Conversational Movement Dynamics and Nonverbal Indicators of Second Language Development: A Microgenetic Approach

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CONVERSATIONAL MOVEMENT DYNAMICS AND NONVERBAL INDICATORS OF SECOND LANGUAGE DEVELOPMENT: A MICROGENETIC APPROACH

by

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Abstract

This dissertation study extends on current understandings of gesture and embodied interaction with the eco-social environment in second language development (SLD) while introducing new aspects of movement analysis through dynamical modeling. To understand the role of embodiment during learning activities, a second language learning task has been selected. Dyads consisting of a non-native English-speaking student and a native English-speaking tutor were video recorded during writing consultations centered on class assignments provided by the student. Cross-recurrence quantification analysis was used to measure interactional movement synchrony between the members of each dyad. Results indicate that students with varied English proficiency levels synchronize movements with their tutors over brief, frequent periods of time. Synchronous movement pattern complexity is highly variable across and within the dyads. Additionally, co-speech gesture and gesture independent of speech were analyzed qualitatively to identify the role of gesture as related to SLD events. A range of movement types were used during developmental events by the students and tutors to interact with their partner. The results indicated that language development occurs within a movement rich context through negotiated interaction which depends on a combination of synchronized and synergistic movements. Synchronized movements exhibited complex, dynamical behaviors including variability, self-organization, and emergent properties. Synergistic movement emergence revealed how the dualistic presence of the self/other in each dyad creates a functioning intersubjective space. Overall, the dyads demonstrated that movement is a salient factor in the writing consultation activity.
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Last, but not least, I am sincerely appreciative of the many hours of time each tutor gave me and their willingness to be observed while at work. Without their assistance, and the participation from each of the students, this project would not have been possible.
Dedication

This dissertation is dedicated to my parents for endlessly supporting my dreams and endeavors, my brother, Bobby, for always being my toughest competitor, and to Scott, for standing by my side every day of this doctoral journey.
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Chapter 1: Introduction

Second Language Learning in Context

People learn second languages for all kinds of reasons and throughout various stages in life. As a native English speaker, when I began learning Spanish in the 8th grade, I remember approaching it with ease and a rather systematic outlook: if I learned new words and applied grammatical rules, then I’d learn the language. I received my first real challenge to this theory a year later. My friend and I were decorating the school halls for homecoming when my Spanish 2 teacher, Ms. Wolfe, walked by us and asked, “¿qué haces?” I think we both gave her completely blank stares. She repeated it, but then had to ask us in English, “what are you doing?” This was probably the first time I’d been approached to use the language outside of the confines of the classroom or a homework assignment, and the first time I had the notion that I really didn’t understand what speaking Spanish really meant. Prior to the hallway encounter, I had never had the chance to experience the language.

Contrast my experience with that of Eva Hoffman, a Polish-Jewish immigrant who arrived in Vancouver, Canada as a child in 1959. Eva describes her struggles with not only the English language, but with all that language enables us to do.

When my friend Penny tells me that she is envious, or happy, or disappointed, I try laboriously to translate not from English to Polish but from the word back to its source, to the feeling from which it springs. Already, in that moment of strain, spontaneity of response is lost. And anyway, the translation doesn’t work. I don’t know how Penny feels when she talks about envy. The word hangs in a Platonic stratosphere, a vague prototype of all envy, so large, so all-encompassing that it might crush me-as might disappointment or happiness. (Hoffman, 1989, p. 107)
Eva describes how language is so much more than code switching. She appears to understand what English words are related to Polish words, but without a feeling to accurately tie to the words, all meaning is lost and ability for free expression is curtailed. She continues,

Now, this picture-and-word show is gone; the thread has been snapped. I have no interior language, and without it, interior images-those images through which we assimilate the external world, through which we take it in, love it, make it our own-become blurred too…I’m not filled with language anymore, and I have only a memory of fullness to anguish me with the knowledge that, in this dark and empty state, I don’t really exist. (p. 107-108)

These two anecdotes of second language development (SLD) provide starkly different vantage points of what could be fundamentally viewed as the same activity. SLD, however, does not encompass one activity. It traverses numerous domains of existence requiring cognitive, social, and emotional adaptability (Swain, 2013). SLD can be affected by age (Johnson & Newport, 1989), context (Clément, Baker, & MacIntyre, 2003; Collentine & Freed, 2004), motivation (Masgoret & Gardner, 2003; Waninge, Dörnyei, & de Bot, 2014), instructional variables (Long, 1983; Norris & Ortega, 2000), native language (Kobayashi & Rinnert, 1992; Park, 2013; Stam, 2015), and other personal and socioeconomic factors (Brown, 2006).

**Introduction to the Problem**

Like Eva Hoffman, thousands of immigrants still arrive the United States (U.S.) and Canada each year with varying degrees of English proficiency. One particular group of new arrivals, though not necessarily immigrants, are international students who have traveled to the U.S. to attend colleges and universities. Specifically, non-native English-speaking students (NNES) represent the vast majority of the international student population (IIE, 2016). For the
NNES student, the language barrier interjects itself into many other aspects of the adjustment process from the social/cultural to the academic. For example, written language proficiency has been tied to increased academic performance (Andrade, 2006; Mamiseishvili, 2012), while oral language proficiency has been identified as a factor contributing to social inclusion (Sherry, Thomas, & Chui, 2010). Understanding language proficiency implications has been the focus of several reviews on the international student experience and continues to garner support for ongoing inquiry.

International students often receive language support through English language programs and centers and are assisted with their development of academic English through the assistance of teachers, TAs, peers, and other program support staff. Understanding the nature of these communicative interactions and their outcomes has been the focus of numerous research studies covering a range of parameters from range of theoretical perspectives as well. Regarding assistance with academic writing tasks, a great deal of support has been directed towards encouraging language development through communicative approaches which focus on fluency, not just accuracy, in writing (Canale & Swain, 1980). Additionally, sociocultural approaches to SLD consider the development of any language skill as a product of social interactions by which language learning is a negotiated process of meaning-making between the learner and their interlocutors (Lantolf, 2000; van Lier, 2000). This embodied, semiotic, and interaction-based meaning-making activity leads to the language learner’s development.

Adopting a sociocultural view of SLD has led to a number of research studies supporting the view that SLD is affected by a number of different conditions within the learner’s immediate social and larger cultural environments, as well as by individual factors such as motivation and willingness to communicate (Lantolf, 2000). Additionally, SLD from a sociocultural viewpoint
has explored how learning a new language affects the learner’s identity. Like Eva Hoffman, second language learners have described changes in their identity when switching from one language to another. For example, Peltier and McCafferty (2010) observed how Italian teachers used gesture as a social semiotic to guide their students to inhabit the languaculture of Italian speakers. In this regard, the students were not just learning to speak Italian, but were engaged in developing Italian speaking identities of an embodied nature.

Gestures are visible bodily actions produced willingly in conjunction with speech. Gesture is not ancillary to speech, but instead forms a functional unit from which meaning is derived. Research on gesture within SLD research has been carried out in sociocultural traditions and considered to play a role for both the learner and their interlocutors. However, gesture is not the only form of embodiment within language development. Embodiment can entail other nonverbal communicators such as gaze, facial expressions, and postural orientation. Embodiment can additionally entail extrapersonal communicators like dress, hairstyle and accessories (McCafferty, 2008). While the research literature has focused primarily on the role of gesture in SLD, other forms of embodiment have been paid less attention to date.

**Statement of the Problem**

In the social and psychological sciences, much research over the past half century has been carried out in the cognitivist tradition. Cognitive scientists have pursued the study of cognition following the mind-as-computer metaphor, which views cognition as processing input into directed behaviors through algorithmic mechanisms (Overton, 2014; Samuels, Margolis, & Stich, 2012). These traditional cognitive views have been called into question by many researchers who argue that cognitive science pursuits rely too heavily on individuals as existing
without context, who think and develop in primarily linear patterns (Firth & Wagner, 1997; Thelen & Smith, 1994; van Geert, 1991; van Gelder & Port, 1995).

Within the field of linguistics specifically, cognitivist views have been heavily influenced by Chomsky (1979) and the nativist perspective. Chomskian views assume that each individual is born with a universal grammar mechanism which allows a child to develop complex language patterns without exposure to every possibility of language patterning (Cook, 1985). Other early views on language and culture were presented by Sapir and Whorf who used the term linguistic relativity to understand the relationship between thought and language (Kramsch, 2004). The Sapir-Whorf hypothesis follows that the mind is an empty container into which language is poured. Whorf (1956) describes that,

> a person’s thoughts are controlled by inexorable laws of pattern of which he is unconscious. These patterns are the unperceived intricate systematizations of his own language – shown readily enough by candid comparison and contrast with other languages…His thinking itself is in a language. (p. 252)

So while Chomsky viewed language as innate and simply needing to be activated in the child, Sapir and Whorf saw the mind as a blank slate ready to be shaped by the language inputted.

This notion that language conditions the mind, and therefore puts humans at the mercy of the language which they speak, has also been the source of many criticisms. For example, the conclusion that thought cannot exist without language falls short considering that humans themselves created language, not the other way around. Also, in an example related to SLD, bi- and multi-lingual speakers are not governed by independent ways of thinking as they switch between languages (Kramsch, 2008). The speakers offer their own ways of creating meaning through hybrid understandings between the affordances of the different languages they speak.
Although criticized for its extreme yet vague assertions, the Sapir-Whorfian hypothesis was one of the first to present an alternative to the Cartesian type of worldviews thought of as universal in nature. This budding perspective of language and thought has been adapted into more modern conceptions of the relationship and is still generally accepted in weak forms.

As mentioned in the previous section, sociocultural views, also known as sociocultural theory (SCT), consider language development as occurring at the intersection of culture, context, and also the individual’s own meaning-making behaviors. SCT both refutes traditional cognitivist thinking and the Sapir-Whorf hypothesis. SCT instead affords the possibility of the individual to affect the language, not just the language affecting the individual. This worldview of dialectical materialism serves as a general psychological theory to explain higher order forms of cognition (Lantolf, 2006).

Following the works of L. S. Vygotsky (1896-1934), SCT has produced a rich and diverse body of literature expanding the views of language development beyond traditional perspectives, especially as it pertains to the embodied nature of language and communication. A gap that still exists in the literature though, is the extent to which SCT has been able to address other elements of embodiment in language development and communication. The methods available within the SCT framework are limited to primarily qualitative descriptions and analyses. However, another research approach complementary in perspective to SCT called complex dynamical systems (CDS) theory provides quantitative methodology solutions. Within the CDS framework, several tools are available for the measurement of learning, development, and human interaction as non-linear and embodied behaviors. Importantly, this includes the ability to measure movement as an embodied aspect of development.
Together, these forms of analysis provide a comprehensive methodological toolkit to study language development with a focus on embodied actions performed in context-rich environments. The purpose of this study is to explore the role of movement in SLD by using a combination of traditional SCT methods and a dynamical modeling technique called cross-recurrence quantification analysis. SLD is observed in the context of a writing consultation between a second language English learner and a native English speaker.

**Research Questions**

Two central research questions guide this dissertation. The research questions are:

1. What synchronous movement patterns emerge during dyadic interaction between a non-native English-speaking student and an ESL trained writing tutor?
2. How do embodied aspects of interaction, as determined through analysis of movement, relate to second language development?

To answer these research questions, a convergent mixed methods research design with a microgenetic approach to development will address different aspects of movement within the study to answer different specific questions about the embodied nature of development. The different aspects of movement analyzed are considered representations of *embodiment*, or *embodied learning*, in which bodily movement and the interaction of the body with the environment are integral aspects of cognitive development (Fischer & Zwaan, 2008; Gallagher, 2005; Shapiro, 2011). For research question (RQ) 1, a quantitative dynamical modeling technique will be used to measure the amount of interactional synchrony the two interlocutors are engaged in via the degree of bodily movement change. For RQ 2, qualitative analysis of movement (including gesture and co-speech gesture) will be used to identify how movement contributes to SLD. The combined analysis will allow for qualitative and quantitative data.
sources to be compared as they relate to each RQ to produce a more complete account of the results as a whole (Creswell & Plano Clark, 2011).

Lastly, the microgenetic approach provides a process-driven account of development by focusing on understanding the nature of development as it is unfolding in real-time and within a natural context (Kuhn, 1995; Siegler & Crowley, 1991).
Chapter 2: Literature Review

Second Language Development Research

A Brief History

The study of second language learning has existed as a research topic for just under a century. Second language learning and its educational applications are central tenets of the field of applied linguistics research, a field which has been traditionally encompassed under the umbrella of linguistics research (Tarone, 2015). The study of language was originally called to be a study of science, and given the timing (1925), the study of language assumed a behaviorist theoretical standpoint. Following Skinner’s behaviorism, learning presents itself as the formation of habits through conditioned responses to presented stimuli. Skinner’s publication of Verbal Behavior (1957) and his theory of operant conditioning were met with scathing opposition from Chomsky (1959) who in turn provided his own distinct view of language learning (as cited in Larsen-Freeman, 2007). Chomsky argued that language learning is a systematic and innate process triggered by the presence of an internal mechanism called universal grammar (UG) and is therefore not a product of exposure. His distinction between competence, our ‘true’ language knowledge, and performance, the knowledge expressed through utterances, has had widespread implications for the systematic study of language.

