.245	0.169	-1.445	-0.585	0.160	-3.667**	-0.020	0.185	-0.107

C[D] x 0[90,180] x Social x Connection	-0.010	0.029	-0.336	-0.044	0.028	-1.557	-0.076	0.033	-2.323*
C[D] x 0[90,180] x Social x ManipHard	0.003	0.073	0.045	-0.068	0.070	-0.968	0.236	0.081	2.908**
C[D] x 0[90,180] x Connection x ManipHard	0.327	0.105	3.102**	0.614	0.101	6.084**	-0.208	0.115	-1.804†
N[C,D] x 90[180] x Social x Connection	0.039	0.022	1.764†	-0.037	0.022	-1.707†	-0.027	0.025	-1.085
N[C,D] x 90[180] x Social x ManipHard	0.075	0.065	1.154	-0.054	0.059	-0.919	0.092	0.069	1.346
N[C,D] x 90[180] x Connection x ManipHard	0.051	0.094	0.542	0.322	0.085	3.781**	0.023	0.098	0.231
N[C,D] x 0[90,180] x Social x Connection	0.075	0.013	5.596**	0.024	0.013	1.756†	0.007	0.015	0.476
N[C,D] x 0[90,180] x Social x ManipHard	-0.084	0.036	-2.314*	-0.061	0.034	-1.790†	-0.024	0.040	-0.595
N[C,D] x 0[90,180] x Connection x ManipHard	-0.188	0.054	-3.481**	-0.058	0.051	-1.128	-0.045	0.059	-0.765
C[D] x Social x Connection x ManipHard	-0.061	0.043	-1.409	-0.106	0.031	-3.471**	0.019	0.048	0.403
N[C,D] x Social x Connection x ManipHard	0.011	0.021	0.522	-0.009	0.014	-0.617	-0.020	0.022	-0.934
90[180] x Social x Connection x ManipHard	0.024	0.021	1.109	0.011	0.020	0.551	0.021	0.024	0.898
0[90,180] x Social x Connection x ManipHard	-0.020	0.013	-1.571	-0.023	0.012	-1.870†	-0.006	0.014	-0.435
C[D] x 90[180] x Social x Connection x ManipHard	0.114	0.057	2.008*	0.086	0.054	1.590	0.100	0.063	1.594
C[D] x 0[90,180] x Social x Connection x ManipHard	-0.090	0.034	-2.659*	-0.094	0.032	-2.928**	-0.089	0.038	-2.376*
N[C,D] x 90[180] x Social x Connection x ManipHard	-0.010	0.027	-0.384	-0.045	0.026	-1.749†	-0.012	0.030	-0.414
N[C,D] x 0[90,180] x Social x Connection x ManipHard	0.046	0.016	2.796**	0.011	0.016	0.719	0.007	0.018	0.382

†$p < 0.10$; *$p < 0.05$; **$p < 0.005$

Appendix F. Full Results of Maximal Linear Model of Experiment 3.

