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COMPLEMENTARITY AND LINGUISTIC DIVERGENCE IN COLLABORATIVE DIALOGUE

A dissertation submitted in partial satisfaction
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By

Jackson Tolins

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TABLE OF CONTENTS

List of Figures

Abstract

Complementarity and Linguistic Divergence in Collaborative Dialogue

Jackson Tolins

Language is fundamental to the human ability to work collaboratively on shared tasks. Current theories of dialogue, the format in which language use is shared and coordinated, emphasize cognitive processes that bring conversational partners' talk into alignment. Driven by automatic priming of linguistic representation and the synchronization of embodied actions, the success of an interacting pair is ascribed to the degree to which the two converge. Such convergence, however, cannot explain how language use allows dyads to extend their abilities beyond those at the individual level, nor how a dyad might produce a novel idea. Instead, a new theory of dialogue must be developed, one that takes into account both convergent processes as well as processes that support divergence and complementarity. Borrowing a theoretical framing from dynamical systems and extended cognition, such a model is described as an interpersonal synergy. The role of divergence in supporting collaboration is tested across three domains in which collaboration has been previously tested. In Experiment 1, we test whether linguistic divergence supports joint decision making in a perceptual task, replicating and extending previous work that found that indiscriminate alignment negatively correlates with collective benefit. In Experiment 2, dyads engage in a creative humor production task together and alone. Here we correlate turn-by-turn divergence with collaborative success. In

Experiment 3 we explore the extent to which overlapping or complementary contributions assist in the construction of a collaborative memory over repeated conversational rehearsals. Across these three domains different methods for measuring conversational divergence are established. We find that turn-by-turn progressivity predicts the extent to which pairs produce more humorous and creative jokes. However, we fail to correlate measures of conversational divergence with collaborative benefit in the decision-making and memory tasks. These studies and new methods represent a first step in developing a fuller theory of dialogue as the basis for the coordination of distinct information and contributions, such that both convergent and divergent processes may benefit the ability of conversational partners to engage in socially extended cognitive activities.

viii

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CHAPTER 1

Introduction

From the mundanity of moving a couch into a new apartment to the intricacies of

constructing international treaties, language use is motivated by the need to

coordinate individuals engaged in collaborative activities. We use language as a

means to organize our behaviors and tailor our actions to achieve shared goals.

At the same time we turn language in on itself, explicitly negotiating when

contributions in a conversation are needed and what form these contributions

should take (Clark & Henetz, 2014). Linguistic activity is inherently entangled in

our social lives, the words we speak take on a force in a conversation not only

through their symbolic relationship to thoughts and things in the world, but

through their ability to produce and coordinate behaviors in such a way that our

individual actions enable a shared project.

By acting as means for coordinating joint activity, language use extends

the abilities of the interacting conversational pair, or *dyad*, beyond that of the

individual, and can even allow us to accomplish tasks that would be out of reach

to the individual entirely. Indeed, group-level performance is more strongly

associated with conversational factors rather than the individual or average

intelligences of group members (Woolley, et al., 2010). The role of language in

making possible complex group performance has been shown in such diverse

arenas as naval navigation, military command and control, team sports,

organizational work, and medical care (Cooke, Gorman, Meyers, & Duran, 2013;

Hutchins, 1995), as well as in realms considered 'individualistic' in nature, such as memory and decision making. It is this ability to engage in complex tasks and coordinate diverse roles through language-mediated sociality that has driven humanity's success as a highly adaptive and altruistic species (Smaldino, 2014).

A critical question to ask, then, is how our language processing system is geared towards enabling this social behavior. How can the fact that language is learned and used within these highly social and collaborative activities form the basis for our understanding of the cognitive processes involved in language production and comprehension? Answering this question is complicated by differences in the choice that various researchers have made regarding what the appropriate level of analysis should be for psycholinguistic research. Within traditional cognitive science, the appropriate level of study when considering language is the individual. Even when studying how language may be involved in social interaction, processes of interest are restricted to those that would be found within a single mind. Within this paradigm, dialogue is understood as the aggregate of individual language processes that happen to be occurring at the same time and place. Emphasis is placed on how language users encode and decode meaning, and the standard experimental procedure involves a single individual isolated from any particular context, social or otherwise. Across such theories, reading and writing, rather than language use within spoken or collaborative interaction, are taken as the fundamental instance of linguistic

processing (Linell, 2005). We will call such theories part of the *individualistic* approach.

For a number of other paradigms, however, both within the cognitive sciences and more generally within language studies, dialogic activity involves processes that can neither be isolated from a given context nor be reduced to the level of the individual (Clark, 1996; De Jaegher, Di Paolo, & Gallagher, 2010; Fusaroli & Tylén, 2012; Linell, 2009). These studies take as fundamental the locus of language use within the context of social interaction. Meaning, rather than being something that can be sent from a speaker to be decoded by a listener, is a collaborative achievement produced by two speakers engaged in cooperative action. Given that meaning exists at the level of the interaction, rather than the individual, dialogue can analyzed and studied as an emergent structure with dimensions and features that are qualitatively distinct from what occurs at the level of individual processing (Fusaroli & Tylen, 2012). While not denying a role for individual-level cognition and autonomy in the co-construction of talk within joint action (De Jaegher & Di Paolo, 2013), these theories argue that such factors cannot wholly explain language use and other explanatory factors are sought at the interpersonal level (Dale et al., 2014). Here, rather than an egocentric, message-based, interpretation of how speakers and listeners understand communicative intent, active engagement within the dynamics of conversation plays a critical role in meaning making and language use. We will call such theories part of the *dialogic* approach.

3

How language provides the means for achieving shared goals within the context of dialogue differs across these two paradigms. Individualistic theories focus on mutual understanding, defined as the degree to which two individuals' mental internal representations are equivalent. Conversational success thus requires the creation or activation of similar mental representations in two interacting individuals, achieved through the re-use of linguistic resources across comprehension and production systems of single individuals within a conversational context (Pickering & Garrod, 2004). Based on this, the degree to which two speakers mimic each other's language use can be used as a predictor for their performance on a given task (Garrod & Doherty, 1994; Louwerse et al., 2014).

In considering the dialogic interaction to be a socially distributed system, where the processes of meaning making and language use exist at the level of joint activity, dialogic perspectives move beyond a focus on mutuality and isomorphism in representation. Instead, they orient towards a functional understanding of dialogue, focusing on language not as a means of sharing information but as a constraint on ongoing coordinated action (Rączaszek-Leonardi & Kelso, 2008; Rączaszek-Leonardi, Dębska, & Sochanowicz, 2014). Linguistic repetition across interlocutors is not taken as a direct indicator of conversational success. Instead, both convergence on some dimensions relevant to the interaction, as well as critical differences and progressivity across turns

and speakers, provide a conversational momentum critical to dyadic performance (Clark & Schaefer, 1989; Fusaroli et al., 2012).

The goal of the current suite of studies is to demonstrate the role of complementarity, measured through linguistic divergence turn-by-turn and across local interactions, as a necessary ingredient in the dyad's ability to succeed at a task, extending their performance beyond that of the individual. Drawing on pragmatic theories of dialogue including the *collaborative language theory* (Clark, 1996) and the *interpersonal synergies theory* based on dynamical systems approaches to cognition (Dale, Fusaroli, Duran, & Richardson, 2014), the current work argues that repetition and cohesion alone are not enough to account for the role language plays in human sociality. Instead, we must take seriously the role that progressivity plays in driving the conversational partners to build on each other's contributions through the expression and coordination of unique perspectives, experiences, and knowledge. While the development of procedures and scripts may be particularly useful for organizing distinct contributions within frequently repeated problem spaces (Mills, 2014), a collaborative account of dialogue must also provide an understanding of the function of language within distributed cognitive systems engaged in creative processes. Beyond positing a role for linguistic divergence itself, the current studies test the relationship between previously researched convergence and our new measures of local divergence. We suggest that the two dimensions of interaction are likely mutually dependent, with cohesion along some dimensions

of an interaction allowing for the rapid and successful integration of divergent contributions along others. Successful interaction will thus require both some degree of cohesion as well as differentiation.

Through this balancing act, coordinating common ground through repetition of linguistic resources while also providing a means for differentiation in role and the coordination of distinct informational and behavioral resources, language use in dialogue forms the basis for the creation and maintenance of socially distributed cognitive systems. The ability to coordinate distinct roles and knowledge may have been critical to the development of group success (Sterelny, 2012), a trait likely to be selected for as an evolutionary pressure on groups (Smaldino, 2014). Theories of language must be firmly grounded in an understanding of the functional nature of dialogue as enabling these systems, and in doing so consider linguistic processing that leads to both cohesion and differentiation.

Before presenting the three experiments that form the basis for the exploration of complementarity in linguistic contributions as fundamental to collaborative benefit, we first review the history of psycholinguistic research related to dialogue in Chapter 2. In particular, we focus on the distinct paradigms within the cognitive sciences, contrasting individualistic and dialogic theories and how these perspectives influence the type of research conducted. Following an exploration of how language processes are shaped within dialogic contexts, Chapter 3 builds on a novel extension of dialogic and collaborative theories that

draws extensively on enactive and embodied accounts of cognition and applies dynamical systems framework to the study of language-mediated interactions. This account provides for the real exploration of dialogue as a form of socially extended cognition. Such a perspective motivates the inclusion of differentiation and complementarity within socially extended cognitive systems, setting the stage for the empirical study of linguistic divergence as a factor in collaborative success.

The three experiments presented here, (Chapters 4 through 6), explore the role of linguistic divergence within a variety of domains. Experiment 1 replicates a collaborative decision-making task and prior linguistic analysis of the talk produced in order to achieve a shared decision (Bahrami, et al., 2010; Fusaroli, et al., 2012). It doing so, it seeks to re-interpret the prior findings on collective benefit in terms of our novel theoretical framing regarding linguistic divergence. Experiment 2 extends our understanding of the role of linguistic divergence beyond tasks that are both iterative in nature and based on achieving a single correct answer. In this experiment, participants must work together to produce a novel, creative, idea each trial, in this case a novel joke to caption a drawing. We expect the degree of humor and creativity displayed in the output of the collaboration will be predicted by the degree of local divergence in the task-oriented dialogue. Finally, Experiment 3 explores the role of linguistic divergence in a common test-bed for socially extended cognition; transactive memory. A transactive memory is one that is distributed across multiple

individuals, both created and recalled through active participation. The third

experiment explores the role of linguistic divergence in both the development

and quality of transactive memories forged in collaborative dialogue.

CHAPTER 2

Investigating Dialogue

Language use is inherently social. In that dialogue is the basic form in which language exists, psycholinguistics, as the study of the cognitive processes related to language use, should be directly aimed at understanding what processes are employed in dialogue. The following reviews the major paradigms and trends within the psycholinguistics of dialogue. It contrasts two major approaches, the first of which, *monologism,* takes language processing in isolation as the basic exploratory domain of research. Here, little concern is given to the actual use of language within social activity. Emphasis is placed on the internal construction of word and utterance meaning. The second approach, in contrast, takes dialogue and the situated context of language use within sociality as fundamental to our understanding of language processing. While *dialogism* is a broad theoretical approach that includes conversation analysis, discourse analysis, interactional linguistics, and others, within psychology dialogism has coalesced around the collaborative theory of language as outlined by Herb Clark (e.g. 1996), and more recently the extension of the collaborative approach through the theoretical framing of dynamical systems under the guise of interpersonal synergies. The presentation of these two approaches also includes a number of arguments in the field regarding the nature of language processing, some of which are touched on below. These include the degree and temporal timing of social and contextual influences of linguistic processing, the role and

extent of egocentric and automatic priming in conversation, and the extent to which mutually shared information, or common ground, influences production and comprehension.

These debates allow us to set the stage for a larger discussion about the role language plays in human social life. We introduce the interpersonal synergies perspective, which builds on earlier dialogic theories to emphasize the role of dialogue in establishing and maintaining socially distributed cognitive systems with functionality beyond that of the individuals involved. It is through this paradigm that we are able to fully emphasize the role of complementarity and linguistic divergence as a driving force in successful dialogue.

Monologism

To what extent must the study of language processes take into account the social basis of language learning and use? The majority of psycholinguistic research has historically answered this question with "very little." The basic model of experimental study of language within cognitive psychology been unconcerned with the dialogic nature of language, and has traditionally focused on intra-individual processes isolated from any particular context. The general consensus seems to be that the individual should be studied first, and once completely understood, anything related to actual language use in social interaction is simply a matter of putting icing on the cake.

Scientific research of language from the cognitive revolution on has focused on the individual, with the end goal of discovering how language is processed in the mind of a single speaker, isolated from any particular context, social or physical. The basis of language research removed from any particular social context or collaborative activity is supported by the general framing within the cognitive sciences of cognition as a form of information processing. Linell (1998, p. xii f.) argues that "such a framework adopts some version or other of the following theories; cognition as individually based information processing, communication as information transfer, and language as a code." The first of these basic assumptions of mainstream psycholinguistics resonates with the focus of the cognitive sciences generally since the development of the field, which treat the individual purely as an information processor (Bruner, 1990; Linell, 1998). The *mind as computer* metaphor defines cognition as abstract symbolic manipulation, with the goal of cognition as the detection of information from the environment and the internal re-representation of stable truths of the distal world (Varela, Thompson, & Rosch, 1991).

Taking such a view, defining the currency of cognition as information, requires that language itself be geared towards information transfer, a conceptualization referred to as the *conduit metaphor*. Language as information transfer, or as the product of individual minds engaged in encoding and decoding abstract thoughts into the particular code of language (Trueswell & Tanenhaus, 2005), leaves little room for the exploration or inclusion of

sociocultural and contextual factors, instead focusing research exclusively on processes that can take place within individual minds.

The exclusive and implicit emphasis on monologues since the beginning of psycholinguistic research has continued through to current mainstream texts. A review of both general cognitive psychology as well as psycholinguistic textbooks by O'Connell and Kowal (2003) found that dialogue or social interaction was rarely if ever mentioned. This was demonstrated by a review of the bibliography of the most recent psycholinguistic textbook at the time (Harley, 2001), in which of the 1,966 total references, only 54 had titles regarding dialogues or language in social interaction. When pragmatic information has been considered, it is typically as a constraint on individual, modular language processes, exploring where along the path of production or comprehension might context modulate the process. Meaning making as such is still encapsulated as a process of the individual mind. Thus, while we have learned much about the individual processes involved in language use, including accessing and structuring the mental lexicon, online parsing of sentences, and planning and articulation of words and utterances, this research paradigm has moved the field away from the study of how language exists naturally in the world (Brennan et al., 2010). Developing against this background of monologism, the collaborative paradigm explored next sought to correct this research bias, focusing research efforts on language in conversation and the negotiation of meaning through active participation.

Collaborative Theory of Language

One of the first theories within cognitive psychology to take social interaction as the fundamental locus of language use was the collaborative theory of language (Clark, 1996; Clark & Wilkes-Gibbs, 1986). In contrast to the information-processing, monologistic paradigm, the collaborative theory of communication takes as a starting point the notion that words are not primarily used in individual cognitive processes, but to facilitate the accomplishment of social goals as a form of joint action; that is, language is conceived of a tool for social coordination. Indeed, meaning making through language itself is seen as an example of a joint activity, rather than something that must be encoded and decoded through language (Clark, 1996).

Precursors of this theory trace back to philosophers of language such as Grice and Austin. These scholars focused not on how language acts as a medium for transferring information, but on language use as a cooperative activity. Austin (1962) argued that utterances, rather than being true or false statements in relationship to some externally measurable world, are more often the medium for performing social actions, which he called *speech acts*. Declarative statements, previously the sole interest of psycholinguistic research, are only one of a variety of such speech acts (indeed a less common one), which Austin, and later Searle (1969) cataloged into action types also including such actions as requests, commissives, and interrogatives. Clark's (1996) collaborative theory

13

expanded on these notions by developing a fuller theory of how it is that humans use language to accomplish social goals, shifting the paradigm of research from single utterances to fully contextualized dialogue. According to these models, while an action may be found in a single utterance, it is not considered successful until it has been overtly taken up by the recipient (Austin, 1962; Clark, 1996; Clark & Brennan, 1991; Goffman, 1983).

Language in dialogue can be understood as being similar to performing a musical duet or dance, allowing individuals to accomplish shared goals and complete social transactions. A theory based on collaborative activity changes the roles played by both speakers and hearers. Rather than being passive recipients or decoders, listeners must play an active role in providing explicit uptake of a speaker's talk in order for communication to be successful (Austin, 1962; Clark & Marshall, 1978; Bavelas, Coates, & Johnson, 2000). Under the collaborative perspective, meaning does not exist inside individual minds, which can then be transferred into and out of the linguistic medium. Meaning is rather found in the active negotiation between conversational partners (Brennan, et al., 2010; Reddy, 1979; Schober, 1998), with utterances making possible a suite of conditional next actions and a particular response providing a reciprocal interpretation of the previous utterance's meaning.