However, based on assumptions of the competence-performance distinction, the ‘reality’ of one’s language knowledge exists as a mental representation fundamentally separated from the experience of observing knowledge from use. Atkinson (2011) has identified the underlying principles of competence-performance as a guiding force to the direction of applied linguistics research for over half a century in addition to Chomsky’s support of representationalist and reductionist viewpoints towards cognition and cognitive processes.
Traditional Cognitive Science

The predominant influence of Chomskian nativism birthed the cognitive revolution for applied linguistics and still holds court for many researchers today. Chomsky credits the works of French philosopher René Descartes (1596-1650) as influential to his theories, as do many others for the impact of Cartesian philosophy on modern cognitivist traditions (Samuels et al., 2012). Cognitive science is rooted in the tradition of the mind-as-computer metaphor, or what has been called the mechanistic assumption. “According to this very widely held view, the mind is indeed a mechanism of some sort – roughly speaking, a physical device decomposable into functionally specifiable parts” (Samuels et al., 2012, p. 10). A mechanistic view of the mind is a direct reflection of classic Cartesian mind-body dualism. For Descartes, and the traditional cognitive scientist, the body and mind exist as separate entities whereby the inner workings of the mind function as exclusively detached from the physical body and world. The mechanistic mind does, however, still adhere to the rules of reductionism inherent to the physical world.

Overton (2014) explains the Cartesian worldview and the reductionist stance through the principles of splitting, foundationalism, and atomism. Splitting is the act by which reductionism occurs. The ‘whole’ of a system is understood by splitting the system down to its individual parts until a foundational ‘rock bottom’ has been reached. At this foundational base, the purest forms of the elements, the atoms, exist. It is within these atoms that the ‘reality’ of the inner workings of the world resides, and with it, the truth of the inner workings of the physical world (Overton, 2014).
Second Language Research Today

While cognitive psychology prevailed as the mainstream influence for applied linguistics throughout the remainder of the twentieth century and into the first decades of the twenty-first century, alternative approaches were also being explored. The individual/cognitive approach has been countered by social/contextual theories of development rooted in the roles of cultural impact (Lantolf, 2000), emergentism (Larsen-Freeman, 1997), and historicity (van Lier, 2000) on the developmental process. Firth and Wagner’s (1997) argument for a reconceptualization of the second language development (SLD) field was perhaps a tipping point for drawing adequate attention to the social and contextual origins of language (Larsen-Freeman, 2007). Firth and Wagner (1997) argue that the predominantly held “individualistic and mechanistic” views of SLD have “resulted in a skewed perspective on discourse and communication, which conceives of the foreign language speaker as a deficient communicator struggling to overcome and underdeveloped L2 competence, striving to reach the ‘target’ competence of an idealized native speaker” (p. 285). As this quote entails, their critical assessment of L2 research extended beyond simply calling for a greater representation of social views of language development, but also included specific challenges to well-established concepts such as nonnative speaker (NNS), learner, and interlanguage (Larsen-Freeman, 2007).

Traditional cognitive views focus on the NNS as continually struggling from deficiency, with their successful development measured only in comparison to a native speakers’ (NS) ability. By drawing a more emically based perspective to the learner as a negotiator in their language development, able to be aided by their own resources (versus ‘handicaps’), social views

---

1Though the term acquisition is more commonly used than development, I am using the term development (per Larsen-Freeman, 2011) to account for the fact that language skills do not achieve a final state, but rather continually adapt throughout the lifespan.
of SLD provide a fundamentally different perspective. For the purposes of this dissertation, three separate, but related theories which take a social/contextual view will frame the nature of inquiry for the study. First, the sociocultural perspective based on the works of Lev Vygotsky (1896-1934) provides a coherent understanding of the social nature of learning and development based on the concepts of mediation and internalization (Lantolf, 2000). Next, complex dynamical systems theory (CDS) takes an emergentist approach, focused on the non-linear, self-organizing behaviors inherent to the learner as a complex system (Thelen & Smith, 1994; van Geert, 1998). Finally, an ecolinguistics perspective relies on contextual and historical underpinnings to any human interaction (van Lier, 2000; 2004). The following sections will provide a detailed review of each theory with discussion of research applications in SLD.

Sociocultural Theory

Introduction

Vygotsky’s theory of human development, coined sociocultural theory by contemporary researchers (Wertsch, 1985), posits that higher order human mental functioning is social in origin. Social interactions are mediated by the appropriation of cultural artifacts, both physical and symbolic. These interactions are a negotiated process by which learner assigns meaning to cultural artifacts and subsequently internalizes this sense of meaning. Thus, the concepts of mediation and internalization are central to the understanding of development through the SCT lens. Additionally the zone of proximal development (ZPD) serves as a model for understanding the conditions for learning activities to lead development through interactions (Vygotsky, 1978).

Although much of Vygotsky’s work focused on the general development of the child, his theory has been extended for use through hundreds of works in SLD over the past thirty years or so (Lantolf & Beckett, 2009). Vygotsky’s constructs of mediation, internalization, and ZPD
have been used to explore topics such as feedback, collaboration, non-verbal aspects of language, reading and recall, problem solving, learner strategies, and others. This review will focus on SCT-L2 research examples related to the topics of mediation, internalization, and collaboration in the ZPD that address SLD for adult learners. SCT also has instructional implications that will be included where relevant to understanding the interactive student-tutor task studied in this dissertation.

**Mediation and Internalization**

Human culture produces artifacts which as physical or symbolic tools and signs that provide the basis for productivity and communication within a given culture. Physical tools I interact with daily such as a computer, a car, a lightbulb and a yoga mat are only considered meaningful or necessary to me because I have been acculturated to their functions. Often, an understanding of how to use a cultural tool becomes mediated through a demonstration from a competent other. If children receive a toy phone, they will immediately know to raise the phone to their ear and start talking because they have watched their parents talk on the phone. Meaning can also be created through individual interaction with an artifact. In the movie *The little mermaid*, Ariel the mermaid recovers artifacts from human shipwrecks and consults her friend Skuttle the seagull about their possible functions. One object Ariel recovers is a fork. Although he has never encountered a fork either, Skuttle confidently assigns it the name ‘dinglehopper’ and decides Ariel should use it to comb her hair. In absence of cultural appropriation, Skuttle has negotiated his own meaning and assigned the ‘dinglehopper’ a symbolic title and physical function.

A main interest of Vygotsky was uncovering how it is that words (as symbols) come to have meaning. How can it be explained, from a Vygotskian perspective, that Ariel would be able
to internalize ‘dinglehopper’ as a meaningful symbol attached to the object? Consider what Wertsch (2007) describes as implicit mediation. “Implicit mediation involves signs, especially natural language, whose primary function is communication, that are part of a pre-existing, independent stream of communicative action that becomes integrated with other forms of goal directed behavior” (Daniels, 2008, p. 6). It is observed that Ariel takes the artifact and concurrently pairs an understanding of 1) the goal directed action of hair brushing with, 2) a symbolic naming of the object to her activity of meaning making. This implies that there are both embodied and semiotic components to the meaning making process. While embodiment will be attended to in greater detail in upcoming sections (see Embodied Cognition), Vygotsky was most compelled by the role of language and the dialectical relationship between language and thought (Daniels, 2008). Tie this then back to Skuttle and his ability to assign a new name to the artifact (and also granting Skuttle temporary human status). The language that humans use has developed cultural meaning through its negotiated use by others over time. Our internalization of language as a cultural artifact is what capacitates the formation of individual thoughts. As individuals equipped with language, we perpetuate the cycle of the language/thought and individual/cultural dialectical influences (Bahktin, 1981). Skuttle used his mastery of the language system to continue its evolution with his own naming delegation to solve the fork/dinglehopper problem. Unfortunately for Skuttle, the meaning started and ended with him and Ariel.

The second type of mediation, explicit mediation, includes the incorporation of signs into human action for purposes of reorganizing that action (Daniels, 2008; Wertsch, 2007). For example, tying a string around one’s finger as a reminder to buy milk at the store or memorizing the mnemonic ‘please excuse my dear Aunt Sally’ for the ordering of mathematical operations...
are examples of explicit mediation. In his older works, Vygotsky (1978) argued that through the mastery of external symbolic or psychological tools, humans could in turn control behavior from the outside. Daniels (2008) addresses the two critical issues this argument brings to the foreground. First, it assigns the individual active agency in his/her own development. Second, it asserts that the sociocultural context and presence of cultural tools available to the individual during development will affect the individual’s development. “He [Vygotsky] distinguished between psychological and other tools and suggested that psychological tools can be used to direct the mind and behavior. In contrast, technical tools are used to bring about change in other objects” (Daniels, 2008, p. 10). Language, as a psychological tool, has the potential for a profound impact on mind and behavior.

**Zone of Proximal Development**

The concepts of mediation and internalization are perhaps best conceptualized by the ZPD model. As defined by Vygotsky (1978) the ZPD is “the distance between the actual development as determined by independent problem solving and the level of potential development through problem solving under adult guidance or in collaboration with more capable peers” (p. 86). Although only referred to in brief towards the end of his life, Vygotsky discussed the ZPD in terms of assessment and instruction (Daniels, 2008). He was interested in assessing a learner’s progress and it appears his intent was to utilize the ZPD as a measure of developmental progress. Chaiklin (2003) outlines three basic assumptions of the ZPD: generality, assistance, and potential. Generality denotes that the ZPD applies across cultures and subject matter to be applied to any activity where learning takes place. Assistance is central to the learning/development process because assisted performance “helps conceptualize the difference between the level of actual performance and the learning potential of the child”
The ZPD indicates where the child’s learning zone is, and by offering the child adequate learning activities, development can then flourish. Third, the potential indicates what level the child is capable of progressing to next.

The ZPD persists Vygotsky’s central claim that learning leads development and is amenable to microgenetic approaches to understanding the developmental process (Daniels, 2008). The ZPD also considers the whole child as an active agent engaged in social relations with others to negotiate their own learning and developmental progress. It should be clarified that the assistance provided in the ZPD does not require an expert/novice relationship between the learner and the assistant, but by any capable ‘supportive other’ (Vygotsky, 1978). Lastly, the scope of the ZPD serves two purposes: indicating transition from one developmental level to another, and the functions needed for that transition (Chaiklin, 2003).

**Perezhivanie**

In the final years of his life, Vygotsky focused his research on understanding sense-making as an outcome of sign-mediated operations. He turned to the Russian concept of Perezhivanie to incorporate the role of emotional memory in sense-making activity (Dafermos, 2018). As a result of both Vygotsky’s untimely death as well as translational challenges, the meaning of Perezhivanie has been subjected to multiple interpretations (González Rey, 2016). According to recent literature, Perezhivanie may be best understood in terms of living though an experience, so long as that experience entails an ‘overcoming’ of some boundary. The ‘overcoming’ aspect emphasizes the dialectical relationship between the individual and the event (Blunden, 2016). An event does not merely happen to an individual, rather the impact of the event is influenced by the eco-social environment and one’s emotional commitment to the event. In other words, “Perezhivanie as a unit of analysis emerged as an attempt to overcome the
subjectivist-objectivist gap and develop a dialectical understanding of the changing interrelation between social environment and personality” (Dafermos, 2018, p. 185).

To study sense/meaning-making as a subjective activity, Perezhivanie offers a lens through which emotions, as intellect, can be examined. This subjectivity occurs at two levels: the social and the individual (González Rey, 2016). An individual’s situated personal history affects their appropriation of present social interactions, in that the outcome of the Perezhivanie is an emergent property of the individual’s personality and the aid of other actors present during the experience/activity (Blunden, 2016). Within the ZPD, the Perezhivanie is critical to the transformative potential of the developmental event (Mahn & John-Steiner, 2002). Through Perezhivanie, the emotional senses present during human experiences become incorporated with other senses in the individual’s self-organizing internalization process (González Rey, 2016). Once the individual overcomes their experience, they will inhabit a new space emotionally and psychologically.

Second Language Development Research from a Sociocultural Perspective

Early Studies

Early SCT-L2 studies paved new ground for understanding L2 development as a mediated process. Aljaafreh and Lantolf (1994) studied corrective feedback negotiated between an L2 learner of English and a tutor discussing written text. Findings indicated that development is an uneven process dependent upon the type of mediation occurring between the dyad. Feedback can be delivered effectively in both explicit and implicit forms with different levels of effectiveness depending on the location of the learner’s ZPD. Additionally, the learner may have different ZPD locations for different features of language development. A follow-up study confirmed that ideally, feedback should transition from explicit, or direct, forms to increasingly
more implicit, strategic forms of feedback to challenge the learner higher in their ZPD (Lantolf & Aljaafreh, 1995). Failure to guide the learner through their ZPD resulted in a regression from the progress made from one tutoring session to the next. For example, a tutor who retained focus on explicit feedback, such as constructing the proper structure for the leaner rather than with her, did not allow the leaner to practice autonomy in the task. The explicit forms of feedback are less of a negotiation and more of a one-sided guidance - conditions not ideal for movement up the ZPD.