	Explicit Marking			Matcher Oriented			Path-Based		
	Est	SE	*t*	Est	SE	*t*	Est	SE	*t*
Hard[Easy]	1.898	0.556	3.417**	-0.118	0.375	-0.315	-0.374	1.353	-0.277
90[180]	0.100	0.499	0.200	1.227	0.465	2.639*	0.725	0.451	1.605
0[90,180]	-0.284	0.314	-0.905	-0.140	0.262	-0.536	-0.402	0.252	-1.594
Impress	0.295	0.109	2.706*	-0.142	0.066	-2.165*	-0.015	0.282	-0.053
Effort	0.578	0.220	2.632*	-0.166	0.147	-1.131	-0.378	0.499	-0.757
Friends	0.589	0.258	2.285*	-0.455	0.168	-2.711*	-0.770	0.637	-1.209
Parallel	0.992	0.410	2.421*	-0.991	0.278	-3.559**	-1.285	0.974	-1.320
H[E] x 90[180]	1.889	0.985	1.918†	2.412	0.930	2.594*	2.162	0.900	2.401*
H[E] x 0[90,180]	0.281	0.618	0.456	0.993	0.523	1.898†	-0.013	0.502	-0.026
H[E] x Effort	1.095	0.439	2.495*	-0.384	0.294	-1.304	-1.123	0.998	-1.125
H[E] x Friends	1.843	0.515	3.581**	-0.447	0.335	-1.334	-1.060	1.274	-0.832
H[E] x Impress	0.477	0.218	2.187*	-0.155	0.131	-1.180	-0.538	0.565	-0.953
H[E] x Parallel	2.962	0.818	3.622**	-0.960	0.557	-1.723†	-2.014	1.947	-1.034
90[180] x Effort	0.574	0.395	1.454	0.854	0.365	2.340*	0.901	0.365	2.471*
90[180] x Friends	0.525	0.439	1.195	1.118	0.411	2.722*	0.978	0.405	2.413*
90[180] x Impress	0.383	0.180	2.127*	0.043	0.156	0.275	0.285	0.155	1.836†
90[180] x Parallel	0.151	0.723	0.209	2.206	0.692	3.189**	1.308	0.664	1.969*
0[90,180] x Effort	0.403	0.265	1.522	0.663	0.206	3.224**	-0.007	0.202	-0.036
0[90,180] x Friends	0.481	0.283	1.699†	0.860	0.237	3.629**	-0.112	0.233	-0.481
0[90,180] x Impress	0.120	0.143	0.842	0.230	0.096	2.407*	-0.187	0.096	-1.957*
0[90,180] x Parallel	1.008	0.447	2.253*	1.751	0.388	4.512**	-0.294	0.371	-0.794
Effort x Friends	0.665	0.211	3.148**	-0.357	0.138	-2.588*	-0.615	0.538	-1.142
Effort x Parallel	1.215	0.423	2.872**	-0.713	0.291	-2.449*	-1.272	0.984	-1.293
Friends x Parallel	0.833	0.380	2.196*	-0.844	0.251	-3.361**	-0.891	0.910	-0.978
Impress x Effort	0.000	0.102	0.002	-0.290	0.064	-4.524**	-0.339	0.203	-1.673†
Impress x Friends	0.239	0.084	2.856**	-0.089	0.057	-1.552	-0.379	0.167	-2.276*
Impress x Parallel	0.246	0.126	1.953*	-0.157	0.086	-1.826†	-0.230	0.283	-0.810
H[E] x 90[180] x Effort	1.176	0.792	1.485	0.677	0.730	0.928	1.671	0.730	2.289*
H[E] x 90[180] x Friends	1.481	0.873	1.697†	1.583	0.822	1.926*	1.735	0.810	2.142*
H[E] x 90[180] x Impress	0.763	0.359	2.125*	0.802	0.312	2.572*	0.384	0.311	1.236
H[E] x 90[180] x	0.490	1.441	0.340	3.795	1.384	2.743*	2.100	1.327	1.582

Parallel									
H[E] x 0[90,180] x Effort	1.214	0.527	2.305*	1.363	0.411	3.316**	-0.076	0.402	-0.188
H[E] x 0[90,180] x Friends	0.835	0.565	1.477	1.584	0.474	3.342**	-0.693	0.466	-1.486
H[E] x 0[90,180] x Impress	-0.044	0.286	-0.153	0.395	0.192	2.061*	-0.288	0.192	-1.504
H[E] x 0[90,180] x Parallel	0.908	0.893	1.017	2.233	0.776	2.877**	-1.292	0.740	-1.746†
H[E] x Effort x Friends	1.277	0.421	3.031**	-0.342	0.276	-1.240	-1.493	1.077	-1.387
H[E] x Effort x Parallel	2.442	0.845	2.889**	-1.452	0.582	-2.494*	-2.427	1.967	-1.233
H[E] x Friends x Parallel	2.660	0.757	3.514**	-0.523	0.502	-1.041	-1.633	1.821	-0.897
H[E] x Impress x Effort	0.556	0.202	2.752*	0.173	0.128	1.349	-0.300	0.405	-0.739
H[E] x Impress x Friends	0.389	0.168	2.313*	-0.366	0.114	-3.194**	-0.577	0.333	-1.731†
H[E] x Impress x Parallel	0.726	0.253	2.875**	-0.257	0.172	-1.494	-0.430	0.567	-0.758
90[180] x Effort x Friends	0.402	0.358	1.123	0.705	0.339	2.078*	0.833	0.330	2.523*
90[180] x Effort x Parallel	0.385	0.764	0.504	1.788	0.729	2.454*	1.323	0.706	1.875†
90[180] x Friends x Parallel	0.506	0.666	0.759	1.711	0.620	2.758*	1.037	0.611	1.696†
90[180] x Impress x Effort	0.362	0.173	2.097*	0.438	0.151	2.896**	0.377	0.155	2.428*
90[180] x Impress x Friends	0.278	0.150	1.858†	0.477	0.140	3.404**	0.311	0.139	2.227*
90[180] x Impress x Parallel	0.347	0.226	1.539	0.387	0.211	1.837†	0.541	0.213	2.535*
0[90,180] x Effort x Friends	0.521	0.243	2.146*	0.935	0.194	4.821**	-0.162	0.188	-0.863
0[90,180] x Effort x Parallel	0.968	0.447	2.165*	1.534	0.402	3.813**	-0.233	0.382	-0.612
0[90,180] x Friends x Parallel	0.841	0.410	2.050*	1.347	0.352	3.829**	-0.250	0.344	-0.728
0[90,180] x Impress x Effort	0.072	0.158	0.453	0.243	0.094	2.581*	0.073	0.097	0.752
0[90,180] x Impress x Friends	0.134	0.108	1.238	0.235	0.081	2.901**	-0.016	0.081	-0.196
0[90,180] x Impress x Parallel	0.098	0.144	0.678	0.222	0.121	1.830†	-0.125	0.122	-1.029
Effort x Friends x Parallel	1.032	0.406	2.543*	-0.601	0.273	-2.206*	-1.066	0.966	-1.103
Impress x Effort x Friends	-0.107	0.097	-1.099	-0.288	0.061	-4.716**	-0.105	0.164	-0.641