This conceptualization of language as collaborative action is supported by a variety of evidence that indicates that speakers and listeners take each other into account in the production and comprehension of talk. The basis for these

effects is the conversational *common ground.* Common ground is a concept

capturing the set of knowledge, beliefs, and values that are jointly shared across

the conversational pair (Clark, 1996; Clark & Marshall, 1978; 1981). This

mutually shared knowledge forms the basis for the successful construction of

utterances given a particular addressee in a particular context, allowing

speakers to reduce the shared cognitive burden of engaging in the dialogue by

relying on mutually available information. In order for communication to be

successful, Clark suggests that utterances are fundamentally shaped by the

conversational common ground. Clark and Marshall (1978) treat common

ground processing as reliant on a number of heuristics as aides to overcoming

this obstacle, including the heuristic of physical and linguistic co-presence as

well as shared community membership.

Common ground thus exists at two general levels, the *personal* and the

communal (Clark, 1996; Clark & Marshall, 1978). Personal common ground

consists of mutually shared experiences, interpretations of such experiences,

and conversational history. Personal common ground plays a strong role in

shaping how talk is produced and understood, and may even lead to the creation

of private keys, referential descriptions that are unique to a particular pair

(Clark & Shaefer, 1987). And yet, clearly two individuals who have never met

before, and therefore share no personal common ground, may still engage in

successful conversation. They do so by relying not on personal common ground

but on communal common ground. For any given community, a set of knowledge

15

and practices can be assumed to be shared. Establishing shared membership within a community opens access to specialized terminology, references to specific individuals, and in-group language practices (Clark, 1996; Clark & Marshall 1981; Horton & Gerrig 2005a).

The collaborative theory emphasizes the process of *grounding* in interaction, through which dialogue partners establish and extend mutually shared information (Clark & Brennan, 1991). This process contains two stages: a presentation and an acceptance (Clark & Wilkes-Gibbs, 1986; Clark & Schaefer, 1989). For discourses to develop in useful directions, contributions within dialogue typically involve the presentation of discourse new information, that is information that is not yet confirmed to be mutually known. Contributing discourse-new information is the first step in the process of grounding. From a collaborative perspective, however, this information is not considered a part of the common ground until after the second stage, the acceptance, is completed (Schober & Clark, 1989). This provides a requirement of active participation from both interlocutors, with the individual in the role of speaker providing the presentation and the addressee displaying the acceptance. An addressee can display their acceptance through a variety of conversational moves such as backchannels, repetitions or relevant next discourse actions, each of which demonstrates varying degrees of acceptance of the speaker's talk (Bangerter & Clark, 2003; Brunner, 1979, Clark & Shaefer, 1989; Tolins & Fox Tree, 2014; Tolins, Zeamer, & Fox Tree, under review). In providing a role for both

participants in the production of talk, the collaborative theory is truly

interactional, with the product, the dialogue itself, the outcome of the actions of

both the speakers and their addressees (Bavelas, et al., 2000; Brennan, et al.,

2010; Clark & Krych, 2004).

Convergence in Dialogue

The collaborative theory sparked a broad interest in language use within

social activity, and an increasing use of more naturalistic research paradigms

that respect the contextualized and action-oriented nature of dialogue (Pickering

& Garrod, 2004). One of the key features of dialogue found in these studies,

unique to this interactive format, is the increasing similarity in speech and

bodily actions across conversational partners over conversational time.

Behaviors such as laughing, smiling, and self-touching are frequently repeated

across conversational partners (Chartrand & Bargh, 1999). Similarly, verbal

behaviors such as word choice, syntactic constructions, and pronunciation are

shared across speakers.

As two speakers interact, they are increasingly likely to display

isomorphism in their bodily movements and actions (Charney, 1966, Chartrand

& Lakin, 2013). This is demonstrated across two major arenas, research on

mimicry and imitation and research on bodily synchronization. The mimicry

literature focuses on the reproduction of particular actions across interactants.

For example, participants engaged in more foot-shaking when speaking with a

confederate speaker instructed to shake their foot and more face-touching when speaking with a confederate instructed to touch their face (Chartrand & Bargh, 1999). This kind of imitation includes both non-communicative actions such as these, as well as co-speech gestures and other embodied communicative practices (Holler & Wilkin, 2011; Louwerse, et al., 2012). While this mimicry is boosted by affiliative goals and shared opinions, it is often unconscious, suggesting a direct link between the perception of an action and its production.

In contrast, research on bodily synchronization has focused on the temporal alignment and coordination of action over isomorphism in form. Taking gross measures of bodily movement, such as continuous body sway, studies have found that two participants allowed to gesture and speak freely while discussing a shared task demonstrated heightened bodily coordination compared to when co-present but engaged in two separate conversations (Shockley, Santana, & Fowler, 2003). Follow-up studies have found similar coordination in head movements on task involving manipulation of a visual scene (Giveans, Pelzer, Smith, Shockley, & Stoffregen, 2008). This pull towards synchronization when engaged in a shared task or conversation has also been found in rhythmic behaviors such as sitting in rocking chairs and swinging pendulums (Schmidt, et al., 1990, Richardson et al., 2005). Temporal synchronization has also been found in the eye movements of pairs engaged in conversations regarding a shared visual scene (Richardson & Dale, 2005).

Both mimicry and synchronization emphasize the mutual influence of embodied actors engaged in shared social activity. Each appears to support the development and coordination of joint action. As such, both support positive outcomes, both in terms of affiliation and rapport, and in task success (van Baaren, et al., 2004; Lakin, Jeffries, Cheng, & Chartrand, 2003; Richardson & Dale, 2005).

Similar to the development of isomorphism across embodied actions, the language use of conversational partner also develops similarity across a dialogue. As with embodied mimicry, the speech practices of a speaker influence those of a conversational partner, leading to a similarity in message formation. This is true at a number of levels. Many dimensions of the speech styles of speakers become more similar over conversational time, including speech rate (Webb, 1969), pronunciation (Pardo, 2006), and accents (Giles et al., 1991). Similar alignment of linguistic style is also found in text-based dialogic mediums (Riordan, Markman, & Stewart, 2013).

In referring to objects in shared visual scenes, for example, speakers may craft messages based on a number of different conceptualizations (Brennan, et al., 2010). Once a particular reference has been produced however, it is likely to be taken up by a conversational partner. This is true even when that particular label is no longer the most relevant way to refer to the object. Clark and Brennan (1991) had speakers play an object labeling game in which a target object was contrastable only with subordinate category labels, for example a *penny loafer*

was distinguishable from a *sandal.* In the next round of the game, the set changed such that the speakers could refer parsimoniously to the *penny loafer* as the *shoe;* there was no longer any contrasting member of the category. Rather than change their referring expression, however, speakers maintained the now overly-informative label. This was true only if their conversational partner was similarly maintained. When they switched conversational partners they were likely to change to more parsimonious labels (Clark & Brennan, 1991). This partner-specific effect suggests that the use of particular lexical items is shaped by the conversational history shared between specific speakers, and that part of the work of conversation is to establish shared precedents that shape word use (see also Garrod & Anderson, 1987).

A number of studies have shown that speakers are more likely to use a particular syntactic construction in producing talk if the same construction has been previously spoken by an interlocutor, mirroring the priming of syntactic structures found within a single speaker (Bock, 1986; Fox Tree & Meijer, 1999). Levelt and Kelter (1982) asked Dutch store owners either "*What time do you close?*" or "*At what time do you close?*" and found that the responses tended to match the structure of the question, with "*Five o'clock*" being an exemplary answer to the first question and "*At five o'clock*" to the second. In more controlled experimental settings involving a confederate speaker trained to use particular expressions, researchers found that marked syntactic constructions, utterances with less frequent grammatical structures, are more likely to be

produced by participants who had previously heard the confederate use a similar construction, regardless of the degree of lexical overlap (Branigan, Pickering, & Cleland, 2000). Participants were more likely to produce marked constructions if they had heard a similar construction in a previous part of the experiment. Both this finding, and findings related to the strength and persistence over longer stretches between comprehension and production, are similar to effects found within paradigms testing how producing a particular construction primed producing a similar construction later (Bock et al., 2007). Structural priming of this kind has also been reported in corpus analyses of spontaneously produced dialogue (Gries, 2004).

Given the persistence of repetition across comprehension and production, tied with the frequent shifting between these two linguistic processes in collaborative dialogue (Sacks, et al., 1974; Stivers, et al., 2009), as well as the degree of convergence found across the variety of modalities relevant to communication reviewed above, convergence is a likely candidate for a mechanism by which collaborative activity is successfully achieved (Pickering & Garrod, 2004). And yet, theories of dialogue contrast in both the mechanism underlying this convergence, whether it is caused by automatic and domain general priming mechanisms or through conscious efforts to reduce the collaborative workload involved in comprehension and production, as well as the locus and nature of conversational effects in linguistic processing. In the following sections, we review these debates, focusing on understanding the

likely drivers behind convergence and the degree to which social and contextual factors influence convergence.

Theoretical perspectives on the role of convergence in dialogue require assumptions regarding the nature and role of conversation in human life, which are explored in the last section of this chapter. These relate to more general trends within the cognitive sciences that view cognition either as a form of information processing, such that conversation consists of information transfer, or take a functionalist and pragmatic approach in which cognition is in service of producing adaptive behavior and conversation supporting adaptive behaviors that are social in nature.

What drives convergence within dialogue?

As illustrated with the review above, a substantial literature has now illuminated a wealth of evidence that cohesion across conversational partners is established in the course of an interaction. Communication itself is highly multi-dimensional in nature, involving a large range of verbal and embodied modalities. A progressive increase in similarity across interacting conversational partners, taken as either temporal alignment or physical/spatial imitation, has been demonstrated for many of these dimensions from low-level bodily movement to words and syntactic constructions and even pragmatic devices.

Why does such similarity or coherence across interacting speakers occur? Generally these effects are understood as a means of reducing the cognitive

work required to both produce and understand utterances, although there are theoretical differences about the underlying mechanism through which this occurs. Bell's theory of audience design (Bell, 1984), Giles' theory of accommodation (Giles, Coupland, & Coupland, 1991), and Clark's collaborative theory (Clark, 1996) all emphasize that cohesion and the re-use of linguistic resources are strategic adaptations by speakers towards their conversational partner. To the degree that speakers may tailor their utterance so that they align with their addressee's knowledge and experiences, including the history of the particular conversation currently unfolding, such utterances demand less of their recipients. Clark and Wilkes-Gibbs (1986) argue that such message adjustment is shared across an interacting pair, such that the dyad strives to successfully coordinate on a task with the *least collaborative effort*. Within the larger framework of the collaborative language theory, in order to achieve this least collaborative effort, speakers actively make explicit and negotiate what is shared between the conversational partners. By relying on mutually shared knowledge and previously shared experiences, speakers may ensure that they have been understood while at the same time minimizing the degree of effort spent producing comprehendible utterances.

In contrast, mechanistic theories such as Pickering and Garrod's (2004) interactive alignment model, argue that any similarities that arise over the course of a conversation are side effects of a linguistic processing system that makes use of a shared representational substrate across production and

comprehension. The starting place for this model's account of dialogue is found in a series of demonstrations of priming within a single individual. Early studies on syntactic processing, for example, found that speakers were more likely to use a particular construction if they had produced a message containing the same structure previously. As illustrated above, this priming is found both within a single speaker's linguistic production processing as well as across comprehension and production, suggesting that the two systems, typically studied in isolation in psycholinguistics, make use of the same cognitive resources and infrastructure (Pickering & Garrod, 2013). It is this mechanism of priming across comprehension and production that forms the basis for the interactive alignment model of dialogue. Hearing a conversational partner produce talk using a particular word or syntactic construction makes a listener more likely to produce talk that is similarly structured, and by repeating this process across multiple turn exchanges two speakers become aligned.

Priming of this kind is thought to occur at all levels of linguistic representation, such that hearing a speaker use a particular phonetic style, word, or construction heightens the activation of these particular representations, making them more ready to be deployed in the following turn, when the current listener becomes the speaker. Priming of linguistic representations mirrors explanations of embodied mimicry, which researchers have argued is motivated by direct connections between motor perception and motor action (Chartrand & Bargh, 1999). Further, the interactive alignment model argues that priming at

one level of linguistic representation percolates to other levels, such that an increase in similarity at one level will drive increased priming at other levels (Pickering & Garrod, 2004). This type of cohesion, rather than being an explicit effort on the part of a speaker to adjust talk to their particular partner, is driven by inherently egocentric and automatic processes, while still serving conversational success by facilitating mutual understanding.

The proposal of the interactive alignment model as the basis for linguistic processing within dialogue relies on the assumption that taking common ground into account is cognitively expensive. In order to construct messages that reduce the shared cognitive burden across speaker and addressee, speakers must take into account what they know about their interlocutor, both in terms of prior knowledge and shared perceptual scene. Doing so, according to the assumptions of the interactive alignment model, is a non-automatic process that is therefore restricted to just those contexts where it is required, for example during misunderstandings and repair. This assumption fits well with a modular approach in which any pragmatic information that might otherwise influence comprehension or production is restricted through informational encapsulation.

In contrast, for those researchers for whom language use is inherently collaborative, such that coordination and interaction form the foundation of linguistic processing, common ground and other kinds of contextual cues are primary and drive language use from the earliest moments of message formation or comprehension (Brennan & Hanna, 2009). These pragmatic influences extend

25

so deeply, and speakers are so finely tuned in coordinating their processing

moment by moment that both message construction and comprehension could

be considered collaborative acts, with responsibility shared across speakers

(Bavelas, et al., 2000; Clark & Krych, 2004). While originally conceived as a form

of encyclopedic knowledge (Clark & Marshall, 1981), more recent work has

shown that common ground can be understood in terms of general memory

mechanisms (Horton & Gerrig, 2005) and *one-bit* pragmatic attributions

regarding a conversational partner (Brennan, et al., 2010).

Partner-Specific Processing in Dialogue

Dialogue requires the coordination of linguistic and cognitive processes

across interlocutors. How these joint processes are conceptualized is critical to

theories of dialogue, and forms the foundation on which our exploration of the

role of linguistic divergence is built. Questions regarding whether core linguistic

processes are inherently egocentric and automatic, and whether common

ground and other pragmatic and contextual information are inherently effortful

to process has led to a large debate within psycholinguistics regarding the

degree to which social factors penetrate linguistic processing from the earliest

moments. By showing that an influence of conversational partner, or rather the

influence that knowledge or assumptions about a conversational partner,

extends throughout linguistic processes, researchers within the collaborative

paradigm hope to show that the interactional role of language is indeed primary,

and that there is no need to restrict an influence of conversation to processes such as automatic priming. The following section considers experimental evidence testing the locus and temporal order of social effects on linguistic processes beyond priming, contrasting two main approaches, one of which places social influences in a secondary, later stage of linguistic processing, and one which argues that social information influences processing from the earliest moments it is available. In doing so, we set the stage for a conceptualization of dialogue as supporting socially extended cognitive systems that may vary in the degree to which they require and benefit from linguistic convergence or divergence.

The collaborative nature of grounding in the development of a conversation, emphasizing language as joint action (Clark, 1996) moved psycholinguistics away from the treatment of language as an individual process and towards the conceptualization of dialogue as the appropriate unit of study. Attempts to incorporate dialogue into psycholinguistic models, however, tended to still focus on the individual rather than the dyad. Preserving the model of mind as information processor, a number of theories proposed that dialogue differed from monologue as individually contained information processing with the addition of partner-specific influences on these processes. The argument thus moved from monologic versus dialogic conceptualizations of language to the degree and temporal order in which contextual information may constrain

processing, preserving the primacy of the individual and the tenets of the mind as computer metaphor within the cognitive sciences.

Models similar to the interactive alignment model explored above have attempted to preserve the dominant status of the individual as the locus of psycholinguistic research. Developed from stage-based, modular accounts of cognition, egocentric, or two-stage models rejected the possibility of early integration of pragmatic information, based again on the assumption that the type of detailed common ground representations suggested by Clark and Marshall (1978) would be too cognitively demanding to search through online (Keysar, Barr, Balin, & Brauner, 2000; Keysar, Barr, Balin, & Paek, 1998; Shintel & Keysar, 2009). Models of this type, including the *monitoring and adjustment theory* (Horton & Keysar, 1996) as well as the *perspective adjustment theory* (Keysar, Barr, & Horton, 1998), suggest two stages of language processing, the first of which is entirely egocentric and automatic, and forms the basis for the majority of psycholinguistic research. The second stage is considered entirely optional, and involves the incorporation of pragmatic and contextual information that would include common ground. The second stage would be drawn upon solely as a means of fixing errors in processing. Such models continue the assumption of language use as a form of information decoding, with the addition of a secondary step in which contextual or partner-specific information may modulate how the information in the utterance is decoded.

Two-stage models, in which language processing is informationally encapsulated and inherently egocentric (Keysar, et al., 1998; Pickering & Garrod, 2004), rely on evidence that speakers create utterances that do not take their addressees' needs into account, at least during initial production. In some studies, speakers failed to produce referring expressions that appropriately disambiguated the target reference (Arnold, Wasow, Asudeh, & Alrenga, 2004), whereas in others, speakers provided more information than addressees would need, considering their shared presence in a particular physical scene (Dell & Brown, 1991; Horton & Keysar, 1996; Wardlow Lane, Groisman & Ferreira, 2006). Studies of comprehension in support of the two-stage model have also presented evidence that in the earliest moments of processing listeners are not constrained by the mutually shared scene, i.e. by common ground information.