Swain and Lapkin (1998) studied the interaction of two adolescent French immersion students working together to solve a puzzle task arranging pictures into a logical story sequence. The authors focused on two main aspects of the function of dialogue in the task: first, dialogue as an enactment of mental processes, and second as an occasion for L2 learning. From an SCT standpoint, the authors describe how language as a mediating tool facilitates performance between the task presented and the accomplishment of the task. They state, “language becomes a mediating tool by its first having been used by others in order to regulate behavior, including cognitive behavior” (Swain & Lapkin, 1998, p. 321). Language as a mediating tool was measured through language-related episodes (LREs) which are defined as “any part of dialogue where the students talk about the language they are producing, question their language use, or correct themselves or others” (Swain & Lapkin, 1998, p. 321).

For example, the two students in the study, Kim and Rick, demonstrated an LRE while negotiating morpho-phonological rules for the word ‘sonnement.’ This word does not actually exist in French, however the students successfully used their understanding of feminine and masculine article assignment to apply the rule in a new context. The LREs observed during the interaction followed sequences where the students generated and assessed alternatives, then
applied the emergent knowledge to solve a linguistic problem. This process was one of co-construction, whereby both students contributed to the construction of the language and expression of meaning to develop their storyline. The authors concluded that “learning does not happen outside performance; it occurs in performance” (Swain & Lapkin, 1998, p. 321), supporting their claims about language in use as a cognitive tool.

Other early SCT-L2 studies explored topics such as ability to mediate thinking using the first language (L1) (Pavlenko, 1997), learner strategies mediated by private speech (Donato & McCormick, 1994), non-verbal accounts of mediation (McCafferty, 1998), and text recall comparisons between NS and NNSs (Appel & Lantolf, 1994). These studies spawned a wide scope of inquiry to support the growing interest in SCT-based accounts of L2 learning and development. The remainder of this SCT-L2 review will focus on the topics of collaboration in oral and written tasks, learner-learner versus learner-native speaker interactions, and non-verbal dimensions of L2 mediation.

**Collaborative Mediation**

In a follow-up study to Swain and Lapkin (1998), Watanabe and Swain (2007) further investigated the role of collaborative dialogue between pairs of learners of different proficiency levels. The learners were assigned as high-proficiency or low-proficiency and paired with either a learner of the same classified proficiency level or in a mismatched pair. The pairs were involved in a three-stage task that included pair writing, pair comparison, and individual writing. The pair writing served as a pre-test, while the individual writing task served as a post-test to assess individual development. The researchers used LREs as a unit of analysis for what they called *collaborative dialogue* tasks. Collaborative dialogue refers specifically to dialogue used for problem-solving and knowledge building tasks (Swain & Lapkin, 1998).
The findings demonstrated first that the high-proficiency pairs produced more LREs than the low-proficiency pairs, however the general orientation of the learners had a greater effect on the frequency of production of LREs. Learners who engaged with a collaborative orientation were more successful at producing LREs. The findings also demonstrated that high-proficiency participants paired in a mismatched core performed better on their individual writing post-test than with their own level partner. This demonstrated the learning benefits of being paired with a learner of different proficiency level. The authors stressed that the findings I first described were of the greatest impact, suggesting that a collaborative pattern of interaction is more important on the production of LREs rather than the proficiency differences between the pair.

To explore how mediated collaboration of L2 writing functions within the ZPD, Mirzaei and Eslami (2015) studied L2 learners working together to achieve common writing goals. The collaborative groups consisted of a high-proficiency learner, a low-proficiency learner, and a tutor engaged in one of four instructional conditions: ZPD-activated collaborative, ZPD-free collaborative, fine-tuned L2-input provision, and a prevalent teacher fronted approach. The study specifically focused on the negotiation and scaffolding of metadiscourse within the interactions and its role in addressing the content, organization, and audience issues evolving in the written text. Scaffolding, per Wood, Bruner, and Ross (1976), can be achieved through different techniques, but is typically understood as acts of assisted performance between a novice and an expert (Knouzi, Swain, Lapkin, & Brooks, 2010; Weissberg, 2006). “Traditional definitions of scaffolding postulate that these forms of assistance are gradually appropriated or internalized by the novice until s/he no longer needs expert assistance” (Knouzi et al., 2010, p. 25). Though the term scaffolding has been criticized for placing too much emphasis on the structuring role of the expert (Mascolo, 2005), the conditions of scaffolding introduced by Wells
Scaffolding consists of three conditions: 1) it refers to a conversation involving one participant who is more expert than the others, 2) it is applied to situations where the primary objective is to teach someone something, and 3) it is carried out with the expert participant’s intention of making the novice participant self-sufficient in managing the task at hand (as cited in Weissberg, 2006, p. 248-9).

In Mirzaei and Eslami (2015), the ZPD-activated collaborative writing condition was found to significantly facilitate the learners’ appropriate use of metadiscourse. In this condition, the learners engaged more actively with the linking functions of the metadiscourse resources to the ideas about meaning making they would need for composing individual texts later on. “Therefore they grew progressively more goal-oriented in their use of the resources available to transform their essays into more coherent and user-friendly texts” (Mirzaei & Eslami, 2015, p. 18). This demonstrates that the scaffolding task, which began with full-other regulation positioning low in the ZPD, was successful in gradually progressing the learners to more self-regulated learning over time. The opportunity for cognitive engagement and knowledge building over time was able to become more collaborative and allowed for more self-initiating repair moves over time in the ZPD-activated collaborative writing condition over other collaborative approaches. Therefore, it is not simply the effect of collaboration itself which facilitates learning, but ZPD-activated strategic collaboration that fosters development.

**Learner-Learner versus Learner-Native Speaker Interactions**

In addition to understanding how L2 learners of differing proficiency levels can successfully mediate language development within their dyad, other recent studies have compared the interactions of L2 learner-learner and L2 learner-NS dyads. A study by Dobao
(2012) compared such interactions. This study investigated how the presence of an NS interlocutor affected the frequency and nature of lexical LREs spontaneously generated during task-based interaction. Findings indicated that the lexical LREs occurred more frequently and were more likely to be resolved in the learner-NS interactions versus the learner-learner interactions. This was attributed to the NS’s ability to provide the lexical knowledge needed to produce more frequent assistance. Although no pedagogical interventions were presented in this study, the interactions of both learner-learner and learner-NS both resulted in meaning-oriented LREs. As noted in previous studies (Mirzaei & Eslami, 2015; Watanabe & Swain, 2007) the more collaborative the learner approached the task, the more successful the engagement. Thus, supporting the finding that it is not so much who the learner is engaged with (i.e. expert, lower-proficiency L2 learner, higher-proficiency L2 learner), but rather what the learner’s attitude is regarding the task.

Tociamaza-Hatch (2016) suggests that during interactions between learners and NSs, it is the learner orientation that sets the tone for the interaction, followed by a mirroring from the NS partner. If the learner demonstrated willingness to engage, and the NS followed-up with inclusive exchanges that did not reduce or simplify the task in ways to limit the potential learning, more successful interactions would ensue. Having the ability to engage with NSs increases the number of linguistic affordances within the L2 learner’s immediate environment and allows them more exposure to linguistic affordances (Hoshi, 2015). Introducing a greater variety of affordances then allows the learners to transfer these new resources to future conversations with their peers. Though this study only considered a limited view of the factors that help an L2 learner progress through their ZPD, it does provide evidence that, under the right conditions, interactions with NSs assists the L2 learner’s development.
Non-verbal Mediation

Another key aspect of SLD supported by an SCT research perspective involves inquiry into the role of non-verbal contributions to communication and cognition. An embodied approach to understanding L2 (and L1) development is supported by Vygotsky’s observations of how children use gesture, writing, and drawing as incorporated activities in their development (Negueruela, Lantolf, Jordan, & Gelabert, 2004). Vygotsky paid particular attention to the role of gesture in children’s play activities, describing play as reliant on the function of symbolic understanding. He states, “children’s symbolic play can be understood as a very complex system of “speech” through gestures that communicate and indicate the meaning of playthings. It is only on the basis of these indicatory gestures that playthings themselves gradually acquire meaning” (Vygotsky, 1978, p. 108). For example, a child given a cardboard box might transform the box into a racecar, a spaceship or a house. The actions taken to ascribe symbolism to the box are what create new meaning for the object.

Another term associated with embodied action in language development is mimesis. Mimesis entails that the body is an expressive device, and it has been suggested that mimesis played a role in evolutionary language development and the emergence of consciousness (Donald, 2001). Mimesis plays two prominent roles in SLD (McCafferty, 2008). First, discursively as a mediator of meaning-making for themselves and their interlocutors. Second, for purposes of identity in the tribal sense. By inhabiting certain gestures, the L2 speaker steps into the role of not just speaking the language but inhabiting the languaculture represented by the language (Peltier & McCafferty, 2010).

Defining gesture. In language research, gestures are considered as the naturally produced movements of the hands and arms in conjunction with speech. For Kendon (2000), “roughly
speaking” a gesture “refers to that range of visible bodily actions that are, more or less, generally regarded as part of a person’s willing expression” (p. 49).

Gestures are influenced by a range of social, psychological, contextual, and cultural factors (Gullberg, 2010). In comparison to understanding how gesture is involved with the L1 development, learning gestures in the L2 has some similar and some unique contributions. In both cases, the role of gesture can be considered from one of three perspectives (Gullberg, de Bot, & Volterra, 2008). When considered as a medium of language development, several options have been explored, including using gestures to enhance the learning of mathematics concepts (Goldin-Meadow, Cook, & Mitchell, 2009) or to lighten cognitive load in learning (Goldin-Meadow, Nusbaum, Kelly, & Wagner, 2001). Gestures may also be seen as a reflection of language development, or similarly as language development itself. Especially in the L2, as language develops, changes in gesture can as well (Peltier & McCafferty, 2010; Stam, 2015).

Gestures can be characterized as having different structural, semiotic, and functional terms (Gullberg, 2010). Structurally, gestures can appear in the form of different shapes and sizes, placed in different locations within the ‘gesture box,’ i.e. the physical space around the speaker where their gestures are typically confined to. Gestures occur in qualitatively different movement phases such as a preparation, stroke, hold, and recovery (Kita, Gijn, & Hulst, 1998). Semiotic classifications, meaning the names typically attached to gesture types, include iconic, metaphoric, deictic, beats, and emblems (McNeill, 1992).

1. Iconic gestures represent an action or object referred to in speech.

2. A metaphoric gesture is a special type of iconic gesture representing an abstract concept.

3. Deictic gestures are pointing gestures referring to real or abstract spaces.
4. Beats are quick movements serving multiple purposes such as adding emphasis, introducing new topics, or accompanying corrections in speech.

5. Emblems are culturally determined gestures, such as a ‘thumbs up’ and are not typically considered to play the same type of role in comparison to the others.

For the purposes of understanding spontaneous gestures, consider the following: “speech-associated gestures are the least language-like of all movements in their lack of convention, but they are, perhaps paradoxically, the most systematically related to language and speech” (Gullberg, 2006, p. 106). The co-speech gestures which researchers are concerned with are not deliberately placed but are a naturally produced output with speech.

Gestures are co-expressive in that the two channels, speech and gesture, serve to communicate the same underlying idea unit, but may not necessarily express the same identical aspects of it (McNeill & Duncan, 2000). Whether gesture serves a primary or auxiliary role with speech is not a settled argument. Theories such as the lexical retrieval hypothesis propose that gesture is responsible for generating surface forms of utterances, such as with iconic gestures (Butterworth & Hadar, 1989). Alternatively, but also aligned with the idea that gesture and speech serve connected yet separate purposes, is the information packaging hypothesis (IPH) (Alibali, Kita, & Young, 2000). In this case, the gesture helps with the conceptual planning of thought and allows speakers to ‘package’ spatial information into unit spoken units. The IPH agrees that gesture is involved with the thinking process of speech, or as McNeill (1992) says, “gestures help constitute thought” (p. 245). However, McNeill sees the role of gesture somewhat differently, arguing that gesture and speech serve the same indivisible role. For example, (Kita et al., 2007) found speech and gesture to be part of the same ‘online processing’ acts during the conceptual planning phase for speaking. This dissertation will take embodiment in the
Vygotskian sense and apply it to the understanding of the embodied aspects in SLD and dyadic interactions. SCT theorists who rely on embodied approaches do so to account for the fact that “people live a material existence as embodied beings and that materiality thus becomes a part of our cognitive architecture” (McCafferty, 2008, p. 160).