Impress x Effort x Parallel	-0.022	0.067	-0.330	0.026	0.046	0.560	-0.201	0.117	-1.728†
Impress x Friends x Parallel	0.342	0.146	2.340*	-0.147	0.097	-1.505	-0.164	0.351	-0.469
H[E] x 90[180] x Effort x Friends	1.199	0.717	1.671†	0.587	0.679	0.864	1.724	0.661	2.609*
H[E] x 90[180] x Effort x Parallel	0.849	1.520	0.558	4.243	1.458	2.911**	2.490	1.410	1.766†
H[E] x 90[180] x Friends x Parallel	1.449	1.326	1.093	3.155	1.241	2.543*	1.874	1.221	1.535
H[E] x 90[180] x Impress x Effort	0.978	0.344	2.840**	-0.187	0.302	-0.617	0.418	0.310	1.348
H[E] x 90[180] x Impress x Friends	0.229	0.303	0.757	0.675	0.280	2.410*	0.687	0.280	2.457*
H[E] x 90[180] x Impress x Parallel	0.585	0.452	1.294	0.763	0.422	1.809†	1.045	0.427	2.446*
H[E] x 0[90,180] x Effort x Friends	0.974	0.483	2.018*	1.498	0.388	3.861**	-0.124	0.375	-0.331
H[E] x 0[90,180] x Effort x Parallel	1.488	0.894	1.664†	3.028	0.805	3.763**	-0.874	0.763	-1.145
H[E] x 0[90,180] x Friends x Parallel	0.850	0.817	1.040	1.937	0.704	2.753*	-1.003	0.686	-1.462
H[E] x 0[90,180] x Impress x Effort	0.095	0.312	0.305	0.171	0.188	0.911	-0.305	0.192	-1.588
H[E] x 0[90,180] x Impress x Friends	0.027	0.217	0.126	0.525	0.162	3.244**	-0.046	0.163	-0.286
H[E] x 0[90,180] x Impress x Parallel	0.088	0.290	0.305	0.401	0.243	1.653†	-0.167	0.244	-0.684
H[E] x Effort x Friends x Parallel	2.377	0.811	2.929**	-1.102	0.545	-2.021*	-1.769	1.932	-0.915
H[E] x Impress x Effort x Friends	0.291	0.194	1.503	0.340	0.122	2.782**	-0.399	0.328	-1.216
H[E] x Impress x Effort x Parallel	-0.072	0.134	-0.540	-0.063	0.091	-0.696	-0.142	0.233	-0.608
H[E] x Impress x Friends x Parallel	0.767	0.293	2.622*	-0.270	0.195	-1.388	-0.382	0.702	-0.545
90[180] x Effort x Friends x Parallel	0.552	0.727	0.759	1.526	0.679	2.247*	1.156	0.667	1.734†
90[180] x Impress x Effort x Friends	0.035	0.166	0.209	0.343	0.140	2.447*	0.288	0.140	2.056*
90[180] x Impress x Effort x Parallel	0.275	0.131	2.100*	-0.197	0.111	-1.771†	0.318	0.119	2.683*
90[180] x Impress x Friends x Parallel	0.348	0.255	1.363	0.524	0.240	2.186*	0.505	0.239	2.109*
0[90,180] x Effort x Friends x Parallel	1.072	0.427	2.509*	1.414	0.379	3.735**	-0.231	0.364	-0.636
0[90,180] x Impress x	0.112	0.177	0.633	0.192	0.091	2.095*	0.068	0.094	0.723