This was shown using eye-tracking studies, in which participants were presented with a scene consisting of a set of objects, some of which were in common ground with the speaker and some of which were privileged to the listener (Keysar, Barr, Balin, & Brauner, 2000). Upon hearing referring expressions that could select either an object in common ground or a privileged object, addressees initially looked to both, and only later settled on the object that was perceptually shared. Similar studies have found that while listeners may anticipate references to objects within common ground, upon hearing a referring expression, they still experience interference from privileged knowledge (Barr, 2008). Proponents of this view suggest that where partner-

specific processing does occur, this may in fact actually involve egocentric adjustments, reflecting what is easiest for the speaker rather than adjustments specifically designed for the addressee (Brown & Dell, 1987; Dell & Brown, 1991; Shintel & Keysar, 2009).

The two-stage approach re-establishes the individual as the locus of study within psycholinguistic research. It accounts for dialogic effects by the positing of a secondary, optional, module in which the output of the prior comprehension or production modules are checked against pragmatic information and modified as needed. An alternative model, the *interactive,* or *constraint-based model* (Trueswell & Tanenhaus, 1994) argues against not only the relegation of pragmatic information to a secondary module, but also against all forms of encapsulation required by modular theories of cognition. In the constraint-based model, modules are replaced by correlated constraints from various information sources, such that there is an interaction between phonological, semantic, syntactic, as well as contextual or partner-specific cues that work together to constrain interpretation and production (Brown-Schmidt & Hanna, 2011). As an alternative model to the two-stage approach, the constraint-based model suggests that when available, pragmatic information may influence language processing from the earliest moments, working in tandem with various other constraints (Brown-Schmidt, 2009). While the focus of this model is still on the individually contained cognitive processes, in allowing for immediate effects of

dialogue on language processing, it suggests a path by which conversational partners mutually constrain each other within an interaction.

In support of the constraint-based model, a number of studies have demonstrated that information about a conversational partner can impact production from the earliest moments of processing, and that this processing is partner specific. For example, Lockridge and Brennan (2002) asked speakers to retell stories to addressees that involved either objects that were typical for the action being performed in the story or atypical. Because salient information is likely available early in planning, atypical objects are more likely to appear earlier in syntactic constructions than typical objects (Brown & Dell, 1987). In addition, the informational needs of the addressee were manipulated such that half of the addressees were visually attending the same picture depicting the scene to be retold and half were not. Speakers were more likely to explicitly mention instruments when the instruments were atypical and their addressee did not have a picture of the event, compared to when the objects were typical or when the addressees had pictures (Lockridge & Brennan, 2002). When the addressees lacked pictures, speakers were more likely to mention atypical objects earlier in their constructions, in the same clause as the action verb, suggesting that the informational needs of the addressee can influence early syntactic planning.

Similar studies manipulated whether objects to be named shared features with other objects that were either in or out of common ground, as indicated by

shared visibility. Speakers were more likely to make use of scalar adjectives when two objects from the same category were in common ground compared to when one of the objects was in the speakers' privileged ground (Yoon, Koh, & Brown-Schmidt, 2012). Importantly, however, this effect interacted with the speaker's goals in producing a referring expression. Speakers' utterances were more strongly influenced by the common ground of the interaction when they were making requests compared to when the speakers were making declarative statements (Yoon et al., 2012).

Early contextual or pragmatic effects have been found in comprehension as well. One of the first studies to demonstrate such effects made use of a visual world paradigm in which a confederate speaker and a naïve listener shared a visual scene containing four objects, some of which formed contrastive pairs such as *the empty* versus *the full martini glass* (Hanna, Tanenhuas, & Trueswell, 2003). The objects were divided such that some were in common ground and some were available to just the listener. The researchers found that while there was some interference with objects in the listener's privileged ground, listeners were always more likely to look at a competitor object in common ground than one in privileged ground. In a follow-up experiment, the listener was made aware that the speaker had been given incorrect labels for some of the objects in the display. In order for the listener to then understand the speaker's talk, the speaker's perspective, especially where it contrasted with the listener's own perspective, would have to influence processing early on. This study found that

addressees identified correct targets quickly, even in this perspectival mismatch condition, suggesting that information about the speaker's current knowledge influenced early language comprehension processes (Hanna, et al., 2003). In a similar subsequent study, eye gaze was tracked while participants helped a confederate prepare a meal. The scene contained two different cake mixes, one closer to the speaker and one closer to the listener. Where the listeners looked upon hearing a request for cake mix depended on pragmatic information about the speaker: when the speakers hands were full, listeners looked more at the cake mix closer to the speaker, whereas when the speaker's hands were empty they looked more frequency at the cake mix closer to themselves (Hanna & Tanenhuas, 2004).

A variety of research now suggests that speakers can indeed take into account partner- and conversation-specific information from the earliest moments of utterance construction and comprehension. These findings weaken the claims of the interactive alignment model, which relies on the assumption that making use of common ground in language processing is always cognitively expensive. Instead, it suggests that language use may be deeply and fundamentally oriented towards taking social information into account. This should not be surprising, given that the vast majority of spoken language use exists as part of social activities (Clark, 1996). It remains possible, however, that even with a more inherently social language processing system that the interactive alignment model's automatic priming forms the basis on which

similarity across speakers is driven, making priming the primary factor in conversational success. Recent research, reviewed next, is beginning to cast doubt on this claim as well.

2.3.3 Social Influences on Convergence

Given the proposed mechanisms by which alignment is produced in dialogue, the two theories make different predictions regarding both when linguistic convergence will occur, and with whom one is likely to display convergence. For collaborative theories, the social and pragmatic context should constrain the degree to which two speakers demonstrate convergence, and further argue that this convergence itself is a collaborative activity in the service of reaching a shared goal. Conversely, because the interactive alignment model argues that dialogic effects emerge through individual-centered and automatic processes, convergence should occur regardless of context or social milieu.

What kind of social cues might influence the degree of convergence? One potential cue is the capability of the conversational partner. In reaching towards least collaborative effort, speakers take into account how likely their conversational is to engage in partner-specific processing. When interacting with someone who is unlikely to do such processing, speakers are more likely to adjust or align their own talk. One experimental manipulation in which was tested compared alignment towards a human as compared to computer conversational partner. Studies have found that speakers are more likely to use

the perspective of their conversational partner (Dale & Duran, 2011) and more likely to repeat the lexical choices made previously by their conversational partner (Branigan et al., 2011) when led to believe they are interacting with a computer system rather than another human speaker. That knowledge about another person can modulate the degree to which alignment occurs within a dialogue suggests that the mechanism underlying such convergence in speaking is unlikely to egocentric or automatic, and instead must be mediated by pragmatic and social knowledge.

The nature of the conversation may also influence the rate of alignment, again something that cannot be accounted for by a theory of dialogue based in automatic priming. In a study exploring alignment in conversation conducted through an instant messaging system, the degree of alignment varied depending on whether the pairs of speakers were engaged in a neutral or argumentative conversation. Further, the degree of alignment present on a turn-by-turn basis varied over the course of the conversation (Riordan, Kreuz, & Olney, 2014). A mechanism based on automatic priming cannot account for partner-specific effects in alignment outlined above, nor for variation in patterns of alignment due to conversational dynamics.

Further studies have questioned the role of automatic priming at all levels of linguistic representation. The theory suggests that automatic priming occurs for linguistic resources, such as lexical items and syntactic constructions, but also for other dimensions of talk such as the phonetic realization of speech

sounds and the manner and speed at which utterances are produced. And indeed, studies investigating the manner of talk produced in conversation have found that speakers' utterances display increased similarity. Here again, however, there are reasons to believe that automatic and egocentric processes may not be the mechanisms by which this effect emerges. Pardo (2006) found an increase in similarity in the way words were produced when speakers were engaged in an interaction, a task involving giving and following directions to maneuver through a map, compared to how they spoke the same words prior to or after the social activity. Importantly, this convergence was modulated by two social factors. The sex of the members of the conversation, whether both were male or both were female, interacted with the particular role within the task, whether the direction giver or direction follower, in determining which conversational partner displayed an increased convergence towards the other speaker (Pardo 2006). While this is in line with previous studies that have demonstrated both gender and social status differences in convergence, it cannot be accounted for by a theory such as the interactive alignment model, which considers alignment to be driven by automatic and unconscious priming.

Similarly, in a study on the alignment of prosody, the melodic pitch of the voice, Gijssels and colleagues found that the effects of a conversational partner's speech, while leading speakers to produce speech similar in pitch, do not match the profile typically seen in other priming effects (Gijssels, Casasanto, Jasmin, Hagoort, & Casasanto, 2015). Effects based on priming typically display dose

dependence, such that priming is stronger after multiple experiences with the stimuli, and persistence, such that the effects of priming extend beyond the local context. The authors of this study restrict their claims to continuous dimensions of language production such as pitch. For this aspect of language use in dialogue, however, alignment does not display either dose dependence or persistence, instead it appears that something akin to the accommodation theory (Giles, et al., 1991), in which convergence to the speaking style of a conversational partner is driven by a desire for social cohesion.

While motivating a novel interest in dialogue within the cognitive sciences, the interactive alignment model has also faced a great degree of criticism, both in terms of the inherently egocentric nature of the underlying mechanism, encapsulated from social and pragmatic factors, and in terms of the universality with which the mechanism is applied across dimensions of language use. Indeed, even when considering structural priming, the mechanism on which the model is built, evidence suggests that it may not be universally present. In a corpus analysis of naturally produced dialogue, researchers have recently found significant degrees of syntactic *divergence* across speaker transitions, such that repetition of the same syntactic construction as the previous turn were less likely than chance (Healey et al., 2014). That this effect was found in naturally produced conversations hints at what may be an important factor: Convergence may be functional, employed when needed to aid interaction but not a universal and inherent mechanism at the foundation of dialogue. Such a consideration of

functionality raises important questions regarding the role of dialogue in human activity.

2.4 What is Conversational Success?

Apart from questioning the specific mechanisms of how alignment occurs, the two major theories of dialogue, collaborative theory and interactive alignment, remain disjoint regarding the general conceptualization of the role of dialogue in daily life. Whether taken as audience design based on common ground or automatic alignment, convergence is argued to play a role in conversational success. But what exactly is conversational success? Answering this question varies depending on how dialogue is conceived.

For the interactive alignment model, the goal of conversation is the establishment of similar mental representations in the minds of the interlocutors. Pickering and Garrod (2004; 2009) define *mutual understanding* as equivalency in the activation of mental representations across the speakers involved. Priming of linguistic resources is not an end in itself, but rather is in service of the alignment of underlying conceptualizations, or situation models (Zwaan & Radvansky, 1998), relevant to the current discourse. Conversational success is thus defined through mutual understanding, and is driven by and measured through isomorphism in abstract representation across individuals. The more two individuals make use of the same talk, the more they will

conceptualize a given task domain in the same way, and the more successful they should be at the task.

Such a perspective resonates with the general paradigm in the cognitive sciences in which language is taken as a means of transferring information and more generally the mind is taken as a type of information processor that reconstructs the external world symbolically (Reddy, 1979). Priming within dialogue reduces the difficulty by which information is transferred from one speaker to another, leading to a shared internal representation. It's worth noting that this broad interpretation of the role of language as information transfer and language processing as either encoding (production) or decoding (comprehension) fits both the inherently egocentric two-stage models of comprehension as well as the constraint-based models. Despite their attempt to include pragmatic information as primary within linguistic processing, constraint-based models, with their emphasis on reference disambiguation, are still based on the assumption that the role of the listener is to decode the meaning of an utterance and interpret the underlying speaker intention.

Defining conversational success in terms of mutual understanding and alignment emphasizes cohesion across speakers. And indeed, a number of studies have shown that the more a conversational partner repeats verbal and nonverbal actions of a speaker, the more that speaker will like them and the closer that speaker will feel towards them (Chartrand & Bargh, 1999). Verbal mimicry drives a number of positive outcomes related to social perception

within interactions. Verbal mimicry thus leads to increased trust of the mimicker (Swaab, Maddux, Sinaceur, 2011), increased sales numbers (Jacob et al., 2011), increased sexual attractiveness ratings of the mimicker (Guéguen, 2009), as well as increased compliance with requests for charitable donations (Kulesza, Dolinski, Wicher, & Huisman, 2015). On a more general level, linguistic style matching positively predicts group cohesiveness (Gonzales, Hancock, & Pennebaker, 2010), the success and longevity of romantic relationships (Ireland, et al., 2011), as well as the success of hostage negotiations (Taylor & Thomas, 2008). Mutual understanding driven by local priming and alignment seems to lead to positive outcomes in terms of the perception of the other as being similar to the self.

Mutual understanding as the basis of success in dialogue obscures the degree to which dialogue is pragmatic in nature. That is, while mutual understanding may at times be the goal of conversation, frequently it is not. Linell (2005) argues this forcibly in his description of the written bias in the scientific exploration of language, suggesting that text, with its emphasis on monologistic construction and transfer of information from writer to reader, has supplanted talk as the root basis for investigation. Instead, the shared goal that drives spoken dialogue may be to accomplish some achievement in the world; to act in such a way that a collaborative activity makes some sort of adaptive difference in the lives of those involved. Often this may require mutual understanding, but mutual understanding alone frequently is not enough for

such social activities to be achieved. Even common ground, typically taken as a constraint on dialogue such that it delineates the relevant information that will be present, is not enough to explain how it is that language is brought to bear on collaborative activity (Rączaszek-Leonardi, et al., 2014).

Emphasizing dialogue as a means for achieving shared goals, and in particular those goals that are out of reach of isolated individuals, requires both some degree of cohesion or mutuality, as well as functional complementarity. This functional complementarity could also be described as a forward momentum or progressivity in dialogue through which speakers build on each other's turns, making relevant and available some next action that is both complementary to the previous talk while taking the dialogue in a novel direction. Thus while some studies have gone so far as to measure synchrony of discourse actions such as questions, explanations, and instructions (Louwerse, et al., 2012), progressivity is defined in dialogue not by repetition but in relevant differences across turns (Linell, 2009). These cumulative and contingent actions are at the heart of what conversation analysts label *conditional relevancy*, where producing a particular utterance at a particular point in a dialogue makes relevant certain complementary contributions by the conversational partner, such that the meaning of any particular utterance involves this unfolding development.

Progressivity is measurable in dialogue as the converse of alignment. One arena where this has been recently demonstrated is in syntactic alignment.

Syntactic priming, the re-use of syntactic constructions across speaker and hearer independent of the repetition of particular words, has been taken as a demonstration of the reality of the interactive alignment model. As outlined above, it has been demonstrated within artificial experiments in which the primed construction is presented by the experimenter, as well as in spontaneously produced dialogue involving natural conversation. It is not, however, a universal feature of conversation. In some corpus analyses, syntactic priming is found only with particularly conversation types (Reitter, Moore, & Keller, 206), or only with particular syntactic constructions (Gries, 2005). Indeed, a recent study in which the effect of any lexical repetition was removed in an analysis of conversational talk actually found a significant degree of syntactic *divergence* in a corpus of naturally produced dialogue, with the particular syntactic structure of an utterance less likely to be used by the conversational partner in the following turn (Healey, et al., 2014). While it may be the case that syntactic constructions are primed across speaker and hearer in some settings, it appears that this priming is washed out by the progressivity of dialogue, in which speakers build on each other's contributions, productively constructing the unfolding discourse. This demonstrates the functional nature of dialogue, in which the joint action is based on the coordination of distinct contributions.

CHAPTER 3

Interpersonal Synergies: A Dynamical and Functional Approach to

Dialogue

A recent variation of the collaborative theory borrows extensively from theories of dynamical systems, which focus broadly on complex systems as they change over time, describing the self-organization of components in the emergence of a functional system. Dynamical approaches have been used to describe such diverse phenomena as the movement of heated oil, traffic jams, the behavior of beehives and flocks of birds, as well as human development and cognition (Dale, et al., 2014; Kauffman, 1996; Thelen & Smith, 1994). The present chapter outlines generally the core concepts of dynamical systems, especially as related to dialogue. Within a dynamical account, interpersonal coordination in general and dialogue more specifically are taken as representative cases of the emergence of coordinative structures, called interpersonal synergies (Dale, et al., 2014). The chapter then goes on to consider one of the conclusions of this theory's framing of dialogue, namely that an interpersonal synergy can be considered a socially extended cognitive system (Fusaroli, Gangopadhyay, & Tylen, 2014). Finally, I consider how such a perspective on dialogue changes the basic assumptions of the role of convergence and alignment, and what other aspects of dialogue may be relevant to understanding how language is used.

As with the collaborative language theory, the dynamical perspective, with its interest in functional coordination, takes the appropriate level of

analysis as including the dyad, or conversation as a whole. Dialogic processes cannot be fully explained at the level of the individual, or by the simple aggregation of individual level processes. Both theories emphasize that by coordinating meaning making, active speakers and listeners take on shared responsibility for the creation of talk. Given this focus on co-construction and the development of the dialogue, both the collaborative theory and the dynamical approach are interested in how meaning making is extended over conversational time, and how the structure of the discourse emerges through local interaction.