The role of nonverbal expression in SLD appeared in early SCT-L2 studies (McCafferty, 1998; Stam, 2001) and has covered a range of topics related mostly to the role of gesture in SLD and classroom research (McCafferty & Stam, 2008). In language research, gestures are the naturally produced movements of the hands and arms in conjunction with speech. McNeill (2005) describes gestures as “the spontaneous, unwitting, and regular accompaniments of speech that we see in our moving fingers, hands, and arms” (p. 3). Gestures play an integral role in the thought/speech dialectic are typically characterized for analytical purposes along a continuum to differentiate between gesture types that express different meanings (Kendon, 2000).

**Learner self-regulation.** Sociocultural perspectives on gesture in SLD have studied gesture as it applies to intra- and interpersonal thought and communication. For the L2 learner, gesture was found to play a self-regulatory role during **private speech** acts for a learner engaged in a recall and picture narration tasks (McCafferty, 1998). Private speech refers to verbalized speech in the form of self-talk that functions as a metacognitive regulator assisting in the planning, execution and monitoring of an activity. In this study, gestures coupled with private speech to ‘illuminate’ the speech they accompanied while gestures also occurred in the absence of verbalizations implying other connections to the self-regulatory processes of language production (McCafferty, 1998).

Gestures can be thought of as creating a ‘space for cognition,’ acting as a physical space in which the learner can self-organize and mediate their L2 learning (McCafferty, 2004).
McCafferty (2004) found that an L2 speaker used deictic gestures in discourse as a way to both construct his ideas in space and to elicit lexical assistance from the native speaker. His use of an abstract deictic gesture with the word ‘transport,’ as in to transport ideas from China to another country, followed a trajectory from a space in the gesture box already represented as being China. The native speaker on the other hand used gestures to aid in the L2 speaker’s comprehension. For example, he placed his hand on his heart when he used the word ‘jealous’ to indicate a more universalized understanding attached to the word. Speaking in an L2 or engaging in a conversation with an L2 speaker serves both intra- and interpersonal purposes.

The use of gesture and space offer a coupled system which can self-organize and mediate the L2 learning. Eventually, this leads to what Vygotsky (1986) calls internalization: the process by which the significance of the actions in the interpsychic plane take meaning in the intrapsychic plane (McCafferty, 2004; McNeill, 2005).

This dual space of thinking and speaking form the dialectical relationship between speech and gesture. The Vygotskian dialectic contains 1) a conflict or opposition of some kind and 2) resolution of the conflict through change (McNeill, 2005, p. 92). Speech and gesture create the imagery-language dialectic, a physical space for the process of language to occur. It is what Merlau-Ponty would describe as inhabiting the language. Gesture does not represent meaning, but is itself an inhabitant of the meaning, it is a visible manifestation of thought (McNeill, 2005). McNeill (2005) has proposed the term growth point to represent the minimal unit of the imagery-language dialectic. It is, in the Vygotskian sense, the smallest unit which can still be considered a whole, where parts are determined by wholes and are irreducible to singular meanings in either speech or gesture. The growth point is the mediating link of language and thought where mutual influences from speech and gesture unfold in real time (McNeill & Duncan, 2000).
**Discursive functions.** Real time speaking activities present different types of challenges to speakers of different proficiency levels for managing lexical, grammatical and discourse related problems (Gullberg et al., 2008). It has been observed that L2 speakers produce more gestures in their L2 than in their L1 (Gullberg, 1998) for, likely, a variety of reasons. Problem-solving efforts for managing the multiple demands of real time speaking activities have been observed through changes in gestural patterns over the course of development. Less proficient learners of French use more representational gestures linked directly to speech, while more advanced learners incorporate more emphatic or rhythmically related gestures to speech (Gullberg et al., 2008). Also, gestures are used for mapping conversational elements in space. While McCafferty (2004) found spatio-motoric mapping for physical locations, Gullberg (1999) found spatio-temporal mapping to establish time in the absence of verbal ability to do so.

Gestural rephrasing and the formation of revisited gesture patterns capture unique moments for learning and negotiating meanings across conversations and classrooms (Matsumoto & Dobs, 2017; Smotrova & Lantolf, 2013; Tabensky, 2001). Tabensky (2001) observed gestural rephrasing in the forms of echoing and reformulation. Gestural echoing, or direct mirroring of gestures produced by each speaker, occurred more frequently in the initial conversational exchanges. These echoes likely served to open up the conversation to establish comfort and rhythm. Gestural reformulation, a new interpretation of a gesture conveying the same meaning as the original gesture producer, aided in understanding. For example, a speaker paired the term “that is to say” followed by a gesture rephrasing and verbal meaning interpretation (Tabensky, 2001). A catchment is a gestural feature in the form of a growth point which becomes reiterated by multiple speakers (McNeill, 1992; 2005). For example, a student in a Russian language classroom produced a forward reaching motion (catchment 1) while
negotiating contextual meaning for the phrase “to look outward,” to which the teacher responded with two mirrored circular motions of each hand (catchment 2) (Smotrova & Lantolf, 2013). The student’s interpretation of “looking outward” as a symbol of “looking forward” was corrected gesturally by the teacher responding with a gesture representing “looking to outer sources.” Next, the teacher refined the gesture to mean “small businesses” as the particular “outer sources” (catchment 3). Therefore, the meaning of the phrase in context became understood through the gestural catchment scaffolding. Catchments are then picked up by the students in their own conversations and add a level of clarification to their own attempts to describe the contextual meaning. Catchments provide moments of development on a microgenetic timescale which may aid in the internalization process and follow to ontogenetic levels of development as well (Matsumoto & Dobs, 2017).

**ZPD.** The role of gesture within the ZPD was investigated by McCafferty (2002). A previous study had confirmed that L2 learning in naturalistic contexts involves both linguistic and nonlinguistic features (McCafferty & Ahmed, 2000). This study of an English L2 (ESL) learner in a university setting focused on the meaning making capacity of gestures within the ZPD. The interactions of a native English-speaker with the ESL student were recorded over a span of eight months. During this time, four functions of gesture in relation to the ZPD were identified. First, gesture played a facilitative role in the self-regulatory processes for the ESL student, helping him transform his identity in relation to his ability to communicate effectively in the L2. Second, the co-construction of the discursive tendencies between the dyad demonstrated the role of negotiation in the interaction. As Lantolf and Aljaafreh (1995) described, determining the learner’s ZPD is an act of negotiation. A process of discovery is needed to find where the interaction ‘works’ for the expert/learner pairing. Third, the negotiated gestures played a
transformative role in how they were utilized to traverse the learner across his ZPD. In some instances, a gesture that may have started as an explicit teaching tool to elicit vocabulary spawned other forms of utilizing gesture to serve a variety of functions. Lastly, the gestures helped create intersubjectivity, which is understood as the shared social reality that exists for the pair. Combined, these four findings highlight the role of gesture within the ZPD.

An additional consideration is to think about the role of gesture within the scope of mimetic qualities of communication. An underlying property of mimesis, which we will extend here to include gesture, is the ability to imitate (McCafferty & Stam, 2008). Imitation, in the Vygotskian sense, takes on a special meaning. We can only imitate that which lies in our ZPD, that is, we can imitate something we have the capacity for understanding but haven’t reached independently yet. Imitation, then, is based on its transformative potential (Lantolf, 2005). Therefore, gestures are an effective channel for imitation within the ZPD. Through gesture, the learner embodies aspects of language that can then be internalized to construct meaning for the learner as they develop their new language.

**Complex Dynamical Systems**

To think in systems is to think in interactions. These interactions occur between agents and elements of the system on various levels, across multiple timescales, and with varying degrees of complexity. A system is defined generally as “any collection of phenomena, components, variables” (van Geert, 2003). A collection, then, becomes a system through the consideration of relationships between the components and variables. A number of distinct methodologies exist under the metatheoretical umbrella of general systems theory (GST) which was pioneered by twentieth century biologist Ludwig von Bertalanffy (Byrne & Callaghan, 2014). In describing the major aims of GST, Bertalanffy emphasized the importance of the
theory to provide integration and unification among all fields of science ranging from the natural to the social. In contrast to reductionism, he called his approach *perspectivism*, stating: “we cannot reduce the biological, behavioral, and social levels to the lowest level, that of constructs and the laws of physics,” (von Bertalanffy, 1968, p. 49). He believed that each level, or perspective, produced its own unique constructs which could be organized within and across other levels/perspectives. These perspectives could then be integrated between the natural and social sciences, centered within a general theory of systems.

Specifically, complex and dynamical systems theories have been used, as Bertalanffy intended, across many fields and disciplines in the physical sciences including physics, biology, chemistry, and engineering (Strogatz, 2015), and the psychological and social sciences (Byrne & Callaghan, 2014; Molenaar, Lerner, & Newell, 2014). While field- and domain- specific methods are used for systems theories, a typically unified set of guiding principles directs the nature of the research. Pertinent to the present discussion are the principles discussed in the social and psychological sciences. To begin, a system is considered complex in that the system contains several (possibly unlimited) interacting components. The amalgamation of the individual components produces a whole which cannot be reduced back to its individual parts. As an update to the previous definition of a system by van Geert (2003), Overton (1975) extends the understanding of a system as a ‘collection’ to a more holistic view: a complex system is “a whole which functions as a whole by virtue of the interdependence of its parts” (p. 73). In social systems specifically, this is understood as the behavior of the whole of a society cannot be reduced to those of its individual members while the behavior of individuals is understood as acting within a larger context (Koopmans & Stamovlasis, 2016b).
A system is *dynamic* because it changes over time. System changes arise from internal forces and energy external to the system (Thelen & Smith, 1994). Dynamic systems are also referred to as *dynamical*, specifically when described as a set of mathematical equations used to model system change over time (van Geert, 1991; van Gelder & Port, 1995). Dynamic systems are continually changing. The *state* of the system is the temporary but coherent position of the system at any given time (Waninge et al., 2014). Finally, a current state of behavior exhibited by the system is understood in terms of deviations from past behavior (Koopmans & Stamovlasis, 2016b).

To take a CDS approach, then, positions the researcher to study “a system that has at least two or more key elements that are interlinked with each other but also change over time” (Waninge et al., 2014, p. 706). For the purposes of this dissertation, the term *dynamical* is used in reference to the mathematical analysis carried out on the data. Within this literature review, however, CDS will be used interchangeably with the terms complex systems and/or dynamic systems to retain the original wording present in reviewed articles. It is assumed that each term represents equal ideas.

**Metatheoretical Positioning**

The Cartesian worldview to which Bertalanffy was opposed asserts that the causal nature of the universe exists as purely mechanical system. Rene Decartes’ epistemological contributions to the mechanistic worldview consisted of three key themes for a theory of scientific knowing: Splitting, foundationalism, and atomism (Overton, 2014). Foundationalism argues that there exists a rock bottom, secure and fixed final state of reality. At this fixed and final base exists the atoms, or purest form elements which retain identity regardless of context. The process of splitting becomes that path to reality. Only by separating the components of the
whole down to its individual parts can one understand the purest forms of reality. Therefore, the “fundamental features of this world are split into dichotomous pure forms” (Overton, 2014, p. 24).

Modern cognitive science has based its principles in the mind-as-computer metaphor. Deriving directly from the Cartesian mechanistic worldview, mind-as-computer views cognition as a series of computational processes situated within the confines of the brain/mind. Thus, mainstream cognitive science preserves the dichotomies of mind/body, person/culture, environment/biology, etc. in the tradition of Decartes. Relational and contextual paths to development have no seat at the table of Decartes and the computational cognitivists. Themes of programs, structures and schemas are replaced by concepts of interaction, networks and connections (Thelen & Smith, 2006). The dialectical nature of a systems perspective argues against the dichotomies of the mechanistic view. Whereas for a Cartesian scientist, ‘A’ could never equal ‘not A,’ the relationist posits that ‘A’ and ‘not A’ are one and the same. We are 100% biology because we are 100% environment. This phenomenon of superposition is central to the systems principle that two seemingly incompatible properties can exist simultaneously (van Geert & Steenbeek, 2008). For the mechanist, a system would either be in a stable state or a changing state. Rather, for the relationist, the system remains stable because it is ever-changing.

The traditional representationalist view of cognition is framed through information processing theory. The theory holds that the brain is the driver of cognition, receiving initial sensory input, processing relevant sensory input through symbolic representations in the brain, and producing cognitive outputs. In this case, the mind acts as a computer, breaking down the inputs (the sensory information within modules responsible for independent symbol-processing tasks), and computing symbolic representations as outputs (van Gelder & Port, 1995). The
process is cyclical, one step follows the previous step until the cycle is complete at which point
the cycle begins again.

van Gelder and Port (1995) approach cognition differently. They begin by first
addressing the problem of time within computational models. “At the heart of the problem is
time. Cognitive processes and their context unfold continuously and simultaneously in real
time” (van Gelder & Port, 1995, p. 2). Within symbolic-state cyclical models, the stepwise
discrete process of cognition is a matter of making individual choices and outputting the
appropriate representation. As the choice-making decision increases in difficulty, the process is
said to increase in complexity, but in all, remains the same. Time is left entirely out of the
equation, with no data for actual human choices. The alternative is instead providing a model of
cognition which begins with the assumption of real time. The dynamical approach is one which
accounts for real time through mathematical modeling. Dynamical approaches conceive that
cognition is neither a computational, nor is the mind an independent source of cognition.
Cognition is a whole system, relying on contributions from the nervous system, body and
environment, mutually influencing change and coevolving over time (van Gelder & Port, 1995).