Effort x Friends									
0[90,180] x Impress x Effort x Parallel	0.031	0.088	0.349	-0.091	0.065	-1.406	0.051	0.068	0.740
0[90,180] x Impress x Friends x Parallel	0.262	0.166	1.582	0.302	0.137	2.197*	0.005	0.135	0.037
Impress x Effort x Friends x Parallel	-0.005	0.065	-0.082	0.038	0.043	0.872	-0.137	0.117	-1.167
H[E] x 90[180] x Effort x Friends x Parallel	1.278	1.448	0.883	3.631	1.358	2.673*	2.153	1.332	1.616
H[E] x 90[180] x Impress x Effort x Friends	0.677	0.332	2.038*	0.170	0.280	0.606	0.316	0.280	1.129
H[E] x 90[180] x Impress x Effort x Parallel	0.681	0.262	2.598*	0.061	0.223	0.274	0.826	0.237	3.478**
H[E] x 90[180] x Impress x Friends x Parallel	0.944	0.509	1.856†	1.108	0.479	2.313*	0.875	0.478	1.831†
H[E] x 0[90,180] x Effort x Friends x Parallel	1.500	0.857	1.751†	2.576	0.757	3.401**	-0.741	0.727	-1.019
H[E] x 0[90,180] x Impress x Effort x Friends	0.010	0.352	0.029	-0.147	0.183	-0.806	-0.051	0.187	-0.272
H[E] x 0[90,180] x Impress x Effort x Parallel	0.043	0.176	0.243	0.003	0.129	0.023	0.150	0.137	1.095
H[E] x 0[90,180] x Impress x Friends x Para	0.236	0.334	0.707	0.521	0.274	1.899†	-0.360	0.271	-1.327
90[180] x Impress x Effort x Friends x Parallel	0.392	0.120	3.272**	-0.064	0.105	-0.615	0.291	0.111	2.629*
0[90,180] x Impress x Effort x Friends x Para	0.076	0.093	0.815	-0.016	0.062	-0.260	0.067	0.065	1.030
H[E] x Impress x Effort x Friends x Para	-0.016	0.130	-0.122	-0.108	0.086	-1.252	-0.102	0.234	-0.433
H[E] x 90[180] x Imp x Efft x Friends x Para	0.666	0.239	2.788**	0.150	0.209	0.719	0.666	0.221	3.007**
H[E] x 0[90,180] x Imp x Efft x Friends x Para	-0.007	0.186	-0.037	-0.019	0.124	-0.154	0.145	0.130	1.117

†$p < 0.10$, *$p < 0.05$, **$p < 0.005$

Appendix G. Full Results of Maximal Linear Model of Experiment 4.