Finally, in both approaches the goal of conversation is taken to be successful accomplishment of a shared goal rather than mutual understanding. Within the collaborative theory, mutual understanding is needed only to the extent that it allows for the least collaborative effort to be applied to the performance of some shared task (Clark & Schaefer, 1989). Thus, within this and the subsequent dynamical perspective approaches, the functionalist approach is seen in an interpretation of words and utterances as taking on a role as constraint on a coordinated activity rather than as symbol (Rączaszek-Leonardi & Kelso, 2008). That is, language use serves to reduce the degree of variability in the coordination of two individuals engaged in reaching a shared goal, allowing them to more successfully accomplish their joint task.

We suggest that the interpersonal synergy approach, in allowing for the creation and maintenance of socially distributed cognitive systems, also supports a claim regarding the role of divergent contributions in collaborative

44

dialogue. Language serves not only to coordinate two individuals, reducing

degrees of freedom along particular dimensions, but also to introduce variability

along other dimensions, introducing distinct resources and information spread

across a dyad or group. Increasing the degree of variability, and allowing for

contrastive contributions to be coordinated and synthesized progressively turn

by turn, extends the abilities of the interacting speakers beyond their individual

capabilities. Thus, while convergence may be important for establishing

coordination and cohesion, on its own convergence will not be enough to

establish collective benefit that goes beyond the level of the individual or

aggregate. Instead, we can think of a distributed and socially extended cognitive

system as relying on cohesion as a means of balancing the divergent

contributions of the individuals involved, based on the dynamical systems

framing of dialogue.

3.1 Dynamical Systems

Dynamical systems theory emphasizes an understanding of cognitive processes

as they unfold over time, through interactions among both internal sub-

processes and external influences (Beer, 2000). Rather than being encoded in

innate modules of mind, behavior arises through interactions and mutual

couplings across mind, body, and environment, which together form *soft*

assemblies or coordinative structures (Kello & Van Orden, 2009). This

coordination leads to the emergence of structures that are irreducible to the

level of the individual sub-processes involved. The dynamical model contrasts with both modular theories of mind which form the basis of the interactive alignment model and other similar models that place emphasis on representations and mental computation, as well as with connectionist models in that explanatory focus is placed on understanding the trajectories through state spaces and the parameters that shape this trajectory (Spivey, 2007; Thelen & Smith, 1994). Further, dynamical systems approaches emphasize the functional nature of cognition as opposed to information processing (Varela et al., 1991), in harmony with the pragmatic nature of dialogue and the co-construction of meaning.

The dynamical systems framework was first brought to the consideration of cognition in the realm of motor control. In moving one's arm, for example, there are a high number of degrees of freedom in the muscles and joints, as well as in the specifics of the environment in which the action is being performed, that would make a fully detailed cognitive plan large and unwieldy. A dynamical model proposes that these muscles and joints form a functional synergy, such that the mutually constraining dynamical mechanisms of the coordinative structures produced effectively reduces the degrees of freedom directly, without the need for a fully specified command from the central nervous system. This makes the performance of a stable behavior such as walking or wagging one's finger possible without a mental representation of the behavior of each individual part, as these behaviors are an emergent property of the system (Kay,

Kelso, Saltzman, & Schoner, 1987; Riley, Richardson, Shockley, & Ramenzoni, 2011; Thelen & Smith, 1994). These emergent synergies combine smaller units into a cohesive system, which can act flexibly and reciprocally adjusts to changes within the system (Kelso, Tuller, Bateson, & Fowler, 1984).

By coordinating in such a way, a unitary system emerges with stable states or patterns of behavior, sometimes called *attractors*, which need not be computationally represented or innate*. A classical dynamical experiment demonstrating these attractors involves the coordination of moving one's index fingers up and down on both hands. At slow speeds there are two stable attractors, that is two likely patterns of behaviors in which the system will fall; in-phase coupling in which the fingers move up and down together, and anti phase, in which the fingers move in opposite directions. As the fingers are wagged faster and faster, however, the anti-phase coupling becomes less stable, and participants will automatically switch to in-phase movements (Kelso, 1995). From a dynamical perspective, such patterns of behavior are best explained not through computation on abstract symbols sending out action plans at specific times, but as stable attractors within a nonlinear system (Spivey, 2007; van Gelder, 1998).

3.1.1 Interpersonal Synergy – Dynamics in Social Interaction. Coordinative structures, which form the basis of phenomena as diverse as waves, flocking birds, traffic jams, and human cognition, arise through the temporal coupling of

47

distinct systems into a cohesive whole. This is true for individual behaviors such as motor coordination in producing goal-directed actions, but the same model has also been successfully applied to interpersonal coordination as well (Wolpert, et al., 2003). Numerous studies have now extended the same sorts of synergistic models used to explain individual performance to the scale of the coordination across interacting individuals (Marsh, et al., 2009). Just as the complexity of an individual's motor system is reduced through soft assembly into a synergistic unity, the high degree of variability available across interlocutors engaged in a collaborative task is reduced by the establishment of a functionally driven emergent social unit (Dale et al., 2014; Fusaroli, et al., 2014).

To build on the example of the finger-waving paradigm, studies have demonstrated that the same attractors found for individuals engaged in this task exist in a system in which two individuals each wave a single finger and attempt to coordinate their motor actions (Black, Riley, & McCord, 2007). Further, again focusing on low-level motor behaviors, studies have demonstrated that while engaged in interaction, individuals will spontaneously coordinate their movements. This includes unconscious bodily sway (Shockley, Santana, & Fowler, 2003), as well as eye movements (Richardson & Dale, 2005). The unconscious coordination of low-level behaviors across interlocutors demonstrates the perceptuo-motor coupling that is a hallmark of an emergent coordinative structure (Fowler, Richardson, Marsh, & Shockley, 2008; Riley, et al., 2011; Shockley, Richardson, & Dale, 2009). Importantly, such coordination

appears to be sensitive to the function of the interaction, with coordination increasing based on the nature and difficulty of the task (Ramenzoni, Davis, Riley, Schockley, & Baker, 2011; Louwerse, et al., 2012).

Similar to the high dimensionality found in bodily movement and control, communication involves the use and coordination of a large number of semiotic resources (Goodwin, 2000), each with variable dimensions of use. The variety of cognitive mechanisms relevant to conversation, as well as their context sensitivity, can be integrated through a dynamical systems framework that again emphasizes mutual adaptivity and self-organization across individuals in the formation of a functional interpersonal synergy (Dale, et al., 2014; Fusaroli, et al. 2014). The interpersonal synergy perspective suggests that by engaging in the formation of an interactional unit, or dialogue, the degrees of freedom within the space of the communication are reduced, such that comprehension and production are facilitated and the interacting dyad is able to successfully function within the constraints of the environment. This dimensional reduction in social interaction is visible in the tight complementary structure of the interaction, such that the roles of speaker and listener are distributed and interweaved. Distinct, task-oriented routines emerge through the interaction, constraining individual actions (Clark, 1996; Mills, 2014; Stivers et al., 2009).

An interpersonal synergy will demonstrate behaviors and parameters that are unique to this level of analysis; it is not necessary to posit internal or innate mechanisms at the level of the individual. Importantly however,

interpersonal synergies, as an emergent level of behavior, are not monolithic or compulsory. The processes by which joint action is initiated and sustained are considered critical to an understanding of social engagement (Tollefsen & Dale, 2012). Interpersonal synergies may be more or less difficult to maintain, and coordination may occur in relative degrees (De Jaegher & Di Paolo, 2007). Similarly, the coordination may appear differently in different contexts, given both physical and informational constraints (Duran & Dale, 2014). The interpersonal synergy, once established, is considered autonomous, arising from the individuals involved but taking on a life of its own. This autonomy is demonstrated when the goals of the interaction as a whole are in contrast to, or reshape, the goals of the individuals (De Jaegher & Di Paolo, 2007).

This interpretation suggests that the comprehension system self-organizes by rapidly integrating such social constraints. This conceptualization mirrors models put forward by the collaborative theory of language use, in which meaning and understanding are actively shaped by the social context of the interaction (Brennan, et al., 2010; Brown-Schmidt & Hanna, 2011). By emphasizing the autonomous nature of the systemic level, this theory goes further in developing the explanatory role of the interaction, such that patterns of behavior at this higher level are irreducible to the level of the individual (De Jaegher, Di Paolo, & Gallagher, 2010). More generally, however, the dynamical perspective integrates explanations of phenomena at various levels and across prior theoretical motivations. Such a complex systems account can transition

from explaining low-level perceptuo-motor coupling effects to high level social constraints such as common ground and pragmatic information about an interlocutor (Duran & Dale, 2014), while similarly applying the same conceptual framework at the level of the interaction itself, explaining both interpersonal synchrony and complementarity.

3.2 Socially Extended Cognitive Systems

In taking the dyad as an emergent structure, with patterns of behavior irreducible to the level of the individual, and a collective functionality, the interpersonal synergies perspective supports the interpretation of individuals working together through language as a socially extended cognitive system. While a number of theories within the cognitive sciences have argued for an interpretation of cognition as distributed through mind, body, and world, many of these have focused on the extension of an individual mind. Fusaroli et al. (2014) build on one such individualistic theory to include dialogic interaction. They expand on A. Clark's (1997) concept of active vehicle externalism, in which language is understood as a type of symbolic scaffolding that transforms cognitive activity, to emphasize the intersubjective and inherently social nature of language. This paradigm suggests that language use constitutes a form of socially extended cognition, forming the basis of interpersonal synergies.

By enabling individuals to enter into higher-level cognitive systems, interpersonal synergies make possible new means of behavior that are out of

reach of the individual. This is necessarily true in the case of teams performing actions that would be entirely impossible by solitary individuals, such as navigating a navy vessel (Hutchins, 1995) or piloting an aerial vehicle (Cooke, et al., 2013). But socially extended cognition can also be compared to individual cognition in those arenas where work may be done together or alone. Demonstrations of a boost in performance for the dyad illustrates how interpersonal synergies, as cognitive systems, increase adaptivity and support the extension of cognitive abilities. In the following we survey a number of such arenas, contrasting the performance of the individual and the dyad.

One such study investigated the role of engaging in social interaction on a perceptual decision-making task. Participants engaged in a visual discrimination task either alone or in dyads, able to freely communicate choice as well as confidence (Bahrami, et al., 2010). The pairs engaged in free interaction outperformed isolated individuals. The researchers argue that integration of information such as was found within interacting dyads mirrors the processes by which single individuals accurately weigh information when combining different sources of sensory information. Such an illustration demonstrates the utility of the dynamical approach in parsimoniously accounting for processing at varying levels of analysis.

The role of dialogue in shaping and extending cognitive abilities has also been explored in the realm of categorization. Voiklis and Corter (2012) suggest that collaborative reference tasks, one of the common paradigms of collaborative

language research, could be considered a form of negotiated category learning. The pragmatic requirements of adjusting one's categorization to the constraints of the interaction could act to enhance conceptual representation, directing attention towards those dimensions useful in communication and in doing so shaping the conceptual processes involved. To test this, participants engaged in a categorical discrimination task either alone, communicating with oneself, alone and silent, or in interactive pairs. For both rule-based and family-resemblance-structured categories, engaging in the activity collaboratively lead to faster and better learning of the category structures over both types of individual conditions (Voiklis & Corter, 2012). This suggests that it is not simply language use which drives the effect, as has been previously reported (e.g. Lupyan, Rakison, & McClelland, 2006), but the communicative pressures of engaging in a social interaction. Post-tests revealed that engaging in the interactive task widened the distribution of attention across more diagnostic features and facilitated increased awareness of the relation between the features and the categorization.

Importantly, the success of the dyads within this study was compared to simulated pairs, in which two participants from the isolated condition were combined into a pseudo-dyad, which were then compared to the actual dyads (Voiklis & Corter, 2012). This comparison demonstrated that the success of the dyads could not be explained by simple information pooling, of either attention or structure. Instead, the researchers suggested that the learning advantages

were due to the negotiation across the interactants. This finding supports the conceptualization of the interpersonal synergy as irreducible to the level of the individual, and which emphasizes the role of language as constraining joint activity (Rączaszek-Leonardi, et al. 2014). By engaging in the functionally constrained interaction, in which social interaction led to the coordination of conceptual processes, the interlocutors were more successful at uncovering the underlying categorical structure of the stimulus domain, compared to the capabilities of isolated individuals, including those who engaged in monologic self-oriented talk.

Looking at groups rather than dyads, Woolley and colleagues (Woolley, Chabris, Pentland, Hashmi, & Malone, 2010) found evidence for a *collective intelligence* factor parallel to the *general intelligence* factor established for individuals. That is, a single factor of collective intelligence explains a given group's performance on a wide variety of tasks. Importantly, while this '*c factor*' is correlated with both the average intelligence of the group and the maximum intelligence, it is much more strongly correlated with interactional factors such as the equal distribution of conversational turn-taking and the social sensitivity of group members. This suggests that the group intelligence arises not only from the pooling of the individual intelligences of the individuals involved, but emerges from the way that the individuals interact together (Woolley, et al., 2010). This analysis places emphasis on the dynamics of the higher-order

interaction, and the relationship across the interacting individuals, the ways in

which working together through dialogue creates a functioning system.

CHAPTER 4

Current Studies: The Importance of Linguistic Divergence

in Interpersonal Synergies

Dialogue as a form of interpersonal synergy sets the stage for dialogic theory of language that emphasizes progressivity and divergence as necessary ingredients above and beyond local alignment. Such a theory has roots within earlier work on language in social interaction; in particular, work on joint projects (Bangerter & Clark, 2003; Clark, 1996), communicative projects (Linell, 1998; 2009), and adjacency pairs (Sacks, Schegloff, & Jefferson, 1974; Schegloff, 2007) all emphasize the complementary nature of coordinated social action. The current work builds on these various dialogic theories in order to emphasize the progressive, sequential nature of dialogue, in which speakers provide complementary but distinct roles within an interaction. Based on an interpersonal synergies perspective on the functionality of social interaction, we re-interpret local alignment as in service of the rapid and successful integration of distinct and complementary contributions to a conversation.

Taking a pragmatic perspective, we suggest that alignment, in the form of repetition of linguistic material across speakers, must be functional in nature, serving the coordination needs of the dyad and the achievement of a shared goal. This differs greatly from the interactive alignment model, in which all repetition is considered in the service of establishing mutual understanding, and should

therefore always lead to conversational success. Emphasis on the role of repetition in conversational success is not entirely unproblematic.

Consider one demonstration of repetition found in a collaborative task. Louwerse, Dale, Bard, and Jeuniax (2012) found clear instances of priming of communicative behavior across modalities within a pair of speakers engaged in a map-based direction giving task, including facial expressions, gestures, and words, and further demonstrated that this repetition was driven by task difficulty. This by itself seems to support the interactive alignment model of dialogue. However, these researchers also found repetition of different types of discourse contributions, or dialogue acts, for example yes/no questions, clarifications, and explanations, which were treated by the researchers as similar to the repetition of other types of communicative features. It is unclear, however, how the repetition of dialogue acts may be considered a form of successful understanding that would allow the dyad to perform the task successfully. Surely a yes/no question should not be followed immediately by another yes/no question, but rather a response to the question itself. By overlooking the role of complementarity in conversation, the analysis dissolves differences across types of repetition and coordination that likely play distinct roles in conversational success.

Mills (2014) raises a litany of such concerns, suggesting that repetition based models of dialogue fail to account for novelty, for linguistic change over time, for continued development of referring expressions after conceptual pact

formation, and for the large variety of functional roles that repetition may play in a conversation above and beyond a role in lexical entrainment. Rather than forming the basis for successful interaction, repetition may serve a particular function as a recovery device, aiding in clarification at points of misunderstanding (Louwerse, et al., 2012). Mills (2014) responds to these concerns by arguing for a shift in focus in the field to include research on the development of procedural coordination, which he describes as the conventionalization of patterns of distinct contributions in the service of achieving a collaborative goal. Both procedural coordination and semantic coordination (possibly, but not necessarily visible as lexical repetition) are features of interactive dialogue.

Analysis of priming-based repetition in conversation does indeed suggest that low-level coordination may be a feature of dialogue. From an interpersonal synergy perspective, however, this convergence sets the stage for the rapid and successful coordination of divergent contributions. Consider, for example the collaborative decision-making task described above (Bahrami, et al. 2010). An analysis by Fusaroli and colleagues (2012) on the language used in the task illustrates how both semantic entrainment and complementary contributions play a role in elevating dyadic performance. These researchers quantified the relationship between linguistic convergence and collaborative benefit, the degree to which the dyad outperformed the individual accuracy, presenting two key findings. First, alignment upon a single lexicalization of the dimension

58

relevant for performance on the task, in this case expressions of certainty of

having perceived the correct target, was correlated with collective benefit above

the levels of individual performance. The participants expressed a variety of

linguistic constructions in order to convey confidence in their perceptual

experience that led to their decision. For example, some described how "sure"

they felt ("demi-sure," "very very sure"), whereas others described how they

"saw" things, "knew" things, or "thought" things (Fusaroli et al., 2012, p. 935).