Behaviors of Complex Dynamical Systems

Emergence and self-organization. Central to the understanding of CDSs are the
inseparable concepts of emergence and self-organization. Emergence can be defined as a
“spontaneous coming into being of new, irreducible patterns or forms in a system as a result of
self-organizing interactions among the very components that comprise the system”
(Witherington, 2011, p. 67). The metamorphosis of the caterpillar to the butterfly exemplifies
emergence. From the cocoon, the caterpillar’s emergence as a butterfly cannot be attributed to
strictly additive, linear processes. The butterfly emerges as a qualitatively new entity, although
still the same creature from which it began; and the whole of the butterfly is surely greater than
the sum of a caterpillar with wings attached. The butterfly is instead a *radically novel* form of
the caterpillar (Goldstein, 1999). Given that complex systems exhibit *adaptability-seeking
behavior* the moment of self-organization within the system becomes triggered when the system
reaches a state beyond equilibrium. When the stability of the system is altered through
interactions internal to and external from the system, the equilibrium, or typical state, is
disturbed (Deboeck, 2013). To retain functionality, the system must self-organize and make a
*phase transition* into a qualitatively distinct new state with new conditions of equilibrium
(Thelen & Smith, 1998).

No single element of the system can claim causal priority in the behavior of self-
organization, nor does self-organization involve a centralized controller (Richardson & Chemero,
2014; Smith, 2005). Rather, pattern and order emerge from internal intervention and interactions
which arise suddenly with no apparent change in in the factors of the system (van Geert &
Steenbeek, 2008). Much like an ‘a-ha’ moment when a seemingly unsolvable problem is
suddenly able to be solved, the solution emerges from the system’s desire to solve the problem
and proper self-organization within.

As time progresses, the trajectory of the system follows developmental patterns through
cycles of emergence and self-organization. Each emergent cycle results in the system
experiencing a *phase transition* from a previous state to a qualitatively new state with a new
equilibrium needed to maintain system stability (Thelen & Smith, 1994). In this sense, the
systems are *time dependent* with each phase transition and subsequent system state resulting
from the nested, interactive nature of the system with other systems. Systems have a history and
each state of the system is dependent on the previous state. Additionally, once a system
transitions into a new state, the system cannot return to any prior state (Spencer, Perone, & Buss, 2011). The non-linearity of the system’s developmental trajectory reflects that the effects of the interactive forces on the system are not describable as a sum of the functions of the causal forces (van Geert & Steenbeek, 2008). It is the interactions themselves that act as the dominant force (Richardson & Chemero, 2014).

**Stability.** Self-organizing systems seek stable states. *Attractors* provide a state or set of states around which a dynamical system will fluctuate or converge (Deboeck, 2013). There are several classifications of attractor states, but generally speaking, a strong attractor will lead the system to a state of greater stability than a weak attractor. The core assumption of *soft assembly* refers to the push on small or weak attractors that it takes to move the system from a former state (Thelen & Smith, 2006). Overall, system behavior is assembled from multiple interacting variables that act together to constrain the actions of other variables so that the system organizes and reorganizes freely to meet the demands of the task and context (Fogel, 2011; Spencer et al., 2011).

**Complex Dynamical Systems and Language Development**

Research using a CDS framework within the social and psychological sciences began in the 1980s and 1990s with a series of studies in the field of developmental psychology (Thelen & Smith, 1994; van Gelder & Port, 1995). More recently, the fields of educational psychology and applied linguistics have adapted CDS theory and methods to their practices, with increased publication accumulating in the past 5 to 10 years (Cameron & Larsen-Freeman, 2007; de Bot, Lowie, & Verspoor, 2007; Ellis & Larsen-Freeman, 2006). Educational psychology is an area rich for influence from a CDS perspective using concepts such as emergence, complexity, self-organized criticality, attractors, and catastrophe/chaos theory (Koopmans & Stamovlasis, 2016a).
Direct application of CDS has been recently used in examples such as teacher professional development interventions in science classrooms (Wetzels, Steenbeek, & van Geert, 2016), literacy and technology (Laidlaw & Wong, 2016), embodied mathematics education (Mowat & Davis, 2010), collaborative discourse in classrooms (Stamovlasis, 2016), and assessing motivational dynamics in language learning (Waninge et al., 2014).

Within the field of applied linguistics, increased attention to CDS theory for SLD has emerged with several possibilities for research and applications. After van Geert (1991) introduced dynamical systems modeling of cognitive and language growth for first language learners, Larsen-Freeman (1997) is credited with providing the first example of applying complexity science to SLD. The framework is unique in that both language and language development can be viewed as complex systems in their own right. Also, in addition to the real time ‘micro’ and ‘macro’ developmental learner trajectories, CDS takes the context of development into account (de Bot, 2008; Larsen-Freeman, 2006).

Studies of SLD have approached the question of measuring development through CDS from many individual perspectives. Within a CDS framework, there are in fact an unlimited number of variables and contexts to consider. What unifies each perspective are the theoretical principles followed and the proper measurement techniques applied per the research questions. Any dynamical study of cognitive development should ultimately answer the questions: 1) what develops, and 2) how does it develop? (Thelen & Smith, 1994). In SLD, the current research landscape for CDS has focused on individual learner developmental trajectories.

**Individual Learner Inquiry**

**Variability.** Development from a CDS perspective is well-suited to inquiry at the individual level. Given that each learner is considered their own CDS developing within an
environment of other CDS’s, no two learners will present the same learning trajectories. In an exploratory study of five Chinese learners of English, the overall group development was not an accurate reflection of any one individual’s development on measures of fluency, accuracy and complexity (Larsen-Freeman, 2006). While overall group development progressed, the individual trajectories told a much different story.

For each of the four measures of written language development across the five learners, no single linear path occurred. In fact, each measure showed a combination of increases and decreases in development over a four-month time period with no two learners expressing the same patterns of progression and regression among the same variables. For example, learner ‘R’ showed two initial drops in accuracy followed by a jump of accuracy higher than the initial measurement. While learners ‘U’ and ‘Y’ both showed large jumps in accuracy levels followed by larger decreases, these jumps occurred at different time points and to different degrees. Additionally, if one were to take just the measures of accuracy for each of the five learners and plot them into a representation of an ‘average’ learner pattern of language accuracy, the ‘average’ learner would reflect no single learner’s individual trajectory.

Individual assessment in this case highlights the variability aspect at both the intra-individual and inter-individual levels. Intra- being the within learner variability, and inter- being between learners. Additional case studies reported similar patterns on the intra-individual level for measures of complexity, accuracy, and fluency (Polat & Kim, 2014; Rosmawati, 2014; Spoelman & Verspoor, 2010). Dynamical principles such as sudden jumps, competitive relationships, and non-linearity were observed in each study. Each of these principles contributes to the overall development of the system. From variability, development is born. A system that is stable is said to be resting in an attractor state, with the stronger the attractor, the
less likely the system will change or express development (Thelen & Smith, 2006; van Geert, 2011). Therefore, observations of variable aspects of development provide evidence that language development is taking place.

**Developmental phase transitions.** In a complex dynamical system, when variability reaches a particular threshold, a phase transition emerges. Per chaos theory, it is expected to observe periods of (seemingly) complete randomness during the life of the system (Larsen-Freeman, 1997). This chaos is not truly random, however, as what appears random up close, will display complex geometric structures when plotted over a longer timescale (Thelen & Smith, 2006). Imagine dropping single grains of sand onto a sand pile. While we do not know which grain of sand will eventually cause the avalanche, nor the size of the avalanche that will result, it is known that the sand pile will transition from a period of stability to a period of chaos during the avalanche, followed by a period of relative stability when the pile eventually resettles. It is at the ‘edge of chaos’ were complexity theory resides (Lewin, 1999).

To explore phase transitions in L2 writing development, Baba and Nitta (2014) studied two international university students studying English. Four criteria were used as markers of phase transitions: sudden jumps, anomalous variance, divergence, and qualitative change in the attractor. Over the year of observation, both students exhibited at least one phase transition, as marked by a single event where all four phase transition criteria were met. It is important to note methodologically that the observation of phase transitions was possible in this study due to repeating the same type of task at each measurement. Additionally, the phase transitions for each student differed considerably in their quantitative and qualitative aspects.

**Retrodiction.** Returning to the sand pile analogy, another key principle of chaos theory has been explored in SLD research: that of prediction. Just as it is not possible to predict exactly
which grain of sand, and in what exact location it falls, will cause the avalanche, the outcomes of interacting variables over time in any system are not predictable by conventional mathematics (de Bot, 2008). CDS research is not concerned with prediction in the conventional sense, which would produce predictions in the form of testable hypotheses (de Bot & Larsen-Freeman, 2011). What CDS approaches can predict, are that interconnected systems and variables will interact over time to influence each other’s change and development (de Bot, Lowie, & Verspoor, 2011).

A novel approach called retrodiction has been introduced in CDS research for SLD. By explaining ‘after by before,’ the system data is analyzed in reverse (van Geert & Steenbeek, 2005). Instead of predicting, retrodicting involves starting with the outcomes of the data and tracing back over the patterns to explain how the outcomes came to be (Dörnyei, 2014). Not unlike Piaget, who started with observations of mature states, the CDS researcher can unfold the development through stepwise elimination of properties from the mature state (van Geert & Steenbeek, 2005).

From a qualitative standpoint, Dörnyei (2014) has characterized student learning types in the L2 classroom with retrodictive modeling. In his example, the three-step research template begins with identifying salient student types in the classroom. Completing a thorough inquiry through observations, interviews, focus groups and questionnaires allowed the researchers to identify the main learner types within the specific classroom of study. Once learner types were established, step 2: ‘identifying students typical of the established prototypes and conducting interviews with them’, gave the researchers data for each identified learner type as a dynamical system. In step 3, the main components of each system and underlying dynamic patterns were identified and interpreted. The researchers found the principle attractors in each particular system class and used them to describe learner trajectory patterns. By explaining the observed
phenomenon first through the retrodictive approach, the researchers will be able to make predictions in future studies where testable hypotheses can be applied to similar research settings (Dörnyei, 2014).

The idea of retrodiction can also be applied from a quantitative standpoint. The differential equation \( y_{t+1} = f(y_t) \), forms the basic equation of dynamical modeling (van Geert, 1998; van Gelder & Port, 1995). The equation reads as, “the values of \( y \) at time \( t + 1 \) is a function of “\( f \)” of the value of \( y \) at time \( t \)” (van Geert & Steenbeek, 2005). The value of a variable is considered as a state, while the change in the values is a function of the variable’s current value. Unlike standard developmental equations, where the state at any given time point is considered only as a function of some other variable measures, the differential equation is recursive. Meaning in the dynamical model, each subsequent state is expressed as the previous state plus one additional time point. Instead of plotting, say vocabulary growth, over time, it becomes possible to plot the outcome of vocabulary level after a sufficient growth period, as “a function of the parameter values that have an effect on that outcome” (van Geert & Steenbeek, 2005, p. 11).

The basic equation can be built upon and expanded to many degrees to create, for instance, coupled equations. In a coupled equation, multiple variables can show connected growers to model interaction. As demonstrated by Spoelman and Verspoor (2010), the connected growers of word complexity and noun-phrase complexity, and word complexity and sentence complexity, have been identified in the case of a Finnish learner of English. Competitive relationships were also observed. The competitive relationship between noun-phrase complexity ratio and sentence complexity ratio demonstrated that one language skill may develop at the expense of another skill.
Although differential equation modeling was not used for analysis in the previous study, Lowie, Caspi, van Geert, and Steenbeek (2011) produced a set of coupled equations to model learning trajectories of an advanced learner of English. First, four variables of consisting of receptive and productive language skills measured over 36 weeks were qualitatively and quantitatively analyzed for variability patterns. With the knowledge of the interaction patterns within the system, the researchers then developed the equations. Just as in the previous examples (Dörnyei, 2014; Spoelman & Verspoor, 2010), it has been demonstrated that dynamical systems modeling is concerned with the process more so than the outcomes. Whereas traditional modeling relies on the contributions of external variables applied in differing amounts, the dynamical modeling examples of development focus on the interactive contributions of the variables of the system and time. Dynamically, “development is driven by some sort of inner logic or a sort of inevitability where a developmental process realizes its internal potentialities” (van Geert & Steenbeek, 2005, p. 4).