	Explicit Marking			Matcher Oriented			Path-Based		
	Est.	SE	*t*	Est.	SE	*t*	Est.	SE	*t*
Copresence	-0.020	0.050	-0.407	0.314	0.071	4.428**	0.272	0.141	1.933*
Difficulty	-0.195	0.067	-2.900**	0.008	0.090	0.088	0.116	0.163	0.707
90[180]	0.058	0.033	1.785†	0.039	0.054	0.722	0.183	0.092	1.991*
0[90,180]	-0.087	0.026	-3.321**	-0.294	0.049	-6.038**	-0.048	0.054	-0.889
Effort	-0.019	0.010	-1.808†	-0.039	0.017	-2.257*	-0.015	0.028	-0.516
Connection	0.038	0.009	4.053**	0.004	0.015	0.240	0.007	0.015	0.505
Copresence x Difficulty	0.267	0.073	3.646**	-0.071	0.101	-0.705	-0.052	0.209	-0.247
Copresence x 90[180]	-0.010	0.044	-0.228	-0.025	0.063	-0.396	-0.162	0.099	-1.629
Copresence x 0[90,180]	0.020	0.035	0.589	0.097	0.058	1.675†	-0.057	0.065	-0.883
Difficulty x 90[180]	-0.031	0.048	-0.655	0.036	0.074	0.485	-0.261	0.105	-2.481*
Difficulty x 0[90,180]	-0.113	0.041	-2.735*	0.035	0.068	0.514	-0.038	0.077	-0.490
Copresence x Effort	0.013	0.014	0.976	0.059	0.021	2.818**	-0.003	0.037	-0.086
Difficulty x Effort	-0.004	0.017	-0.234	0.020	0.024	0.821	-0.006	0.046	-0.137
90[180] x Effort	0.004	0.013	0.335	0.003	0.027	0.103	0.070	0.049	1.447
0[90,180] x Effort	0.006	0.010	0.603	-0.019	0.021	-0.899	-0.059	0.028	-2.126*
Copresence x Connection	-0.051	0.013	-3.938**	-0.003	0.019	-0.172	0.051	0.034	1.528
Difficulty x Connection	-0.062	0.014	-4.288**	-0.054	0.020	-2.706*	-0.041	0.032	-1.266
90[180] x Connection	-0.029	0.012	-2.358*	0.003	0.018	0.192	0.014	0.025	0.552
0[90,180] x Connection	0.014	0.013	1.072	0.023	0.024	0.970	-0.036	0.016	-2.300*
Effort x Connection	0.016	0.005	3.294**	0.010	0.008	1.159	-0.002	0.010	-0.203
Cop. x Difficulty x 90[180]	-0.058	0.065	-0.892	-0.076	0.088	-0.865	0.206	0.128	1.603
Cop. x Difficulty x 0[90,180]	0.157	0.053	2.941**	-0.062	0.083	-0.745	0.049	0.096	0.507
Cop. x Difficulty x Effort	0.037	0.021	1.802†	-0.036	0.029	-1.225	-0.003	0.061	-0.048
Cop.x 90[180] x Effort	-0.019	0.019	-1.012	-0.001	0.031	-0.040	-0.083	0.054	-1.554
Cop. x 0[90,180] x Effort	0.005	0.015	0.340	0.068	0.026	2.563*	0.007	0.040	0.178
Difficulty x 90[180] x Effort	0.025	0.024	1.079	0.008	0.035	0.226	-0.074	0.059	-1.241
Difficulty x 0[90,180] x Effort	-0.030	0.019	-1.636	0.027	0.028	0.960	0.064	0.036	1.758†
Cop.x Difficulty x Connection	0.079	0.018	4.402**	0.067	0.025	2.708*	-0.031	0.050	-0.614
Cop. x 90[180] x Connection	-0.018	0.019	-0.979	-0.007	0.023	-0.311	-0.028	0.031	-0.905
Cop. x 0[90,180] x Connection	-0.022	0.017	-1.254	-0.030	0.027	-1.119	0.040	0.022	1.852†
Difficulty x 90[180] x Connection	0.059	0.020	3.019**	0.008	0.026	0.321	-0.018	0.037	-0.483

Difficulty x 0[90,180] x Connection	-0.048	0.019	-2.484*	-0.073	0.029	-2.504*	-0.010	0.029	-0.345
Copresence x Effort x Connection	-0.011	0.008	-1.384	-0.003	0.012	-0.250	-0.055	0.022	-2.437*
Difficulty x Effort x Connection	-0.021	0.006	-3.755**	-0.012	0.009	-1.251	0.009	0.015	0.574
90[180] x Effort x Connection	-0.014	0.007	-1.974*	-0.022	0.011	-1.969*	0.007	0.018	0.416
0[90,180] x Effort x Connection	0.013	0.007	1.844†	0.019	0.013	1.445	-0.020	0.011	-1.865†
Cop. x Diff. x 90[180] x Effort	-0.009	0.030	-0.310	0.006	0.042	0.131	0.121	0.069	1.749†
Cop. x Diff. x 0[90,180] x Effort	0.045	0.024	1.878†	-0.048	0.037	-1.298	-0.019	0.052	-0.357
Cop. x Diff. x 90[180] x Conn.	-0.015	0.026	-0.559	-0.014	0.031	-0.437	0.042	0.044	0.968
Cop. x Diff. x 0[90,180] x Conn.	0.057	0.024	2.392*	0.086	0.034	2.572*	0.012	0.035	0.349
Cop. x Diff. x Efft. x Conn.	0.002	0.009	0.199	-0.006	0.014	-0.452	0.070	0.029	2.404*
Cop. x 90[180] x Efft. x Conn.	0.015	0.013	1.093	0.030	0.016	1.860†	-0.015	0.026	-0.575
Cop. x 0[90,180] x Efft. x Conn.	0.008	0.011	0.686	-0.009	0.017	-0.512	0.050	0.022	2.233*
Diff. x 90[180] x Efft. x Conn.	0.018	0.009	1.968*	0.025	0.013	1.996*	-0.001	0.023	-0.049
Diff. x 0[90,180] x Efft. x Conn.	-0.019	0.008	-2.461*	-0.017	0.014	-1.185	0.015	0.013	1.122
Cop. x Diff. x 90[180] x Efft. x Conn.	-0.014	0.016	-0.886	-0.007	0.019	-0.374	0.003	0.032	0.091
Cop. x Diff. x 0[90,180] x Efft. x Conn.	-0.027	0.013	-2.050*	0.004	0.020	0.177	-0.042	0.027	-1.540

†$p < 0.10$, *$p < 0.05$, **$p < 0.005$