There was variation in the degree to which a given dyad entrained on any single

means of expressing confidence. For example, some dyads favored variations of

"sure" while others fluctuated among the categories across trials. There was also

variation in the frequency of particular lexicalizations of confidence across

dyads, with four more dominant and a number of less common expressions.

Importantly, this study showed that it was the degree of entrainment, not the

particular expression used, that positively predicted performance.

As it stands, this finding could similarly be used as a demonstration of the

utility of priming-based accounts of dialogic success. However, when the

researchers expanded their scope to linguistic alignment of all words, rather

than just those relevant to coordination for the task, they actually found a

negative correlation between alignment and collective benefit. The researchers

took this as a demonstration that models such as in the interactive alignment

model (Pickering & Garrod, 2004), which predict successful performance based

on the alignment of underlying situation models, do not accurately portray how

coordination of linguistic expressions across conversational partners leads to an increase in collective benefit. Instead, they argue for an interpersonal synergy framing, in which alignment is task specific and sensitive to the optimal coordinative dynamics relevant to reaching the joint goal (Fusaroli & Tylén, 2012).

The finding of a negative correlation between indiscriminate alignment and collective benefit was thus viewed as negative evidence for a priming-based model of dialogue. The same finding, however, could also be understood in a different manner, by flipping the explanatory perspective. It may be true that indiscriminate alignment leads to less collective benefit, but this finding could also be interpreted as evidence that divergence is critical to dyadic success. That is, the more unique information each interlocutor contributes to the interaction, the more successful the dyad is at performing the task. Given the joint perceptual decision making task, and the finding that alignment along those lexical dimensions relevant for performance leads to collaborative benefit, what linguistic material is left to lead to the observed negative relationship between general linguistic alignment and dyadic success? While it is possible that the pairs that engaged in one-sided gossip or off-topic chit-chat would be those that performed worse, given a presumption of task-relevant focus this leaves open the possibility that the coordination of unique contributions is a key ingredient for the ability of pairs to outperform their own individual capacities. That is, instead of interpreting the relationship as a negative one between indiscriminate

local alignment and collective benefit, this finding could be re-interpreted as a *positive* relationship between collective benefit and unique informational contributions.

This reversal of interpretation is supported by findings across various domains of interaction. A number of studies have now demonstrated that collaborative benefit is related to the degree to which individuals within the interaction contribute novel information or a novel perspective. In research conducted by Wiley and colleagues (Wiley, Goldenberg, Jarosz, Wiedmann, & Rummel, 2013; Wiley & Jensen, 2006; Wiley & Jolly, 2003) collaboration in dyads and triads leads consistently to performance above that of isolated individuals. This appears to be particularly reliant on the contribution of diverse perspectives across interlocutors. When groups of students engaged in a learning-by-invention task surrounding a particular mathematical problem, groups containing individuals with heterogeneous math abilities generated a broader range of solution attempts than did groups of a more homogeneous nature (Wiley, et al., 2013). Further, this lead to increased subsequent individual performance for members of diverse groups. A similar effect was found when experts coordinated performance with novices. Here, the novice/expert pairs were found to outperform either type of individual working independently (Wiley & Jolly, 2003). Diversity in dyadic success may be especially relevant for the ability of a dyad to perform well in new situations (Canham, Wiley, & Mayer, 2012).

Group success, then, appears to require a skillful balance between repetition and convergence on the one hand, and differentiation and divergence on the other. Indeed, Baumeister et al. (in press) present this balance as the determining factor in groups that perform better than the sum of their individuals compared to those that perform worse than the sum of their individuals. These researchers suggest that it is those groups whose members are highly differentiated, in knowledge, skills, or specializations that illustrate the collaborative benefit at the basis of interpersonal synergies. Too much convergence, despite its role in creating cohesion across the group, is likely to lead to such negative group effects as social loafing and group thought (Baumeister et al., in press).

While these researchers emphasize differentiation as a status that individuals in a group may have, they do not consider the role that language plays in allowing for the successful coordination of such highly differentiated group members. Importantly, it cannot be the case that simply having different backgrounds, knowledge sets, or specializations produces dyads and groups that engage more successfully with the task at hand. Rather, it is the introduction of diverse contributions into the conversation that leads to broader exploration of the task domain and informational resources (Stasser & Titus, 1985) and leads to collaborative benefit (Woolley, et al. 2010). These findings thus hint at a role for divergent and complementary contributions as key factors in dialogue, but have not yet provided an analysis of the actual talk itself.

At its heart, language as a human activity is inherently social, allowing us to work together to coordinate and collaborate on complex tasks and maintain complex social relations (Brennan, et al., 2010; Clark, 1996). An interpersonal synergy perspective, based on the tenets of dynamical systems, captures this collaborative activity, showing how language-mediated coordination gives rise to complex coordinative structures that function in such a way as to exceed and extend the abilities of the individuals involved (Hasson, et al., 2012; Hutchins, 1995; Fusaroli, et al., 2014; Sterelny, 2012; Sutton, Harris, Keil, & Barnier, 2010). Treating dialogue as an emergent coordinative whole shifts the focus away from mutual understanding as the basis of collaborative success. Instead, success is understood as the adaptive constraint on joint action in service of reaching some common goal. Language, then, is to be treated not as a means of sharing ideas from one mind to another, but as a tool by which social activity is constrained and developed. The current studies demonstrate how diversity in contribution, and the ability to coordinate such talk, provides the means by which collaborating dyads accomplish these feats.

CHAPTER 5

Experiment 1: Linguistic Convergence and Divergence in

a Collaborative Decision-Making Task

Previous research on dialogue and collaborative activity has emphasized local

repetition, also referred to as alignment, as the basis for successful group

performance (e.g. Pickering & Garrod, 2004). These theories suggest that local

alignment of linguistic resources across speakers, driven by unconscious and

egocentric priming across comprehension and production processes, leads to

alignment of underlying situation models relevant to the shared task. Such

alignment of relevant situation models boosts performance by supporting

mutual understanding. In order to study how alignment supports collaboration,

researchers have implemented tasks in which participants must repeatedly

accomplish a shared goal. These include referential card tasks, involving the

sorting of abstract shapes (Clark & Wilkes-Gibbs, 1986), map tasks involving

both a director leading a follower through a route (Louwerse, et al., 2012), and

maze tasks in which two participants must work together to successfully escape

a maze (Garrod & Doherty, 1994). Across all these tasks, semantic coordination

is found to support performance, leading to more accurate and more efficient

communication over conversational time and repeated joint activity.

These tasks typically compare across different dyads working together,

contrasting dyadic performance entailed by higher or lower degrees of

alignment. Another measure of collaborative dialogue is the comparison of the

individual against the dyad. Fusaroli and colleagues (2012) conducted such an

analysis on the talk produced in a collaborative decision making task, in which it

was found that the dyad as a pair outperformed the most sensitive individual of

the pair in a perceptual decision making task (Bahrami, et al., 2010). These

researchers were interested in what features of the talk produced correlated

with collective benefit. Dyadic performance on the task showed that local

alignment, measured trial-by-trial across speakers along particular task-relevant

semantic dimensions (in this case metacognitive expressions of perceptual

confidence) was positively correlated with collective benefit. In contrast,

indiscriminate local alignment, that is alignment of all words beyond just those

related to perceptual confidence, was negatively correlated with collective

benefit (Fusaroli, et al., 2012). These findings are in direct contrast to the

predictions of priming-oriented models of dialogue (e.g. Pickering & Garrod,

2004), which suggests that all repetition should improve communication and

therefore performance. Instead, it supports a functionalist, dynamic perspective

(Dale, et al., 2014), in which some semantic domains related to particular task

relevant dimensions of talk are constrained in successful interaction while

others remain diverse and complementary. Both aspects of the talk appear to

support collective benefit.

     The measure of indiscriminate alignment used in this analysis, which was

negatively correlated with collective benefit, included both the lexical items that

made up the task-relevant dimension in the first finding, as well as all other talk.

In doing so, the authors use the finding to argue against the interactive alignment model's predictions. However, it is also possible to reinterpret this relationship as a positive correlation between collective benefit and local disalignment, or divergence. We suggest, then, that a key component of collaborative benefit is the ability of the dyad to coordinate and integrate distinct perspectives and contributions in a way that allows them to perform better at the task than the individuals separately. Following this, we argue that performance on a collaborative task is positively correlated with both discriminate alignment of confidence terms, and discriminate *divergence* of other task-relevant dimensions of talk. By showing how these two aspects of an interaction work together to establish dyadic performance, we take a functionalist perspective in which the dyad represents a socially extended cognitive system, one in which diversity in contribution is harnessed.

In the following experiment, we replicate the task and analysis of Bahrami et al. (2010) and Fusaroli et al. (2012). We further conduct new analyses that work to separate out the aligned versus pooled dimensions of talk, arguing that rather than indiscriminate alignment being negatively correlated with collective benefit, it is rather the case that informationally divergent contributions across the dyad are positively correlated with collective benefit. This effect can be measured by taking an inverse of the previously developed local alignment measure, allowing for a test of a correlation between divergence and collaborative benefit.

5.1. Methods

5.1.1. Participants. 76 participants from the University of California, Santa Cruz psychology subject pool participated. Data were taken from 33 dyads who successfully completed the task in the required time frame. Two dyads did not complete the task in the required time, and an additional three dyads did not follow the instructions of the task.

5.1.2. Materials. Replicating Bahrami et al. (2010), the task involved perceptual discrimination of a pair of brief visual displays, one of which contained a contrast oddball. The stimuli were sets of Gabor patches in a circular array surrounding a fixation point. Gabor patches are striped arrays that vary along three dimensions – orientation of the lines, spatial frequency, and contrast. For this stimulus set, orientation was maintained at 90 degrees, spatial frequency at 1.5 cycles/degree, and contrast at 10%. Oddball contrasts were created by adding one of four possible values to the contrast parameter of the Gabor patch (+1.5%, +3%, +7%, & +15%). See Figure 1.
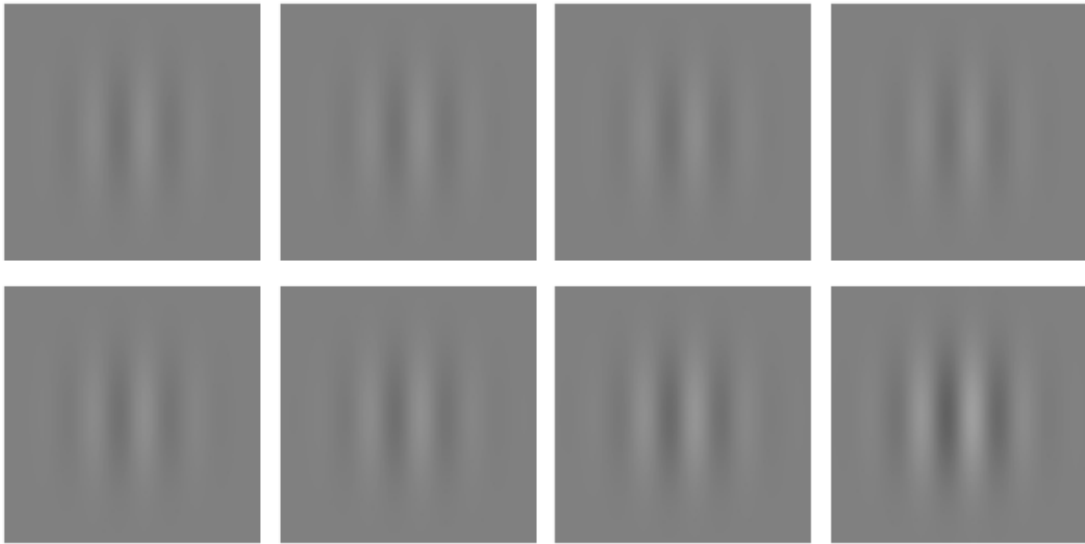
Figure 1. Baseline and oddball Gabor patch stimuli demonstrating differences in contrast parameter at +1.5%, +3%, +7%, and +15% above baseline contrast.

The task took place on a dual screen computer system, allowing for matched presentation of stimuli for each participant. Visual stimuli were displayed on desktop monitors in a dark room, and participant responses were recorded from standard keyboard and mouse clicks. A display board between the two monitors separated the participants visually, requiring that all interaction be done through talk. Information regarding feedback color and response keys for each participant was presented on this display board as a reminder. Participant dialogues were recorded using Audacity (http://audacityteam.org/).

5.1.3. Procedure. Participants were instructed that their task was to decide whether the first or second of a pair of Gabor patch arrays contained an oddball

patch with a distinct contrast. They were further instructed that they were to

make their decision individually, but that whenever the two made decisions that

differed, they would need to talk together until they were able to reach a single

shared response.

Each trial began with a keyboard press from one of the participants, after

they had checked that their partner was ready. A fixation cross was then

presented, centered on the screen. After a brief period (randomized to be

between 500 and 1000 ms) the stimuli were presented for 85 ms each,

separated by a pause of 1000 ms containing a blank visual display. At the end of

each stimulus presentation, participants were prompted for their individual

responses. One participant responded using the keyboard, the other with the

mouse in order for the responses of the two participants to be collected

independently and feed into the same system. These responses were then

displayed to both (either *first* or *second*), color-coded so that the participants

knew who had chosen which response. This feedback was randomized such that

each participant's response might be displayed above or below the other. If there

was disagreement across the dyad, the participants were prompted to provide a

joint decision. Participants were not given instructions on how to reach this joint

decision except that they were to talk to each other until both agreed upon a

shared response. After providing a joint decision, feedback was given as to the

correctness of the joint response, as well as the correctness of the previously

produced individual responses. Participants were allowed to take time to discuss

69

the accuracy of their responses upon receiving feedback before moving on to the next self-initiated trial.

After one practice block of 16 trials, the experiment consisted of 8 blocks of 16 trials. Halfway through, the participants were prompted to switch locations, such that the participant who used the mouse to respond for the first half of the experiment responded on the keyboard for the second half and vice versa. The color-coded response feedback was maintained across this switch.

5.1.4. Measures and Transcription. Individual and dyadic performance on the visual discrimination task were measured through the creation of psychometric functions plotting the proportion of trials in which the oddball was seen in the second interval against the contrast difference at the oddball location. Individual sensitivity was modeled from the individual responses for each trial. Dyadic sensitivity was modeled by combining the trials in which the two participants agreed with the joint responses on trials in which they disagreed. These curves were fit with a cumulative Gaussian function whose parameters were bias and variance, estimated through the use of a probit regression model. Estimated variance was related to the maximum slope of the psychometric curve, such that a larger slope corresponds to a more highly sensitive performance. Sensitivity in discrimination based on these models was then compared for the individual level and dyadic performance by taking the ratio for the dyadic performance slope to that of the more sensitive member working alone, such that values

above 1 indicate a collaborative benefit to performance and values below 1 indicate a collaborative cost.

Trained research assistants created transcripts of the talk produced by the dyads. Based on these transcripts, further coding of all expressions of confidence (Peterson & Pitz, 1988; Wesson & Pulford, 2009), in particular those related to metacognitive perception (Shea, et al., 2104), was conducted, as semantic coordination on such terms has been previously positively correlated with collective benefit (Fusaroli, et al. 2012). An analysis of local linguistic alignment was constructed based on the probability that a given lexical expression used by a participant would be a repetition of an expression used by that participant's partner in the previous trial. This measure can be used for different types of discriminate local alignment, focusing only on expressions of confidence relevant for the coordination of the dyad, or focusing only on other information outside of these expressions of confidence that are relevant to the task. A measure of global convergence to a particular lexicalization of metacognitive confidence was also measured, taken as the proportion of all confidence terms that were based on the most common lexicalization.

5.2 Results

5.2.1. Local Alignment, Global Convergence, and Local Divergence. Local alignment measured the probability of a given word to have been a repetition of

71

the same word spoken by the other participant in the previous collaborative

trial. Local alignment was measured for all lexical items, $M = .0499$, $SD = .0176$,

just those items related to metacognitive confidence, $M = .0592$, $SD = .0302$, and

just those words unrelated to metacognitive confidence, $M = .0498$, $SD = .0176$.

The local alignment of confidence terms and non-confidence terms were

positively correlated, $r(33) = .77$, $p < .001$, suggesting that the mechanisms of

local priming acting similarly across the two domains of task-relevant talk. While

these two dimensions of the talk had correlated transition probabilities, terms of

confidence were more likely to be in local alignment with prior talk than words

unrelated to confidence, MDiff = .0093, paired-sample $t(32) = 2.663$, $p < .05$, 95%

CI [.0022, .0165].

Global convergence represents the proportion of instances of the most

commonly used confidence term compared to the total number of confidence

terms spoken throughout the entire interaction. Across the corpus of talk trained

coders found 32 different expressions related to confidence in perception. The

dyads displayed convergence towards the continued use of a limited functional

set within this category. Global linguistic convergence, the proportion of all

confidence terms produced by a dyad that were coded as being within the same

category, was on average .3777, $SD = .0894$. For 17 dyads, the expression

converged upon was "SEE," for 10 dyads it was "THINK," and for three dyads it

was "SURE." "TELL," "KNOW," and "SAY" were the most commonly used

confidence expressions for a single dyad each. The measure of global

convergence was not significantly correlated with the measure of indiscriminate local alignment, $r(33) = .21$, $p = .23$.