**Ecolinguistics**

Ecolinguistics, or language ecology, is concerned primarily with the act of language use in context or environment. Although considered a research field in its own right, research conducted from an ecolinguistics perspective often cites a collaborative approach taken in conjunction with an SCT perspective or a CDS perspective (Kramsch, 2008; van Lier, 2004). However, given that the ecological approach has its own distinctions from SCT and CDS, it is relevant to discuss it within its own terms. The ecological approach has notably less SLD research conducted specifically within the ecological framework, so the emphasis for the ecolinguistics discussion will be placed more on the assumptions of the theory.
The ecological approach to SLD considers both the psychologically and sociologically conceived characteristics of language use, referred to respectively as the micro- and macro-language ecologies (Kramsch & Steffensen, 2008). Equal attention is given to the role of both the self and the other in the language development process, with specific attention given to the role of identity in discourse practices. From this viewpoint, identity is not a static characteristic, but rather is a role filled in given contexts and influenced by the historical interactions of peoples and cultures over time. The ecolinguist is engaged in the study of language in practice, concerned less with the grammatical and other structural components of language and more with the use of language as a means of political positioning and meaning making (Uryu, Steffensen, & Kramsch, 2014).

The ecological approach is closely linked to the works of Bakhtin and the dialogical view of language (Holquist, 2002; Kramsch, 2004). Through the dialogues of human interaction, the person, situation and culture merge, creating meaning in context. The dialogical perspective is built upon two accounts: first, the psychological realm is brought into being through dialogical properties of our existence (Salgado & Gonalves, 2007). In every interaction there is a ‘self’ and there is an ‘other’ from which the directionality of the language is established. Relationships are a reflection of the acknowledgment that two separate identities have come together to interact. As a result of the nature of the interaction, the self and the other assume individual roles establishing meaningful identities within the interaction. A mutual understanding of the psychological space created by the enacted identities allows for meaningful communication to occur. Second, the dialogical perspective is rooted in the cultural context (Salgado & Gonalves, 2007). Conversations are rarely unique and novel encounters but rather the result of historical interactions over time recreated by individuals in present contexts.
Van Lier (2004) draws several connections between SCT and language ecology. He describes that sociocultural theorists and ecolinguistics theorists are all oriented towards a common goal: extending the work of Vygotsky into present-day contexts. The distinction, he argues, lies within the articulation of the framework for research purposes. Like SCT, ecology “accounts for language, semiosis, activity, affordance, self and critical action” (van Lier, 2004, p. 20). The ecological perspective is one of perception, action, and interpretation rooted in learning as a result of active participation in the world through signs and symbols (semiotics) that surround us (van Lier, 2004).

**Ecolinguistics Research**

To investigate the ecology of intercultural interaction, that is the dialogue between multilingual, multicultural individuals, Uryu et al, (2014) utilized the concept of *temporal ranges* with identity dynamics to analyze discourse at a Thanksgiving dinner. This particular Thanksgiving dinner was specially arranged for foreign spouses at an American university to socialize and practice English while making friends sharing cultures and learning about American culture. The researchers demonstrated how past events pertaining to cultures of the participants (German and Japanese roles in WWII, Russian-American cold war relations, etc.) constrained the interactional dynamics within the local level of discourse. Thus, the identities projected by the participants during the face-to-face discourse reflected temporal ranges far beyond any single timescale of an individual lifespan.

Churchill (2008) utilized timescales on the micro-developmental level to understand the process of learning how to use a single-word correctly. Because he used himself as the participant, Churchill (an American living in Japan) was able to track his own development through written samples and discourse with his Japanese wife. With a focal point directed to
what can be considered *actual moments* of learning, Churchill demonstrated how ecological approaches can view the change process in a manner that underscores how desired and/or undesired changes emerge in a system (Fogel, 2011; Larsen-Freeman & Cameron, 2008b; Thelen & Smith, 2006).

**Converging Theoretical Views**

To review, the introductions given thus far to sociocultural, complex dynamical, and ecolinguistics theories have presented updated research alternatives to the predominant views of mainstream cognitive psychology. Each of these three theoretical perspectives takes into account how language, thought, and culture merge in the act of human development and our ability to communicate with each other. Converging ideas of holism, history and context, non-linear development and embodiment all arise from the three viewpoints to provide support for a new account of the language/thought/culture triad within applied linguistics.

**Holism**

As discussed previously, the influence of Decartes and the mechanistic worldview held that scientific inquiry involved deconstructing any system in question down to individual parts. At the lowest level of inquiry, one could find the *universal truth* of how the world functions. The metatheoretical divide between the Cartesian-split-mechanistic worldview and the relational worldview provides the foundation for understanding why the three theories presented share a theoretical common grounding (Overton, 2014). The relational worldview follows that the world functions as an interconnected whole, where each ‘thing’ in the world has the potential to affect all the other ‘things.’ Given this, the parts which make up the whole cannot be parsed out on their own because they are always dependent on the interactions with the other parts in order to
exist. In systems theory, this principle is called *multicausality* (Thelen & Smith, 1994) and is directly related to the concept of a dialectic.

Dialectical materialism, used by Vygotsky, serves as a general psychological theory to explain higher order forms of cognition (Lantolf, 2006). The dialectic can be thought of as the identity of opposites, where two seemingly opposing concepts exist concurrently. For example, an individual’s own identity is shaped by the culture they live in, while their culture is a representation of the numerous individual identities within it. In terms of language development, the way each person acquires language involves the culture in which they are situated in. Learning language in different cultures or context will affect the way the language is used by the learner. In turn, within the smaller pockets of language communities, the language users will interject their own mannerisms onto the language, which then diversifies their community’s use from the use of the language in a broader sense.

**History and Context**

The historical conditions of both the person and the broader historical conditions of human existence each contribute to the states of human culture today. The ecolinguistic and SCT viewpoints place emphasis on the historical perspective of cultures affecting present day language learners. For example, in the previously mentioned study of multilingual, multicultural individuals gathering for a Thanksgiving dinner, it was observed that multiple voices and historicities engaged in the conversations in the present context (Uryu et al., 2014). Taking an SCT perspective would additionally view the cultural-historical activities present in current contexts and the change in relationships across history. The dialogues we inhabit have been molded and formed over time to adhere to social norms while also affecting identity positionality within human interactions.
The CDS perspective assesses time scales from historical perspectives as well, although typically as it pertains to the history of the individual themselves. The dependence on the initial state of the system feeds all possible future states of the system forming a reiterative process whereby system development is nested across time scales (Thelen & Smith, 1994). The individual’s development, especially when concerned with SLD, relies heavily on previous language experience and cultural upbringings. For example, Mercer (2011) took into account the history and motivations of a tertiary-level ESL learner to understand her engagement in learning multiple foreign languages simultaneously. Her attitude and agency with regard to willingness to participate in the language learning process was affected by her previous experience with the languages and differed among the languages she was studying.

The ecological approach additionally considers affordances, described first by Gibson (1979) as whatever tools/signs are provided in the immediate environment to the learner’s assistance or detriment. To Gibson, everything we perceive in the environment is perceived only as it relates to ourselves. Therefore, the environment is perceived not as it actually is, but rather as it is in relation to the perceiver (van Lier, 2004). Contextual considerations central to the SCT perspective include the social-cultural-historical elements. For the CDS perspective, the initial conditions and nested timescales of development are considered, and for the ecological approaches the affordances within the individual’s environment are considered. Each of these notions supports the underlying argument that the activity of meaning-making only emerges in context (van Lier, 2004).

**Development**

The nature of development is argued to take a much different path through the view of the three theories than has been suggested by more mainstream cognitive scientists. By focusing
on the individual over the group, studies have identified how non-linear and highly variable learning trajectories are possible among groups of students. The principle of scaffolding shows how a learner can progress from one developmental level to another through assistance from an adult or more advanced peer (Wood et al., 1976). A learner can also show variability in their understanding of concepts, such as the Piagetian water conservation task (Ping & Goldin-Meadow, 2008). What the learner may not be able to convey verbally about their understanding may be expressed differently through their gestures. From a CDS perspective, this mismatch in the verbal/gestural patterns would suggest movement of the system into a less stable, i.e. more chaotic, state. When a system enters an unstable state, such as grain of sand causing an avalanche on a sand pile, the system must self-organize and remerge as a new, stable state as a result of the chaos. In terms of development, the chaos caused by the gesture/speech mismatch is resolved by the triggered self-organization that progresses the child to a new developmental state. As in Ping and Goldin-Meadow (2008), the Vygotskian internalization process was triggered through a scaffolding of learning iconic gestures to aid in developmental understanding of the water conservation task. In this new developmental state, the child is now able to reconcile the mismatch and convey the same idea through gesture and speech.

Much like CDS, an ecolinguistics perspective views language development primarily through activities of socialization. The learning/teaching experience involves connections emerging naturally through interactions. From Gibson’s ecological psychology, Steffensen and Fill (2014) describe how the acts of perception and action allow the learner to relate to their context. Additionally, the affordances available in the context allow for the learner to engage in a richer learning experience. As Kramsch (2008) notes, learning does not emerge from a directive on a syllabus, but from connections the learner creates based on their experiences in
context and in prior situations. Furthermore, the SCT concept of Perezhivanie describes how emotionally driven experiences mobilize the psychological activity necessary to enable development (González Rey, 2016).

**Embodiment**

A final main point of convergence between the three theories considers the role of embodiment within development and cognition. The embodiment hypothesis follows the idea that intelligence emerges as a result of interactions between an organism and its environment through a means of sensorimotor activity (Smith, 2005). In other words, cognition is made possible not solely because we have brains, but because we have brains connected to bodies. These sensorimotor capacities are additionally embedded within the larger biological, psychological, and cultural contexts (Varela, Thompson, & Rosch, 1993).

As described in the SCT and CDS sections, the role of gesture in language use has come to the forefront of the embodiment in language practice. To fully understand and appreciate the embodied perspective, a comprehensive review of embodied cognition will be given in the next section. To conclude the present review of the convergence between SCT, CDS, and ecolinguistics, it is important to highlight that each of these viewpoints, with their holistic and dynamic centralities, supports the possibility of cognition as an embodied act. Cognition is not an isolated act of the mind, but a fully integrated resourcing of the mind, body, and environment to create meaning and purposeful action in our worlds.

**Embodied Cognition**

**Foundations**

The embodied cognitive science perspective is attributed to Gibson’s foundational work in visual perception and the school of ecological psychology he proposed. Gibson’s (1979)
ecological theory is rooted in three main claims: 1) there is information present in the environment that is 2) available and active to an active agent and that 3) specifies this agent a world of affordances (Shapiro, 2012). Through a series of studies on visual perception, Gibson argues that our eyes alone are not the only sense we use for ‘seeing’. It is our ability to move around in our environment that allows us to perceive an object correctly. Further studies have confirmed that it is through a multi-modal sensory system which provides our conscious perception of our surroundings (Smith, 2005). For example, one’s immediate characterization of an apple as an apple, is not simply a visual account. Knowing an apple is an apple comes from a series of time-locked correlations involving the senses available in an apple-perceiving situation (Edelman, 1987). It is the independent mappings of the senses that, interacting in real-time, congruently build our perception of the apple (Smith, 2005).

**General Themes**

Six views of embodied cognition can be conceptualized under three main themes of embodiment (Shapiro, 2011; Wilson, 2002). First, cognition is situated. It is embodied, embedded, and extended in the context of its environment through behaviors of perception and action (Robbins & Aydede, 2009). Second, cognition is time-pressured, it is a dynamic system which functions real-time (van Gelder & Port, 1995). Third, cognitive work is off-loaded onto the environment. For example, writing out a grocery list transfers the need to memorize what you will need from the store into the environment. The environment is used to ‘hold’ the information for us. Fourth, the cognitive system is distributed between the physical body and the environment.

A weaker view of this idea regards the person plus situation as evidence of environmental contribution to cognition, while more complexity minded views say interactions between co-
dependent sub-systems reach farther than the person and their immediate environment. The fifth view of embodied cognition follows that cognition is for action. Speaking in evolutionary terms, it is the hypothesis that nervous systems were developed because of the organism’s need to move about its environment (Wolpert, Ghahramani, & Flanagan, 2001). Sixth, offline cognition is body based. Even in the absence of particular environments, our sensorimotor perceptual experiences are rooted in the circuitry of our minds. For example, the prevalence of embodied metaphors in language provides evidence for the co-dependence of perception, action and experience in creating thought (Lakoff & Johnson, 1980).

Shapiro (2011) has identified three themes emerging from the multiple independent viewpoints within the embodied cognition research. The conceptualization hypothesis posits that “the concepts on which an organism relies to understand its surrounding world depend on the kind of body that it has” (Shapiro, 2011, p. 4). Casasanto (2009; 2011) formed the bodily relativity hypothesis based on his research that handedness, whether genetic or induced, influences thinking as it applies to motor action and verb meaning, abstract concepts, and emotional valence (see also Casasanto & Henet, 2012; Casasanto, 2014). Handedness may even provide a stronger influence than culture, as was observed on tasks of judging conventional good-is-right and bad-is-left idioms (de la Vega, Dudschig, Lachmair, & Kaup, 2014). In all likelihood, though, it is a co-construction of experiential, linguistic, cultural and bodily relativity that shapes cognition through physical and social experiences (Casasanto, 2016).