5.2.2. Collective Benefit. In terms of task benefit, dyads gained a marginal collective benefit in working together on the perceptual decision-making task, compared to performance of the better performing individual, $M = 1.08$, $t(34) = 1.83$, $p = .076$, 95% CI [-.008, .16]. 11 dyads did not benefit from working together, while 22 did.

5.2.3. Linguistic Coordination and Collective Benefit. The ratio of the maximum slope of the dyad to the maximum slope of the best performing individual was not significantly correlated with the measures of local alignment, including the indiscriminate local alignment, $r(33) = -.001$, $p = .995$, confidence terms local alignment, $r(33) = .07$, $p = .72$, and non-confidence terms local alignment, $r(33) = -.002$, $p = .993$. The degree to which a dyad displayed collective benefit or not was also not significantly correlated with the measure of global converge, $r(33) = .11$, $p = .56$.

5.3. Discussion

This study attempted to replicate and extend Fusaroli, et al. (2012), using English-speaking interactants, (the original study was conducted in Dutch). In contrast to prior studies and to predicted results, the current study was unable

to correlate measures of linguistic convergence with collective benefit. None of the measures of either alignment or divergence were positively correlated with the ability of the pair to outperform their own individual abilities.

In the current data, there was only a marginal trend towards collective benefit, suggesting a very small or weak benefit to working collaboratively on the task. Indeed, a third of the dyads in the study unperformed compared to the more sensitive member of the pair. Performance on average was roughly equivalent to the better performing, more sensitive individual in the dyad. The presence and collaboration of the less sensitive individual did not appear to boost performance such that the dyad was a quantitatively better performing unit.

Collective benefit across the sample was not a requirement, however, for the further analysis of the role of linguistic alignment and divergence in the degree to which collaboration differed from the individual performance levels. Key to this linguistic analysis was the operationalization of alignment in terms of transition probability. The likelihood that a particular word spoken by a given member of the dyad was a repetition of the same word spoken by the other member in the previous collaborative trial was used as a measure of the degree to which linguistic resources were reused across the conversational partners. The inverse of this measure, the likelihood that a given word is conversationally new, in terms of the prior contributions of a conversational partner, can be considered a form of disalignment or divergence. Fusaroli et al. (2012), found

that alignment along particular semantic dimensions positively correlated with collaborative benefit, whereas general alignment was negatively correlated. Here, we reinterpreted the negative relationship between indiscriminate alignment and collaborative performance as a positive one between divergence along all other dimensions of talk besides the one required to coordinate this distinct information, (again, the metalinguistic lexicalizations related to confidence), and collective benefit. However, we were not able to uncover any relationships between performance across individual and dyad and the measures of either alignment or divergence.

One key difference from the results of the original study (Fusaroli, et al., 2012), is the degree to which alignment of any kind was found in the corpus of talk collected. In Fusaroli, et al. (2012), the average transition probability across all dyads was .5997, meaning that roughly 60% of all lexical items were repetitions of the same items spoken by the other participant in the prior interactive trial, with the range across dyads covering .15 to .9 for all words within a pair's talk. In contrast, within the current study the average transition probability across all dyads was .0498, with a range from .0148 to .0919. In other words, the dyad with the highest degree of local alignment in the current study had lower transition probability than the dyad with the lowest degree of local alignment in the prior study.

It is not clear initially why such a sharp contrast in the degree of local alignment should be present across the two studies. It suggests that the

participants in the current corpus made use of more variable language, shifting

the way they shared and coordinated information on each collaborative trial.

The automated analysis of the degree of alignment across conversational

partners and collaborative trials worked at the level of the word. While spelling

was standardized, the program would still have treated conjugated verbs and

plural versus singular nouns separately. It's possible that taking these into

account may lead to higher degrees of alignment than currently measured.

   The participants in the current study did, however, demonstrate a more

global convergence to a particular lexicalization of metacognitive confidence in

their perception of the visual stimuli. Global convergence here represents that

degree to which a particular lexicalization for metacognitive confidence was

selected for use across all collaborative trials. This measure was calculated as

the proportion of instances of the most common confidence term to all instances

of all confidence terms. Of the 32 terms used, the most commonly converged

upon were SEE (17 dyads), THINK (10 dyads), and SURE (3 dyads). TELL, SAY,

and KNOW were the most commonly used confidence term for a single dyad

each.

   As an initial step in the direction of analyzing the role of complementarity

in collaborative activity, the current findings are not able to support a model of

dialogue that emphasizes interactional synergies and divergent contributions.

However, because of the lack of collaborative benefit in the current data, it

remains possible that a fine-tuning of the task such that this benefit would

emerge may also be accompanied by a correlation between performance and linguistic divergence. Further, decision-making is just one domain of many in which pairs of individuals may work together to boost performance. In the subsequent chapters we look elsewhere, at collaborative activities such as creativity and memory, in order to further test for divergence as a driver of collective benefit.

CHAPTER 6

Experiment 2: Linguistic Divergence in Collaborative Humor Production

The majority of experimental paradigms exploring semantic coordination and its

role in collaboration have focused on iterative tasks involving a shared

referential domain. In the dyadic *referential card task*, for example, the shared

goal is for one participant with a particular array of shapes to instruct the other

participant in order to lead them to arrange their own shapes to match (e.g.

Clark & Wilkes-Gibbs, 1986). In many variations on map tasks, the goal is for one

participant with an outlined path to direct the other participant through that

particular route (e.g. Louwerse, et al., 2012). Across multiple trials, participants

align on the semantic concepts used to describe locations in the map, for

example by producing expressions based on interpreting the map as a matrix or

as a figure (Garrod & Doherty, 1994). In both task types collaborative success

has been correlated with similarity in speech and behavior (Pickering & Garrod,

2004). As with the collaborative decision making task of the prior experiment,

the iterative nature of the tasks allows for a high degree of routinization, which

may over emphasize a role for local alignment.

In the present experiment we focus instead on a collaborative task that is

non-iterative. A domain of tasks in which divergent contributions may be

especially critical to collaborative benefit involves conversational partners

working together to create something new, whether an idea or a product. A

number of studies have demonstrated that diversity within such group activities

boosts performance in terms of this kind of productivity (Brodbeck, et al., 2007).

These studies assumed that the identities of the individuals involved are

indicative of diverse knowledge sets. However, most have not considered how

these distinct backgrounds may be brought into a conversation and coordinated

with those of others in order to build something new or solve a complex

problem.

In an exception, the *hidden profile* paradigm provides an illustration of

how conversation leads to group success when information critical to making

the best possible decision is spread across members of a group. In this task,

small groups must determine the single best solution to a problem set. At the

beginning of the task each individual receives a particular set of information,

such that the information required to reach the optimal solution is spread across

the group while information supporting suboptimal decisions are shared. It is

only through discussion, and in particular the contribution of privileged, or

privately held, information, that this optimal profile emerges (Stasser & Titus,

1985). Conversation provides the structure through which insight from distinct

perspectives may be brought to bear on a collective problem. In the following

experiment, we demonstrate how divergence across conversational

contributions is critical to supporting and implementing collaborative creativity.

Creativity requires the combination of distinct conceptual frames

(Fauconnier & Turner, 2008). Within a collaborative creative task,

conversational partners work together to explore a problem space and integrate

distinct perspectives. In one study collaborativity was tested with a multiple-uses task where participants were asked to come up with novel uses for everyday objects either within interactive dyads or individually (Howes, et al., 2015). Interacting pairs came up with uses that were more complex and creative than did participants in the individual condition. In particular, the researchers found that more complex uses were arrived at through collaboration: participants in the conversational context were likely to build on ideas that were introduced by their partner, and it was these ideas in particular that outperformed those produced by isolated individuals.

One arena that may be particularly fruitful for the study of conversational divergence and collaborative benefit is humor production. Humor requires both creativity generally as well as an ability to consider multiple frames of interpretation for the same situation. While psychological research on humor has considered its production and comprehension (Krikmann, 2006), as well as its role within communication (Meyer, 2000), very little work has been done on the collaborative production of humor. In contrast, conversation analysts have taking a highly interactional approach to humor, focusing on jokes as both an interactional resource as well as a joint achievement (Norrick, 2003; Norrick & Chiaro, 2008).

The goal of the collaborative humor experiment was to test the role of linguistic divergence across conversational turns in the joint production of a creative idea. We measured the ability to produce humorous ideas at the level of

80

the dyad and the level of the individual, and tested for the role of linguistic divergence in driving collaborative success.

6.1. Methods

6.1.1. Participants. 68 participants were drawn from the University of California, Santa Cruz psychology subject pool. Dyads consisted of pairs of participants who had no or little previous social interaction (i.e. who were not friends). Participants received course credit for participation. One pair was dropped from the analysis for failing to perform the task as directed, leaving 33 dyads that completed the task.

6.1.2. Materials. 50 comics were drawn from a large collection of single frame illustrations published in the New Yorker magazine with their original captions removed. Three research assistants independently rated the illustrations for humor potential on a seven-point scale (0 – no potential for humor through 7 – extremely high potential for humor). From the larger set, the 14 comics with the highest average humor potential ratings were selected as stimuli for this study. This set including a range of illustrated topics including aliens, cavemen, baseball, restaurant scenes, cowboys, and animals. Illustrations were presented in printed packets with a single image per page and space provided for the participants to write down their responses.

Participants worked in separate rooms, allowing for both isolation during the individual trials and control over the means of interaction during the collaborative trials. Interactions were conducted through the use of a text-based chat-tool platform (Skype). This was done to eliminate the use of nonverbal communication channels and for ease of transcription and coding.

6.1.3. Procedure. Participants were instructed that they were to engage in a humor production task with the goal of coming up with the funniest caption they could for each illustration in a three-minute time frame. Piloting of this study suggested that participants interpreted "Come up with the funniest caption that you can" as "Come up with the first caption you can think of, and then sit there for the rest of the three minutes." In order to motivate a deeper exploration of the problem space of each comic, the instructions were modified such that for both the individual and collaborative trials, participants were instructed that in order to produce the funniest possible caption, they should come up with as many as possible for the first two and a half minutes, and then use the remaining 30 seconds to select their final choice. Only the final selected response was used for analyses.

Each dyad engaged in 14 humor production trials. Of these, half were individual trials, in which the participants worked alone, and half were collaborative trials in which the participants worked together to produce a single response, with individual and collaborative trials interwoven. Whether

the first trial was individual or collaborative was counterbalanced across dyads. Within the pairs, a single participant was randomly selected as the responder for the collaborative trials, such that the other participant only wrote down their captions for the individual trial comics. A research assistant started each trial, gave a warning when 30 seconds of the trial was left in order for the participants to be able to write down their final choice, and ended each trial at the three-minute mark. After each collaborative trial the text conversation was recorded and removed from the interaction window such that participants did not have prior talk available at the beginning of each new collaboration. The total time of the experiment was roughly 45 minutes, including a brief post-study questionnaire that asked participants about their perception of both their own and their partner's contributions on the task.

6.1.4. Measures and Transcription.

Humor ratings. Three independent judges rated the comic captions for each illustration along 7-point scales for humor. Scores were based on the raters' understanding of the joke, whether it was witty, as well as the kind of physical responses that they had to the particular caption. A 7, the highest humor rating, was given to captions that elicited spontaneous laughter, a 5 to those that elicited a smile or smirk, and a 3 was given to captions that were understandable as an attempt at humor but that did not elicit any embodied response. A score of

a 1 or 2 was reserved for those captions that were not viewed as funny and/or did not make any sense.

Creativity ratings. Creativity was rated by three independent judges, using a 7-point coding scheme based on a conceptualization of creativity as taking aspects from the depicted scene and reinterpreting them to create something unique. A 7 was given to captions that took something present or implied in the cartoon and reinterpreted it into something brand new and relevant. A 5 was given to a reinterpretation of similar novelty to one that received a 6 or 7, but that was not necessarily based on a relevant reinterpretation to the scene. A 4 was given to an obvious or expected reinterpretation. Scores between 1 and 3 represented captions that provided very little to no reinterpretation of the visually depicted scene of the comic.

Originality coding. All captions, individual and collaborative, were coded for the underlying theme by two undergraduate research assistants blind to condition, with the instructions to always try to maximize theme category membership before creating an additional theme. Disagreements in theme were resolved by the author. The number of unique instances were counted, and this value was divided by the total number of captions in the data set for each illustration to produce a percentage. Based on this measure, the higher the percentage, the

more common and less original the particular comic caption was within the total

set collected. See Figure 2.

COFFEE FIRST – 20 instances, 37%

"Hey King Arthur, chill the hell out. Let me finish my coffee."

"I know I'm a dragon and all, but don't I get to finish my coffee before being slayed?"

SUGAR – 3 instances, 5.5%

"I just wanted to borrow some sugar."

"Whoa man. I just need some sugar."

KNIGHT'S TRAINING – 1 instance 1.8%

"No, Jerry. You need to look more aggressive. The dragon isn't going to take you seriously in that stance."

Figure 2: Sample captions collected from the corpus illustrating variation in originality for the same stimulus image.

Conversation. Text conversations were recorded from the Skype interactions and separated by trial. Repeated contributions from the same participant were combined into single turns. Spellings were standardized and punctuations removed in order to allow for automatic calculation of divergence across turns. Within trial divergence measure was calculated based on turn-by-turn progressivity. A script using the python programming language was developed that read transcript files and automatically compared the lexical items across turns within a given trial and produced a local divergence measure. For each turn, the proportion of non-repeated words in relation to the conversational partner's just prior turn was calculated. An average distinct contribution measure for each participant, the dyad, as well as a difference score across dyad members, was calculated for each trial. See Figure 3 for a demonstration of a single trial.

(*a*)

(*b*)

t1p2u1 so far I thought of indecision decision making a hobo trying the food before ordering
t1p1t2 yea I was thinking of a hobo being indecisive boo problems
t1p2u3 I meant hobo don't judge your customers
t1p1u4 or happy hour gone bad
t1p2u5 yeah that's good happy hour makes us equal something like that yeah yours is good do you wanna decide on that
t1p1u6 sounds good

(*c*)

Participant	Trial	Utterance	Repeated Word Count	Distinctive Word Count	Total Word Count	Proportion Distinct
2	1	1	Initial Utterance	N/A	15	N/A
1	1	2	4	7	11	63.64
2	1	3	1	6	7	85.71
1	1	4	0	5	5	100.0
2	1	5	2	19	21	90.48
1	1	6	1	1	2	50.0
Participant 1 Average Distinct Word Proportion = 71.21%						
Participant 2 Average Distinct Word Proportion = 88.09%						
Trial Dyadic Divergence = 77.966%						
Unique Contribution Difference Score (P1 - P2) = -16.88%						

Figure 3: (*a*) Single-panel comics image under discussion in (*b*) Sample conversation from a single trial of the collaborative humor task, demonstrating how the pair works together to propose ideas and settle on a single answer (*c*) Output of the linguistic divergence measure for the talk produced in trial (*b*).

6.2. Results

Because the measure of divergence were created through a turn-by-turn analysis, collaborative trials in which the pair produced fewer than three turns were dropped from the analysis, (9 trials, representing 1.5% of the data), as these did not allow for a divergence score to be created for each participant nor the dyad as a whole.

6.2.1. Collaborative Benefit. We define collaborative benefit as the ability of the pair to outperform either of the individuals involved (Fusaroli, et al., 2012; 2014). For each dyad, we recorded the average humor and creativity ratings of the funnier individual as well as the average humor and creativity ratings for the collaborative trials. Trials produced by the funnier individual were rated as numerically more humorous (M = 3.94 SD = .40) than the trials produced by the dyads working together (M = 3.81 SD = .38), although this difference was not significant $MDiff$ = .13 t(31) = 1.659, p = 1.07, 95% CI [-.03, .28]. Similarly, the average scores of the more original individual (M = .18, SD = .05) and the originality of the collaboratively produced responses (M = .17, SD = .06) did not significantly differ, $MDiff$ = .01, t (31) = .71, p = .485, 95% CI = [-.02, .04]. Trials produced by the more creative individual were rated as more creative on average (M = 4.39 SD = 0.45) than the trials produced by the dyads working together (M = 4.16 SD = 0.42), $MDiff$ = 0.23 t(31) = 2.931, p =.006 , 95% CI [.07, .40].

6.2.2. Divergence and Collaborative Performance. While the dyads

underperformed compared to their most humorous or creative individual

member, it is still possible that dialogic progressivity played a role in

collaborative performance. To test this, we created a model that predicted a

trial's humor rating based on the degree to which the talk used to produce the

caption contained linguistic divergence. A mixed-model analysis with random

intercept for dyad and trial was performed, comparing a null model against

models that contained the dyads' divergence score averaged across

conversational turns within a trial, as well as the average of the funnier

individual, and the number of turns produced per trial. Only the measure of

dyadic divergence improved model fit against the null, $X^2(1) = 5.253$, $p < .05$, $B =$

1.76; no other variable or interaction between variables improved fit (all $p >$

.05).