The replacement hypothesis removes all reference to representational processes traditionally thought to be governing cognition. The most opposed to the mind-as-computer metaphor, replacement theories follow the works of Thelen and Smith using previously described dynamical views of cognition. According to Chemero (2013; 2016) this ‘radical’ form
of embodied cognitive science is the most aligned with the ecological ideas of Gibson, tracing
directly back to James’ functionalism and Kant’s transcendental philosophies. While
additionally, Merleau-Ponty’s assertion of the lived body creates the possibility of having a
conscious awareness of the world. From these collective viewpoints, there is no ‘mystery’ of the
mind housed within a mechanical body. The question is asking rather, what are the interactional,
co-dependent forces between the body-mind-environment from which cognition emerges?

Finally, the constitution hypothesis, takes a less ‘radical’ position on the idea of
embodiment. Specifically, the constitution claim is that, “the body or world play a constitutive
rather than merely causal role in cognitive processing” (Shapiro, 2011, p. 4). While still in
opposition to the computational directives of the standard cognitive view, a constitutional view
still supports the argument of symbolism and the manipulation of symbols for the production of
thought. Also referred to as connectionism, or theories of extended cognition, these views still
hold the belief that some degree of internalization occurs on the part of the mind (Clark &
Chalmers, 1998; Clark, 2006). For a representationalist, cognition is an environment dependent,
moment to moment activity: “we conceptualize knowledge and knowing as emergent or made at
a precise moment from multiple components in relation to the task and to the immediately
preceding activity of the system” (Thelen & Smith, 2006, p. 301). Whereas, for a connectionist,
cognitive tools such as language provide their own internalized loop which then connect to outer
loops of the body and environment: “as embodied agents, we are able to create and maintain a
wide variety of cognitively empowering self-stimulating loops whose activity is as much an
aspect of our thinking as its result” (Clark, 2006, p. 10).
Researching Embodied Cognition

Foundations

Thelen and Smith’s (1994) seminal work with the use of dynamic systems methodology for the developmental sciences incorporated aspects of embodiment to revisit the classic Piagetian A-not-B error task. Piaget (1964) answered his original question of ‘when do infants acquire the concept of object permanence?’ through a series of experiments on infants involving an object-hiding task. The infant is placed next to a table with 2 objects, A and B, placed on the table. The infant watches a researcher place an attractive toy underneath object A, after which the infant reaches to retrieve the object from under object A. After several repeated trials with the toy hidden underneath object A, the researcher switches to place the toy under object B, with a brief time delay between presenting the toy and hiding it. While 12-month old infants will successfully retrieve the toy from its new hiding place, the 8- to 10-month old infants will continue to reach for the toy from its prior hiding position, underneath A. Piaget suggested that compared to younger infants, the 12-month old’s have acquired an understanding of object permanence. His theory follows that an internal, biological mechanism has allowed for the development of object permanence in the older infants compared to the younger ones.

Thelen and Smith (1994) approached this task through an alternative lens. By placing simple manipulations to the trials, including time between toy presentation and hiding or posture of the infant, the error comes and goes in the younger infants. This can be explained dynamically through the formation of relevant memories of the context and the body’s interactions with the sensory surface. After the infant has observed multiple trials of hiding the toy under A, the infant has developed a strong association with the location A. This activation point is said to exert strong inhibitory influence over the other points around it. With shorter
delays in time between the presentation of the toy and hiding it under the new location B, the younger infants do not make the error of reaching for A. In the longer delays, the error of reaching for A occurs because the memory of the activation point A is the result of habit formation, not developmental absence. Additionally, shifting the infant’s posture (Smith, Thelen, Titzer, & McLin, 1999) or placing small weights on their wrists (Clearfield, Diedrich, Smith, & Thelen, 2006) alters the presence of the error. Younger infants who were allowed to stand did not make the reaching-for-A error, while seated infants continued to reach for A. Similar evidence for the role of the body in the task, as demonstrated by Clearfield et al. (2006) discovered that placing a ‘heavy’ weight on the wrists on A trials and ‘lighter’ weights on B trials (and vice versa) also ceased to make the error. Thelen and Smith (2006) present that the task is a dynamic one, that the constraints placed on the task by Piaget do not demonstrate biological disadvantages, but rather that they impeded the infant’s opportunity for ‘knowing’ how to complete the task. Knowing then becomes an emergent property, “made at a precise moment from multiple components in relation to the task and to the immediately preceding activity of the system” (Thelen & Smith, 2006, p. 301).

**Key Research Questions**

To research “carefully built bodies perceptually coupled to specific environments,” Wilson and Golonka (2013, p. 2) present four key questions for application to any embodied cognition research program. The Piagetian A-not-B task as was presented by Thelen and Smith (1994) will be used to describe each key question:

1) *What is the task to be solved?* The A-not-B task requires that a specific problem be solved. While it may have been generally conceived that the task presents itself as a general problem, it was observed by altering the environment/body/timing of the task, the task demands
changed in a way that it became a different problem in each scenario. As the specifics of the
task/problem changed, so did the infant’s ability to solve it.

2) *What are the resources that the organism has access to in order to solve the task?*

Resources can include the brain, the body, the environment, and also the interaction of these
variables. In the A-not-B task, the resources were altered to create different task scenarios for
observation.

3) *How can these resources be assembled so as to solve the task?* The reason Thelen and
Smith were able to provide such a compelling argument against the general problem model
presented by Piaget, lies in their ability to account for the altered interactions built from different
resource availability. Different resources created different system behavior capabilities,
especially as *embodied* resources were involved.

4) *Does the organism, in fact, assemble, and use these resources?* Through different
examples of system perturbation, Thelen and Smith were able to hypothesize a model of how
certain system conditions allowed for behavior to emerge in a favorable manner.

**Dynamic Systems Framework**

As presented by the A-not-B task, some of the earliest evidence supporting the use of
CDS framework for the psychological sciences is rooted in acts of motor control, perception, and
action (Samuelson, Jenkins, & Spencer, 2015). To more specifically draw attention to the
concerns of the present paper, an additional account of early dynamic systems research in the
psychological sciences is appropriate. Perhaps unsurprisingly, this account has also been
presented by Thelen and Smith (1994). Directing focus away from the prior more *traditionally*
cognitive example, the following example discusses a more authentically driven motor task:
infants learning to walk.
Prior research on infant motor development by motor neurophysiologists in the 1970s and 1980s had led to the hypothesis that a central pattern generator (CPG) was responsible for producing patterns of natural locomotion. After surgically severing the brains from the spinal cords in cats, these investigators observed that the cats could still walk while suspended over treadmills in coordinated patterns similar to normal cats whose brain and spinal cords were still intact. The conclusion was drawn that a network of neurons present in the cat’s spinal cord were responsible for the activation patterns leading to natural locomotion. The resulting ‘traditional’ view then became that the CPG was activated within a hierarchical top-down chain of control starting in the cat’s brain. Of most significance is that within this traditional view, sensory input acts only as a modulator for the chain of command of locomotion.

Thelen and Smith (1994) questioned the practical significance of the CPG theory noting that the surgically altered cats were unable to initiate locomotion, nor could they navigate through variable terrain. Through their own research, Thelen and Smith were able to form a much different view of development, namely that the developmental processes involved in learning to walk are complex and dynamic in nature. In brief, Thelen and Smith discovered that until about 8 or 9 months of age, infants supported over a treadmill exhibited observably involuntary stepping patterns on the treadmill (spinal cord and brain, of course, intact). Despite showing no distress or attention paid to the stepping motions, the stepping action itself was not reflexive (reflexes being characterized as responding independent of the stimulus strength). Instead, the infants were able to adjust gait patterns in response to speed changes of the treadmill forming a “functional synergy…a cooperative unit responsive to its own behavior and to perturbations from external sources” (Thelen & Smith, 1994, p.13).
The implications of the argument against a CPG and in support of a complex dynamic system of development are a significant contribution to the foundation of embodied cognition. The motor system does not assist the brain or act as extension of the brain, but rather *is one* with the brain. The role of the motor system in cognition is especially important to the understanding of language development. As we speak, we produce co-speech gestures. Gestures are not ancillary to speech but form an integrated co-dependent system with the speech. Gesture and speech are tightly coupled during infant language development (Iverson, 2010) and gestures produced by congenitally blind individuals are of equal character to those with normal vision (Iverson & Goldin-Meadow, 1997). In the sections that follow, embodied accounts of how the properties of languages and act of language learning should be regarded as wholly reliant on the coupling of body, conscious mind, and environment.

**Language and Embodiment**

**Researching Language**

What is it about language that makes it so difficult to study? Language is a neurocognitive ability comparable to other neurocognitive abilities, but with its own special implications (Wilson & Golonka, 2013). Language is our main means of communicating with the world and is regarded as feeding the ability to achieve other cognitive tasks (Vygotsky, 1978). A major challenge in the study of language begins with some foundational questions. For example, how is language acquired, where and how does it exist within us, and how is it comprehended? It can be generally agreed upon that language is for communicating, but is it a form of meaning-making or a static set of rules to be followed? Is it that humans are pre-wired for language, and the language wiring must be activated? Or maybe it’s that all languages act as
complex and dynamic systems which work as such under the right condition of interactions including system properties of grammar and syntax.

No doubt some impactful voids exist in our understanding of language that have impeded progress in language research, however that is not to say that language research hasn’t come quite far, especially in the past century (Tarone, 2015). As with the other research areas within cognitive science, language research remains divided over the idea of whether language is or is not represented concretely in the brain, with the former holding the most widely favored position. Given that language is a highly embodied task supported by research in numerous fields linking the co-dependence of speech and gesture (Gullberg, 2006; Gullberg et al., 2008; McCafferty & Stam, 2008; McNeill, 2005), it may be that language can open the door to a more mainstream acceptance of embodied cognition in general. To date, language research from the fields of psychology, neurocognition, and applied linguistics has contributed several theoretical perspectives on how to approach embodied L1 and L2 learning.

**Language Comprehension**

Recent advances in neuroscience have revealed numerous connections between language comprehension and activation of sensorimotor cortical regions in the brain. In general terms, the motor areas of the brain activate during speech (Hauk, Johnsrude, & Pulvermüller, 2004) while the language areas activate during sensorimotor action, especially of the hands (Binkofski & Buccino, 2004). The sensorimotor experiences are not generic sort, but rather are linked to specific experiences (Scorolli, 2014). For example, listening to specific action verbs will activate the corresponding body part areas on the motor cortex, such as the ‘foot’ area activated when hearing the word ‘kick’ (Pulvermüller, Hrle, & Hummel, 2001). Motor areas are additionally active during abstract sentence comprehension (Glenberg et al., 2008) and
responsive to other phonological and grammatical features of language (see reviews by Fischer & Zwaan, 2008; Scorolli, 2014). These pinpointed activations are present during language production and reception, which suggest their function to intra- and inter-personal relations. The specialized mirror neurons are proposed to be active in events of both simulating our own and other people’s behaviors (di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992; Rizzolatti & Craighero, 2004).

Embodied simulations extend also to object and relational properties of language. During a picture verification task, participants were read sentences in which object directionality was implied, i.e. “John placed a pencil in the cup” or “in the drawer.” Later, when asked to identify an object mentioned in the previously heard sentences via picture verification, participants were quicker to respond to examples where the object pictured matched the directionality implied from the listening portion of the experiment (Stanfield & Zwaan, 2001). Perceptions based on spatial relations are also implied in tasks asking for motor responses to answer a question (upward vs. downward movement). Borghi, Glenberg, and Kaschak (2004) found that implying directionality in a sentence, or referencing typical object location, produced motor response latencies proportional to the implied direction. If asked, “does a doll have hair,” the participant would respond “yes” faster if reaching upward was required.

While motor-related activation receives most of the attention, additional research has discovered language perception linked to other areas of the brain, such as emotional processing circuits (Niedenthal, 2007). Fischer and Zwaan (2008) do caution against the risk of overstating the role of motor processes in cognitive activity as there is still much work to be done seeing as there is still debate about whether symbolic representation actually exists in the brain. At present, there is at least preliminary research supporting arguments in favor of a non-
A representational approach through concurrently active action/perception loops, such as with motor neuron circuits. Driven by the theory of motor cognition, this belief stands against the classical two-visual pathways theory that distinguishes semantic from pragmatic representations in the brain (Fischer & Zwaan, 2008). By asserting that all language behavior has co-dependent semantic and pragmatic properties, a theory of motor cognition can help validate the perspective of dynamic embodied cognition.