A similar model was created for predicting a trial's creativity and

originality ratings. Again, dyadic divergence improved model fit against the null,

such that an increase in the turn-by-turn divergence within the talk produced for

a collaborative trial predicted an increase in the creativity of the final output,

$X^2(1) = 9.43$, $p < .01$, $B = 2.55$. No other variable or interaction between variables

improved fit beyond the by trial divergence measure (all $p > .05$). No predictor

improved model fit above the null for the prediction of originality (all $p > .05$),

and in fact while originality was uncorrelated with humor across the full data st

$r(215) - -.02, p = .775$, originality and creativity were negatively correlated

$r(215) = -.17, p < .05$.

6.3. Discussion

Working together to come up with a novel and humorous framing of an illustration requires contributions from both conversational partners. Turn-by-turn, the dyads in this study were successful together when they built on each other's prior utterances as they explored the problem space and possible reinterpretations of the scenes displayed. To the extent that each contribution was distinct and divergent from the one just prior, collaborative performance was boosted. The output of trials with higher degrees of local divergence were considered funnier and more creative.

The third measure, originality, a scale used to measure the prevalence of a particular theme across different individuals and dyads, was not benefited by local divergence. At first, one might presume that originality and creativity are closely related measures. However, in the current data set the two measures were actually negatively correlated. This is likely due to the differences by which these two scales were created. The creativity scale was a subjective judgment, and required that the humorous caption created be both novel and appropriate. The originality scale, on the other hand, awarded higher scores to those captions that were less common within the data set, regardless of whether they were actually appropriate to a particular comic image or not. Because of this,

responses coded as most original were also likely to be those that made the least sense, rather than those that provided a particularly novel or creative interpretation of an image.

The results demonstrate how collaborative success is built up through the progressivity of taking turns contributing to the dialogue. This is in line with previous work, which found that in collaborative creativity tasks, those responses that built on a partner's previous response were more likely to be more complex (Howes, et al., 2105). Unlike this prior study, however, the participants in this study were required to come up with one single shared response, rather than as many distinct responses as possible.

And yet, dyads still underperformed in comparison to the better-ranked individual. While studies of group processes have found both emergent, qualitatively better performance in groups (Fusaroli, et al., 2012; Howes, et al., 2015), there are also instances in which groups underperform the individual baseline, whether taken as the best performing individual or the potential aggregate (Steiner, 1972; Mullen, Johnson, & Salas, 1991). One explanation for this process loss is *production blocking,* by which the dynamics of a group discussion may inhibit the ability of the individual to effectively pursue an ongoing train of thought (Diehl & Stroebe, 1987).

Another possible reason for the lack of collaborative benefit could be the format in which the interaction was conducted. In a post-study questionnaire a number of participants mentioned that the online chat format made contributing

difficult. This was true for both interactional concerns and for simple mechanistic ones. Participants reported that not knowing when a conversational partner might be completing their turn and sending it through the chat program made it difficult to coordinate contributions. Further, many reported that it was difficult to type on one of the keyboards, an older model, leading to coordination issues. Both of these concerns would be ameliorated in a face-to-face version of the same task, in which talk would be more easily produced. This would require transcription however, and also introduces other communicative modalities such as gesture, gaze, and bodily posture, which would also need to be taken into account.

Despite a lack of collective benefit in the comparison between best individual and collaborative performance, the current experiment is still the first to demonstrate a role of local divergence in the quality of the dyad's creative output. Across collaborative trials, those conversations in which the participants introduced more novel linguistic material on a turn-by-turn basis led to more highly creative and humorous joint responses. This research suggests that more broadly, a theory of collaborative language use should include processes of divergence and progressivity as key ingredients to dyadic success.

CHAPTER 7

Experiment 3: Complementarity in the Dialogic Rehearsal of a Collaborative

Memory

The goal of the current thesis is to make the argument for dialogue as the basis of a socially extended cognitive system, based on the theoretical principles of dynamical systems and collaborative language. Critical to the development of this account is a new emphasis on divergence, the degree to which the collaborating dyad successfully coordinates distinct contributions. We found evidence for a marginal trend towards collaborative benefit in Experiment 1, although we were unable to correlate this collective benefit with the measures of linguistic divergence. In Experiment 2 this extended system was visible in the coordination of distinct informational resources brought to bear on the joint task, measured as turn-by-turn progressivity. To the degree that the two interactants were able to successfully integrate their divergent contributions, performance was boosted, suggesting that social extension through dialogue can support collaborative benefit. In the third experiment we seek to connect the measures of divergence and dyadic performance to another domain in which collaborative action is pertinent, that of collaborative memory.

The arena of memory research has become a microcosm for the larger debate regarding whether cognition may be appropriately thought of as extended through interaction (see Sutton, et al., 2010 for review). Conversational remembering is interpreted as a form of scaffolding or coupling, by which two or more individuals' memory processes are intertwined such that they become critically dependent. One

conceptual framing of collaborative memory harmonizes particularly well with the more general emphasis on the role of divergence in both conversation and collaborative success – the *transactive memory system* (Wegner, 1987; Wegner, Giuliano, & Hertel, 1985). As with socially extended cognition more generally, the transactive memory system is complementary, with different individuals taking responsibility for different aspects of the memory. In reproducing a transactive memory, the dialogue must involve the coordination of distinct contributions.

Interpreting transactive memory as a form of socially extended cognition allows for a direct comparison to individual memory and remembering. While controversial, (see e.g. Pavitt, 2003), a number of studies have now shown that the development and use of a transactive memory system allows for the facilitation of group performance, such that together the individuals involved may outperform their isolated abilities. However, some researchers have argued that group performance should not be compared to single isolated individuals, but rather the rational aggregate of all individual capacities. This nominal group contains the sum of all memories recalled individually, prior to some conversational joint recall. Using this as the yardstick by which to define collaborative benefit, in the domain of memory as well as in other activities such as brainstorming, paints a less optimistic picture. Compared to nominal groups, truly collaborative memory performance is significantly reduced, due to what has been labeled *process loss* (Steiner, 1972) or *collaborative inhibition* (Weldon & Bellinger, 1997).

Beyond demonstrating whether or not groups may outperform some particular baseline, either the rational aggregate or the best performing individual, research has attempted to illuminate mechanisms through which group performance may be improved. Comparison here is not between levels, contrasting the individual with the group, but looking across groups for differences in abilities and performance. Clearly, the ability to effectively distribute responsibility for particular aspects of the shared memory is an integral part of collective benefit in this regard. Hollingshead (1998), in a study comparing the ability of dyads consisting of either dating couples or of strangers, showed differences in the effectiveness of particular strategies for achieving this distribution. The pairs were asked to learn and later recall words from six different knowledge domains. When provided the information without the ability to interact during learning, couples outperformed strangers in recalling the words.

Hollingshead (1998) argued that this increased performance is derived from the couples' ability to rely on a shared understanding of domains of expertise within the pair, such that they were able to effectively rely on their partner to remember those aspects for which they were best suited. Strangers, on the other hand, were more effective than dating couples when provided the opportunity to actively communicate during learning. In this context, dating couples over relied on learning strategies that required both members to learn all the words together, whereas the strangers were more likely to actively engage in discussion regarding the delegation of responsibility. This study demonstrates how, across various forms of social relationships and learning strategies, the critical aspect in the performance of a

transactive memory system is the ability to distribute memory uniquely across the individual members.

Importantly, a transactive memory system is dialogic not just in its distributed nature, with each individual taking on the responsibility to act as a reservoir for particular parts of the memory. Transactive memory may also be considered dialogic in that the transactive memory is both formed and recalled within the context of active conversation. It is communication, either within the present context of establishing the memory or in previous interactions through which groups gain knowledge on the distinct expertise of members, that allows for the distribution of responsibility. Thus a transactive memory also requires metacognitive knowledge about the particular form this distribution takes (Wittenbaum, 2003). The dynamics of the conversation play a critical role in shaping the shared memory and establishing the transactive system (Hirst & Echterhoff, 2008).

Given the dialogic nature of collaborative memory, it is appropriate to situate its study within the larger theoretical framework of dialogue and language-mediated sociality. Discursive psychology in particular has emphasized remembering as a social behavior, both in terms of processes of remembering together and in terms of the role of remembering within the larger social activity. Joint remembering is treated as a form of situated activity, and as such is shaped by the interactional organization of the conversation itself (Middleton & Brown, 2005). The particulars of the conversation shape the shared or transactive memories as they are formed and recalled (Hirst & Echterhoff, 2012).

How then might the processes of dialogue be involved in the formation and use of a transactive memory? Tollefsen, Dale, and Paxton (2013) present an analysis connecting the processes of alignment outlined in Chapter 2, by which two speakers' verbal and embodied behaviors become increasingly coordinated over conversational time, to the ability of pairs to form transactive memories. As with other researchers, they take the role of the alignment system within communication as evidence for the formation of socially extended cognitive systems. The alignment itself is seen as the basis by which the cognitive coupling is sustained, with the mutual adaptation across conversational partners giving rise to an interpersonal synergy. As with the collaborative decision making task in Experiment 1, in order for a transactive memory system to be effective, the alignment must be restricted so as not to reduce the ability to contribute the privileged information that has been distributed across the pair. That is, with too much alignment, the priming and repetition of speech across conversational partners, the memory recalled would be redundant across speakers rather than truly transactive. This fits well with the general interpretation we have been formulating across the studies presented here of the functional interpersonal synergy as constitutive of both convergent dimensions, in which communicative behaviors are aligned, and divergent dimensions, by which complementary and distinct contributions are coordinated and integrated. By hypothesis, this system accomplishes two critical tasks, it provides the means by which the participants are coupled in the activity of remembering and it reduces the cognitive work required to integrate complementary contributions.

In that dialogue itself is normatively progressive in nature (Linell, 2009), the role of the turn-by-turn construction of talk should influence the establishment of a shared memory as well. Thus, while previous studies have considered the role of dialogue in the specific activity of distributing responsibility for particular components of a memory (Hollingshead, 1998), this distribution may also arise spontaneously through the progressive drive to contribute novel information in each turn at talk.

Collaborative remembering is often studied within dyads that have a long history of interactions, such as intimate couples, family members, and coworkers. While previous studies have emphasized pre-existing relationships as the basis by which information is successfully distributed, or the active discussion of such distribution, in the current experiment we explore the role of spontaneous dialogic progressivity as the basis by which such responsibility may be established. We explore the stabilization of a transactive memory system across multiple collaborative recalls. In doing so, we suggest that initial divergence, that is those aspects of the memory uniquely contributed by a single interlocutor, will form the basis for establishing the distribution of the memory.

7.1. Methods

7.1.1. Participants. 56 participants from the University of California, Santa Cruz psychology subject pool participated, randomly paired into 28 dyads.

7.1.2. Materials. A stimulus video was created that displayed a speaker and listener engaged in conversation. Both interactants were confederates trained to faithfully reproduce the script. The video displayed a face on view of both, created through the use of a split screen. The speaker's script was a description of a friend along 8 personality traits. This script is based on work within the *saying-is-believing* paradigm (e.g. Higgins & Rholes, 1978) and has been normed such that each personality trait is ambiguous in terms of valence (positive personality trait vs. negative personality trait). In the video version of the saying-is-believing script, the listener provided positive feedback, smiling and nodding and saying "Oh really?" to positive aspects of the description. The script was 400 words long, contained 207 unique lexical items, and took the speaker 3 minutes 5 seconds to produce. Prior work with these stimuli has found that participants readily believe the authenticity of the description as a natural spontaneous interaction.

7.1.3. Procedure. Participants were introduced at the beginning of the study session. They were informed that they would be engaging in a memory task together. Participants watched the stimulus video in the same room. For each recall, participants were prompted to remember as much as possible from the original description presented in the stimulus video. Individual recall was conducted in separate rooms. Collaborative recall took place in the same room in which the stimulus was watched. For all recalls, the participants' speech was recorded and later transcribed. After each collaborative recall participants took a short break, in separate

rooms to prevent the opportunity for continued collaborative remembering. The entire procedure took on average 30 minutes.

7.1.4. Measures and Transcription. In order to measure both individual and dyadic performance, the recorded recalls were transcribed and compared to the original script in two ways. First, the recalls were coded for the presence of correctly recalled concepts. The original script was divided into a list of 31 concepts, and research assistants coded the transcripts for the presence and correct recall of each of the concepts from this list. Both of the individual recalls as well as the first and third collaborative recall were hand coded for the presence of correctly recalled concepts.

Second, we developed a program that automatically compared the words in the recall transcriptions with the script from the original stimuli. The output of this analysis provided insight into four dimensions of the recall: 1) word count, the total number of words produced for each recollection of the memory, 2) unique word count, the total number of unique lexical items produced in the recall, 3) words added count, the number of words from the unique word count that were not present in the original stimulus script, and 4) words omitted count, the number of unique words from the original stimulus script that were not included in the recalls. Total word count provides a measure of the amount of effort put into recalling the memory, as well as some indication of the extent remembered. The unique word count provides a measure of how much information was contributed, collapsing any repetition of the

same information. Finally, the words added and words omitted counts provide insight into the extent to which the originally observed script was faithfully recalled.

A third analysis was conducted comparing the contributions made by each participant. A program was developed that pooled the turns at talk produced by each participant and then provided a list of all the unique lexical items that were produced in the dialogue by just one of the participants. This provided a measure of the degree to which the participants contributed non-overlapping information within the collaborative recall, as well as a measure of the equity of such contributions made by each individual in the pair.

7.1.5 Predictions. The formation of a transactive memory system, if it indeed takes place, should be visible in changes across the three collaborative recalls in terms of the amount of information provided by single members of the dyad. We predicted that across the three collaborative recalls we would see an increase in the unique words produced by just a single individual, and we further predicted that the ratio of words contributed by just a single individual in the pair compared to the total unique lexical items produced would increase with each dialogic remembering. This would represent an increase in how much the two individuals diverge from each other, with a decrease in overlapping words representing an increase in divergence and complementarity as the socially extended memory system becomes entrenched.

We can also make a number of predictions related to the relationship between the first and last individual recalls and the collaborative recalls. Given that the

collaborative rehearsals of the shared memory made the second individual recall non-independent, analyses were conducted by averaging within dyads and using dyad as the unit of analysis. First, we expected that the collaborative memory would involve the pooling of distinct memory resources into a single extended system, with the number of concepts correctly remembered in the first collaborative recall higher than the average number of concepts remembered in the first individual recall. Second, if the two individuals were to take on distinct responsibilities for different aspects of the shared memory, we would expect a reduction in the individual information recalled after the transactive memory had been formed, as measured by the average number of concepts remembered in the second individual recall compared to the first. This would be due to the individuals rehearsing and remembering just their portions of the memory, relying on their conversational partner to remember the rest.

7.2. Results

7.2.1. Individual Recall. Average recall of concepts during the second individual recall, ($M = 15.86$, $SD = 4.13$), was significantly higher than the number of concepts recalled during the first individual recall, ($M = 12.0$, $SD = 3.24$), MDiff = 3.86, $t(28) = 9.73$, $p < .001$, 95% CI [3.05, 4.68]; see Figure 4. Individuals correctly remembered more information following the collaborative rehearsals.

The total word count produced during the recall was significantly higher for the second individual recall, (dyadic average $M = 217.93$ words, $SD = 63.0$), than the first individual recall, ($M = 271.1$, $SD = 69.61$), MDiff = 53.17, $t(28) = 6.01$, $p < .001$,

95% CI [35.05, 71.3]. Similarly, the number of unique words produced by the individuals was higher for the second recall, (M = 113.71, SD = 25.19), compared to the first , (M =136.98, SD = 26.82), MDiff = 23.28, t(28) = 6.56, p < .001, 95% CI [16.0, 30.55]. Interestingly, however, the ratio of the unique word count to the total word count, a measure of information efficiency, dropped from the first recall, (M = .547, SD = .062), to the second, (M = .520, SD = .053), MDiff = .022, t(28) = 2.698, p < .05, 95% CI [.001, .053]. On average, individuals spent more effort in producing the recall following the collaborative rehearsals.

Compared to the original script, the individual recalls contained, averaged by dyad, a higher number of unique words added that were not present in the original script in the second recall, (M = 72.3, SD = 18.9), compared to the first, (M = 57.3, SD = 17.2), MDiff = 15.0, t(28) = 6.51, p < .001, 95% CI = [10.2, 19.6]. At the same time, the second individual recall participants left out a lower number of words that were present in the original script, (M = 142.28, SD = 10.57), compared to the number of words that were present in the original script but left out of the first individual recall, (M = 150.64, SD = 10.56), MDiff = -8.36, t(28) = -5.26, p < .001, 95% CI [-11.62, -5.1].

Taken together, these analyses suggest that the collaborative rehearsal lead to an increase in individual ability to recall the original script, contrary to the predictions made regarding the formation of a transactive memory.
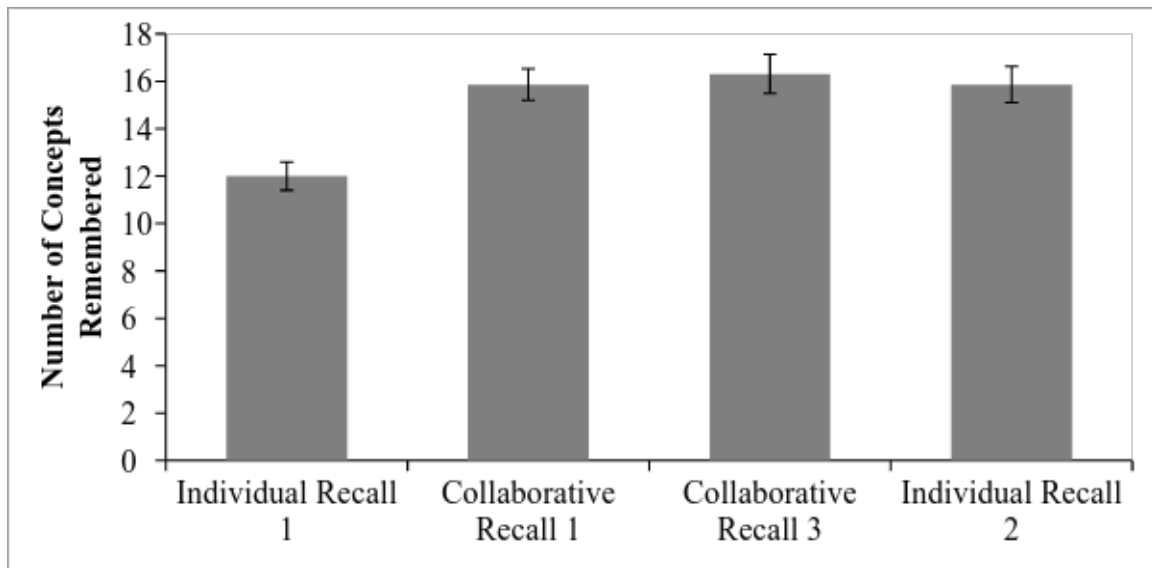
Figure 4: Counts of the number of correctly recalled concepts across the individual and collaborative recalls. Individual recalls were averaged within dyad.

7.2.2. Collaborative Recall. Conceptual coding was conducted on the first and third collaboratively produced recalls, the middle (second) collaborative recall was not hand coded. The number of concepts recalled in the first collaborative recall, ($M =$ 15.86, $SD = 3.53$), was not significantly different than the number of concepts recalled in the second collaborative recall, ($M = 16.31$, $SD = 4.47$), MDiff = -.45, $t(28) = -.837$, $p = .41$. The interacting pairs remembered roughly equivalent amounts of information across the collaborative recalls. See Figure 5.

The automatic comparison of the collaborative recalls to the original script was conducted on all three collaborative recalls. Total word count differed significantly across the three recalls, $F(2, 27) = 16.43$, $p < .001$, partial $R^2 = .55$, see Figure 5. Bonferonni-adjusted post-hoc analyses revealed that total word count was significantly higher in collaborative recall 1, ($M = 335.31$, $SD = 91.19$), compared to

collaborative recall 2, ($M = 323.0$, $SD = 99.72$), MDiff $= 32.31$, $p < .001$. Total word

count was marginally higher in collaborative recall 2 compared to collaborative recall

3, ($M = 296.41$, $SD = 87.83$), Mdiff $= 26.59$, $p = .077$. The number of unique lexical

items used did not differ significantly across the three collaborative recalls $F(2, 27) =$

2.375, p $= .112$. As suggested by these two separate analyses, the ratio of unique

words to total word count increased over the recalls, $F(2, 27) = 20.4$ $p < .001$, partial

$R^2 = .6$. Bonferonni-adjusted post-hoc analyses revealed that this ratio was lower in

collaborative recall 1, ($M = .45$, $SD = .05$), compared to collaborative recall 2, ($M =$

.49, $SD = .06$), MDiff $= .039$, $p < .001$, 95% CI [.019, .060], as well as collaborative

recall 3, ($M = .52$, $SD = .05$), MDiff $= .064$, $p < .001$, 95% CI [.036, .092]. The ratio

of unique words to total word count was marginally lower in collaborative recall 2

compared to collaborative recall 3, Mdiff $= .025$, $p = .1$, 95% CI [-.004, .053]. While

the number of concepts remembered remained equivalent across the collaborative

recalls remained the same, the amount of effort put into to producing them was

reduced over time, leading to a streamlining of the conversations.

In the first collaborative recall, on average 121.19 words in the unique word

count were contributed by a single individual in the first round, 120.78 words in the

second round, and 119.04 in the third round. These differences across round were not

significant, $F(2,28) = .225$, $p = .8$. Dyads varied in the degree to which these

contributions were evenly balanced across the pair, with on average the more

informative member contributing 37.7 more unique words in the first collaborative

recall, ($SD = 26.6$), 38.5 more unique words in the second collaborative recall, ($SD =$

30.9), and 40.07 more words in the third, ($SD = 32.88$), $F(2, 28) = .15$, $p = .866$. We thus did not find the expected formation of a transactive memory, in which we predicted an increase divergence measured in the number and proportion of uniquely contributed lexical items.
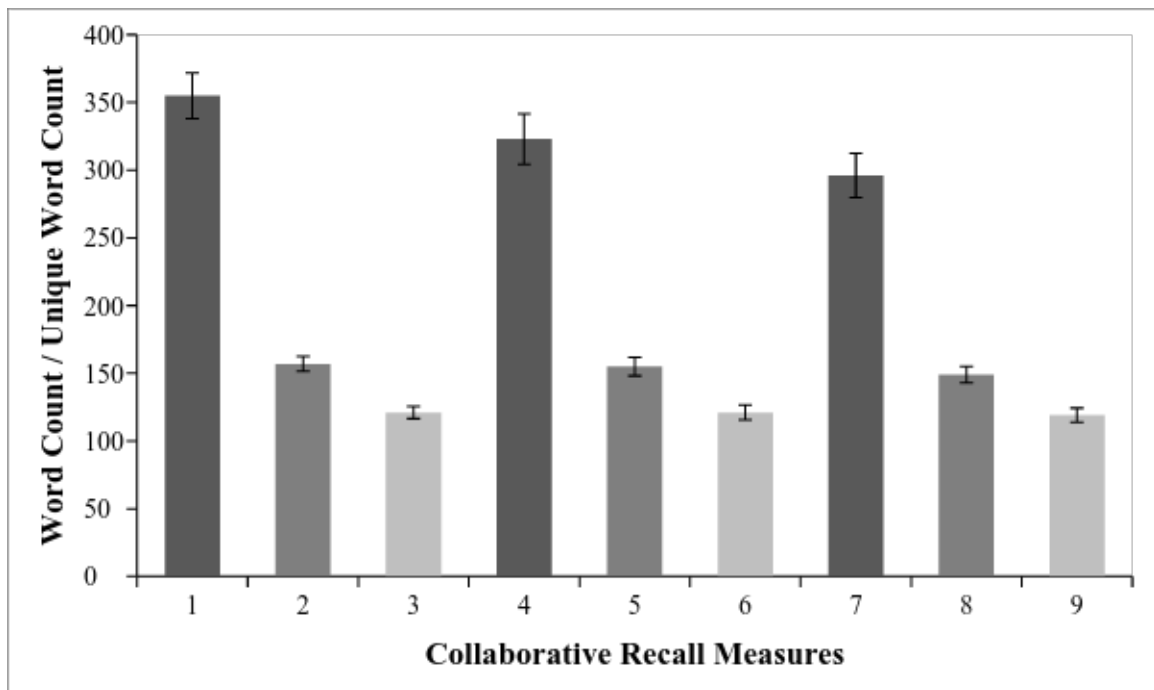

Figure 5: Total word count, unique word count, and divergent word count across the three collaborative recalls.

7.2.3. Comparing individual and collaborative recalls. Dyads' averaged individual recalls included significantly fewer correctly recalled concepts than their first collaborative recall, MDiff = 3.86, $t(28) = 10.24$, $p < .001$. The number of concepts recalled within the final individual recalls, averaged by dyad, did not significantly differ from the number of concepts recalled in the third and final collaborative recall,

107

MDiff = .45, $t(28) = 1.22$, $p = .23$. Given the interactive nature of the collaborative

recalls, a comparison of total word count or unique word count between the

individual and collaborative recalls would be uninformative.

7.2.4. The role of dialogue in supporting the benefits of collaborative recall. The

degree to which dyads, on average, recalled more concepts from the original script in

the second individual recall compared to the first was positively correlated with the

difference between the average number of concepts remembered in the first

individual recall and the number of concepts remembered in the first collaborative

recall, $r(28) = .46$, $p < .05$. The boost in recall between the first and second individual

recall was not significantly correlated with the extent to which participants

contributed distinct words in the first collaborative recall, $r(28) = .17$, $p = .39$, nor

was it significantly correlated with the difference in contribution size made across the

pair, $r(28) = .15$, $p = .44$.

We also found no correlation between the measure of divergence, the uniquely

contributed word count, and the number of concepts correctly recalled in the first

collaborative remembering $r(28) = .257$, $p = .187$.

7.3. Discussion

The present study considered the role of collaborative recall in boosting

dyadic performance beyond that of the individual level, and the role that

conversational divergence played in establishing this benefit. To accomplish this, we

framed conversational remembering in terms of transactive memory systems, which involve the distribution of memory resources across members of a social system. While we did find that collaboration had a benefit both in terms of boosting shared performance beyond that of the individual level, and in positively benefiting later individual recall, we did not find the development of a transactive memory system, and were further unable to correlate the measures of linguistic divergence with collaborative benefit.

Participants demonstrated a gain in how much they remembered from the original stimulus after engaging in collaborative recall with a conversational partner, both in terms of the number of concepts from the original script correctly remembered and in terms of the number of unique words from the original that were present in the recall. Participants spent more effort in the second individual recall than the first as well, with a higher total word count in the final individual recall. While the second individual recalls contained a larger number of words that were not present in the original script, they also contained fewer omissions.

In contrast to the change in the individual recollections, the collaborative recalls demonstrated attenuation in the amount of talk required to produce similarly successful recalls. Across the three collaborative recalls the total word count went down while the number of concepts correctly remained similar. Further, the number of unique words produced remained similar across the three conversations, leading to an increase in the informative efficiency of the interaction.

The increase in successful remembering across the two individual recalls was positively correlated with the number of concepts correctly remembered in the collaborative recall. This suggests that conversational remembering provided an opportunity to engage in rehearsal of information that may have initially been forgotten. Conversational partners can thus act as distinct memory pools, allowing the two members of the dyad to pool recollections and derive a larger, more accurate memory.

We were not able to find any correlations between the current measure of divergence used in this analysis and the benefit that the individuals found in their collaborative recalls. Neither the total number of words that were contributed by a single individual, the ratio of this measure to the total number of unique words, nor the difference across the interacting pair in the size of their unique contribution was correlated with the benefit in individual recall following collaborative rehearsal.

It does not appear that the dyads engaged in the formation of a transactive memory system, in which each would take responsibility for particular aspects of the total memory. If this were the case, we would expect two things. First, it would be unlikely that the individuals would display an increase in the amount remembered if they had partitioned the memory into a transactive system and only remembered those parts for which they were responsible. Transactive memory involves the separation of the to-be-remembered information across members of the transactive system, along with a meta-memory for who is responsible for which aspects of the memory (Wegner, 1987). Second, if the interactions had led to the formation of a transactive

memory system we would have expected that across the collaborative trials, we would see an increase in the portion of the memory that was distinctly contributed by a single member of a pair.

The collaborative benefit that arises from the formation of an interpersonal synergy relies on the ability of the dyad to contribute and coordinate distinct pools of information. It remains possible in the current experiment that a more detailed analysis of the particular concepts remembered first individually, and the relationship between these two sets of individual memories, would demonstrate that collaborative benefit arises from the distribution of information in such a way that the two members of the activity take on differentiated roles. Future analyses could look at a fine grained level at the degree to which the preliminary individual recalls contain the same or different sets of concepts from the original script, and then correlate the degree of differences with both the degree to which the first collaborative memory contains more information than the average of the individual recalls, and the degree to which the collaborative recall correlates with the gain in individual recall by the end of the task.

Rather than the formation of a transactive memory system, it seems that in the current paradigm the dyads used the collaborative rehearsal as an opportunity to be reminded of information they may have missed in the initial individual recall. The conversation appears to have allowed the two individuals to pool their distinct memories into a single, collaborative, recall, and then use the continuing interactions as opportunities to rehearse this larger memory. Such an interpretation demonstrates

how collaboration through language can reduce the cognitive resources required by any one individual. Here, it did not seem to matter which individual contributed which concept to be recalled, both contributions made by an individual and an individual's partner benefitted subsequent individual recall.

CHAPTER 8

General Discussion

The current series of experiments explored the role of linguistic divergence across a variety of tasks in which collaborative performance could be compared to the abilities of the individual working alone. This allowed us to test how the degree of divergence found within task-oriented dialogue produced may support dyadic performance. The collaborative tasks included decision-making, creativity, and memory, representing a broad spectrum of joint activity.

Across the three studies, different measures of linguistic divergence were developed, and while the findings across the experiments did not always support the conceptualization of dialogue as supporting the integration of distinct and complementary distributions, these measures may continue to prove useful in further studies. In the first experiment, linguistic divergence was operationalized as local disalignment, taken as the inverse of the transitional probability that a particular word spoken by a member of a dyad was spoken by their partner in the prior turn. This measure thus measures the reuse of similar lexical resources across repeated interactions in the same task. In the second experiment, rather than looking across repeated trials, linguistic divergence was measured in terms of turn-by-turn progressivity. Here, complementarity and divergence was calculated at an even more local level, comparing just the talk produced in two adjacent contributions to a dialogue, which could then be averaged across a single interaction to provide a measure of divergence within a

113

particular dialogue. Finally, in the third experiment, divergence was again measured within single interactions rather than across. However, rather than measuring complementarity across adjacent turns, this measure collapsed across all contributions made by each participant in the dialogue to consider the degree of overlap in the lexical resources used across the pair.

In the current experiments, it was only the turn-by-turn measure of local linguistic divergence that successfully predicted collaborative success. This may be due to the nature of the measure itself, or because of the particular tasks in which it was employed. Humor production, which also includes creativity, involves coming up with a novel idea or conceptualization on each trial. This finding mirrors previous studies exploring other aspects of collaborative creativity. In a study making use of the alternate uses task, those dyads that more successfully built on each other's ideas with each new contribution produced uses that were more complex and creative compared to individuals working alone (Howes, et al., 2015). It may be that creativity in particular may be a domain in which collaborative activity benefits from complementarity and the role dialogue plays in allowing for the progressive construction of jointly produced ideas.

For the other two experiments, we were unable to correlate the measures of linguistic divergence constructed with collective benefit, or the ability of the pair to outperform the individual levels. Within the collaborative memory task, we did see that the first collaborative recall contained more concepts than the

114

first individual recalls, and that this correlated with the ability of the individuals to recall more on their own later. This suggests that some degree of information pooling provides an opportunity for collaborative rehearsal, leading the individuals to remember more later than their original recall. However, the degree to which the collaborative rehearsal represented a boost in recall performance was uncorrelated with the measures of divergence used to analyze the talk produced within this shared recall. Likely, the degree to which the first individual recalls overlap or represent distinct pools of information correlates with the benefit the individuals receive from collaborative recall. Further analyses could seek to demonstrate this relationship between distinct knowledge and collaborative benefit, such that when conversation does occur, these divergent resources lead to a more functional synergy (Rączaszek-Leonardi, et al., 2014).

In both the collaborative humor task and the collaborative decision-making task, the dyad did not exceed the abilities of the individuals working alone. While in some measures of humor the dyad underperformed, for the collaborative decision-making a marginal trend towards collaborative benefit was found.

How does language support the coordination of individuals in order to allow for the development of functional groups, such as those that have represented a critical aspect of humanity's evolutionary history (Smaldino, 2014)? While the majority of research on dialogue and collaborative

performance has focused on convergent processes such as linguistic alignment and bodily synchronization, based on theoretical perspectives based on dynamical systems such as the interpersonal synergies account, we have argued that alignment can only get so far. Instead, a fuller account of language use in situated activities seems to require both coordination as well as certain degrees of freedom, allowing for distinct resources to be contributed. Patterns of coordination that include this differentiation have been demonstrated both in the lab, over the course of procedural entrainment (Mills, 2014; Cooke et al., 2012) as well as in the wild, in cockpits, navy vessels, and orchestra halls (Hutchins, 1994; Mills, 2013).

While results were mixed, the current studies set the stage for continued research into the role of critical divergence in supporting collaborative activity. It's possible that this dimension of collaboration may be especially critical to the development of novel ideas, such as in creativity-oriented tasks like the humor production study presented here. As with the heightened role of convergent processes in domains such as referential card tasks and map tasks, wherein information is transferred from a director to a follower, divergent processes may be particularly relevant for innovative tasks in which information must be synthesized to form a new product. This again speaks to the subtleties of the interpersonal synergies perspective. This framing of the role of language takes a functionalist approach, such that different configurations of alignment and divergence may be better suited across the various tasks in which individuals

engage in collaborative work. Further research within this domain will do much

to uncover those dimensions of dialogue that shape and are shaped by social

engagement.

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