**Gesture as Embodiment**

Compounding evidence from multiple sources suggests that embodied cognitive systems exhibit behaviors of complex dynamic systems. Following the accounts from understanding the embodied views of language through metaphor and neurocognitive studies, a key component of embodied cognition remains; specifically, the role of gesture. When language is understood as consisting of a co-dependent gesture/speech unit, a new door to embodiment opens. Through direct observation in real-time conversations and learning settings, gesture and speech can be assessed through the embodiment lens in a practical and purposeful way. It was introduced earlier that much of the work in SLD gesture studies has been carried out in the spirit of L. S. Vygotsky. To review, in the previous section on sociocultural theory, SLD gesture studies were described as they relate to the mimetic properties of meaning-making and identity development, the role of gestures in learner self-regulation in conjunction with private speech, and the role of gesture in the ZPD. Given that gesture and SLD research has already been reviewed, the discussion will carry forward addressing how further considerations of embodiment can be addressed in future SLD research.
**Future Considerations**

The Vygoskian tradition in which many SLD gesture studies are carried out offers many direct complementary connections to the ‘key components’ of dynamic embodied cognition. McCafferty (2004) borrows the term *embodied action*, from the embodiment literature to hypothesize about the role gestures play intra- and interpersonally for the L2 learner through the process of *enaction*. McNeill (2005) also explains how, with gesture, the imagery-language dialectic resembles a dynamic dimension of language:

>This combination is of unlike modes of cognition and this fact produces instability. It is this unstable combination of opposites that fuels thought and speech. Instability is an essential feature of the dialectic and is the key to the dynamic dimension. (p. 92)

A dynamic embodied approach can both confirm findings of studies conducted within the sociocultural framework and build upon these findings with a new research perspective, including adding new vocabulary to rephrase ideas and promote cooperative research efforts. A dynamic embodied approach can also guide research study design with a different set of research questions, such as furthering the understanding of internalization in the Vygotskian sense. For example, is there a moment in which we can observe internalization? Is it perhaps an emergent phenomenon accompanied by periods of instability?

Other general questions have been proposed as gaps in the empirical literature that could also be researched within the dynamic embodied lens. For example, discursive properties of L2 can account for interaction across speakers. “Very few studies have empirically investigated how L2 speakers actually use gestures to compensate for problems in L2 speech, and how they align with NSs [native speakers] in interaction to find joint solutions” (Gullberg, 2006, p. 111). This dissertation addresses this gap in the literature. This study will additionally take into account
another embodied property of this dyadic interaction using dynamical modeling techniques which have only just begun to appear in the SLD literature. Specifically, recurrence analysis techniques can be used to measure dynamical patterns of recurrence between paired time series data. The use of recurrence plots in the embodiment literature will be discussed in the next section including a review of the brief accounts of their use in SLD research.

Recurrence Analysis

A growing number of methods for the analysis of process-oriented, microdevelopmental, and non-linear approaches to development have been recently adapted for use in the developmental and educational sciences. As the study of development as a complex and dynamical system has gained traction, more and more techniques of analysis are being employed to directly study patterned behaviors that exhibit variability, stability and interaction among variables. The, perhaps, newest non-linear method to be introduced for SLD is called recurrence quantification analysis (RQA), which measures recurrent behavioral states (Marwan, Romano, Thiel, & Kurths, 2007). One of the main principles of dynamical systems states that systems behave in cycled, fractal-type patterns from which patterns can be detected among the noise (Kello, Beltz, Holden, & Van Orden, 2007; Van Orden, Holden, & Turvey, 2005). Detecting and quantifying recurrent behavioral patterns exposes information about the underlying dynamical behaviors inherent to the system.

Recurrence analysis begins with transformation of time series data, such as quantified behavioral data, from a 2-D visualization into a multidimensional phase space. It is assumed that certain behaviors in the system will recur across time. Therefore, to detect recurrence, the time series is set to a specified delay for which it is expected that the time series will return to the same behavioral patterns. To visualize recurrent patterns, the delayed time series is then plotted
into a multidimensional phase space through a process called phase space reconstruction (Marwan et al., 2007). For an example of phase space reconstruction, see Figure 1.

From the phase space reconstruction, the behavioral data is mapped onto a recurrence plot (RP) (Figure 1, image b) and formally expressed by a matrix. In the matrix, an identified behavior is coded as either present (1) or non-present (0). When plotted onto the RP, the data becomes visualized as a function within two time series on each of the x and y axes. For example, if a recurrent behavior is present at time point $i$ and again at time point $j$, a data point will be plotted on the respective $i, j$ coordinate. Once all data points are plotted, the RP will appear as a series of scattered dots with more dense areas representing pockets of patterned behavioral states, i.e. attractor states. The RQA quantifies the characteristics observed within the RP which details the dynamical behavioral patterns numerically.
Figure 1. Phase space reconstruction of the Rössler system (A) and its corresponding recurrence plot (B). Plot A shows the trajectory of the system, with the two black dots representing a recurrent behavioral state between two times ($i$ and $j$) which exist within a threshold of phase space area called a neighborhood (grey circle). Recurrence is marked by a black dot in the RP (plot B) for times $i$ and $j$. Non-recurrent points are left white on the RP. Adapted from Marwan, N., Romano, M. C., Thiel, M., & Kurths, J. (2007). Recurrence plots for the analysis of complex systems. *Physics Reports, 438*(5), p. 246.

Recurrence plots were introduced about 30 years ago and have been used primarily in the natural sciences (Marwan, 2008). Recent uses in the psychological sciences regarding language development and conversational coordination have used RPs and RQA to investigate conversational coordination between children and caregivers (Cox & van Dijk, 2013; Dale & Spivey, 2006), conversational coordination between staff and clients with intellectual disability (Reuzel et al., 2013), the interactive effect between reading fluency and dyslexia (Wijnants, Hasselman, Cox, Bosman, & Van Orden, 2012), and speech gesture attunement in young children (de Jonge-Hoekstra, van der Steen, & Cox, 2016). Only one study to date has been
identified as using RQA for the purposes of SLD (Sun, Steinkrauss, van der Steen, Cox, & de Bot, 2016).

While RQA was designed to study the recurrent structure of a single signal cross-recurrence quantification analysis (CRQA) was adapted to study recurrent structures between paired signals (Shockley, Butwill, Zbilut, & Webber, 2002). In the CRQA, recurrence reflects that the behavioral state of one of the systems also occurs in the other system (e.g. one interlocutor speaking to another) at some point in the time series either earlier, concurrently or later (Reuzel et al., 2013). The paired behaviors are not simply matched for behaviors occurring at the same moment but may be scaled across all measurable time scales. For example, CRQA has been used to understand temporal patterns of verbal and non-verbal behaviors between and within speakers for different time scales during conversation or speech (de Jonge-Hoekstra et al., Reuzel et al., Sun et al., 2016). CRQA offers robust dynamical measures not available to traditional methods of central-tendency measures such as means, SDs, and ranges (Marwan et al., 2007).

To better explain the specific measures made available through CRQA, three relevant studies will be reviewed. Reuzel et al. (2013) studied how gaze direction and speech rhythm synchronized during conversations about quality of life between support staff and their clients with intellectual disabilities. First, a global measure of recurrence rate (RR) is simply the percentage of the plot that is filled with points, or black dots as they will be referred to hereafter (Dale & Spivey, 2006). By global, the authors mean that they are drawing a general quantitative measure with minimal dependence on statistical assumptions (Reuzel et al., 2013). Next, a single diagonal line, the line of synchrony (LOS), appears from the bottom left corner of an RP to the top right. The LOS reflects simultaneous recurrences, or in this case when the client and
staff exhibited the same nonverbal behavior at the same (i.e. they were looking at each other). The number of recurrent black dots (the points indicated by a “1” on the matrix) divided by the total number of points on the line (the length of the time series, or all “1’s” and “0’s”) indicates the central tendency measure of the percentage of synchrony (%sync).

Because the RP carries an abundance of information about the recurrence of behaviors within specified temporal proximities the most interesting part of the analysis will analyze other diagonal lines above and below the LOS. This diagonal recurrence rate (RR_{diagline}) of width \( w \) is the sum of black dots in the band of specified \( w \) around the LOS, divided by the total number of dots (black and white) in that area (Dale & Spivey, 2006). A larger \( w \) selected reflects a longer time delay so it can be observed how much earlier or later in the conversation the recurrent behavior occurred. If the client’s time series is plotted on the horizontal axis and the staff’s time series is plotted on the vertical axis, an RR_{diagline} that appears above the line indicates synchronized nonverbal patterns that were initiated by the client. Vice versa, an RR_{diagline} that appears below the line indicates synchronized patterns indicated by the staff member.

The authors took several recurrence measures from what is called the LOS-profile. The longest diagonal line (RR_{peak}) provides an estimate of the overall coordination between the interlocutors. Next, the time delay within which this RR_{peak} is obtained, called the \( \tau_{peak} \), indicates the optimal delay needed to observe synchronized patterns between the interlocutors. Lastly, the ratio between the total relative amount of recurrence that occurs in the \( w \) on either side of the LOS indicates how strongly one of the interlocutors dominates the conversation (Reuzel et al., 2013).

Two of the three main research questions that guided the analysis are relevant to the conditions in this dissertation. First, it was asked what kind of attunement and synchronization
occurs between staff and clients in their gaze direction and speech rhythm. The global RR and %sync were used to determine that, although staff and clients look (gaze) at each other more often than based on statistical chance, on average there was no coordination of gaze patterns. Alternatively, the speech rhythms between the interlocutors were generally more synchronized than gaze patterns. Some gaze patterns between individual dyads were synchronized, however, with one pair displaying an RR\textsubscript{peak} of approximately 48% synchronization. But compared to the highest individual synchronization for speech rhythm, which reached 74% synchronization, the gaze patterns were markedly less synchronized.

The second research question investigated the patterns of dominance in the dialogue. Because no significant results were found for gaze in the first research question, only speech rhythm initiation was analyzed for the current research question. The mean $\tau$\textsubscript{peak} variable indicates response time of one interlocutor to the other. The reported mean $\tau$\textsubscript{peak} of -3.38 means that it took the staff about 3.5 seconds longer to become silent once a client began talking compared to a client becoming silent when the staff member started talking. This pattern was true for 12 of the 16 interactions that displayed a $\tau$\textsubscript{peak}, with a notable variety of mean $\tau$\textsubscript{peak} displayed between the different dyads. Also, the sum of the RR\textsubscript{diagline} reported from the LOS-profiles indicates how strongly one interlocutor is dominating the conversation over the other. Again, a wide variety of individual patterns were observed from one dyad to the next, but overall the mean value of the difference between staff and client speech rhythm initiation was 0.83%. This demonstrates fairly balanced speech rhythm initiation.

Although gaze coordination was not observed overall by Reuzel et al. (2013), previous studies have indicated otherwise. Richardson and Dale (2005) first observed gaze coordination for interlocutors who were viewing a computer screen. Later, coupled eye movements were
identified in spontaneous dialogue for interlocutors looking at each other (Richardson, Dale, & Kirkham, 2007). It is possible that the lack of gaze coordination in Reuzel et al. (2013) was affected by either behavior patterns affected by the client’s intellectual disability or by communication methods the staff were trained to use.

Other measures of nonverbal components of communication between interlocutors that have been studied with RQA or CRQA include postural coordination, facial and head movements, face touching, and manual gestures (Louwerse, Dale, Bard, & Jeuniaux, 2012; Richardson, Dale, & Shockley, 2008; Shockley, Santana, & Fowler, 2003; Shockley, Richardson, & Dale, 2009). RQA and CRQA were used in one study each of L1 and L2 development comparing gesture and speech dynamics for preschool and early elementary aged children (de Jonge-Hoekstra et al., 2016; Sun et al., 2016). Both of these studies observed dynamic synchronization of within subject behaviors. To the best of my knowledge this study will be the first to observe SLD using recurrence analysis between subjects using adult L2 learners engaged in conversation.
Chapter 3: Methodology

Introduction

In this chapter, the methodology for this dissertation is described, including theoretical assumptions, participants, task, and data analysis. The purpose of this study is to explore the role of movement in SLD by using a combination of traditional SCT methods and dynamical modeling with cross-recurrence quantification analysis. SLD is observed in the context of a writing consultation between a second language English learner and a native English speaker.

The two research questions are:

1. What synchronous movement patterns emerge during dyadic interaction between a non-native English-speaking student and an ESL trained writing tutor?

2. How do embodied aspects of interaction, as determined through analysis of movement, relate to second language development?

To answer these research questions, a convergent mixed-methods approach is used to address qualitative and quantitative measurement aspects of each research question. Each RQ has been designed with a primary data analysis method focus. For RQ 1, CRQA is used to describe characteristics of interactional synchrony between two interlocutors via quantified movement time series. For RQ 2, qualitative analysis of movement, gesture, and co-speech gesture is used to identify key developmental events. Integrated data analysis will be embedded throughout the individual analysis of each RQ to inform findings of the primary analysis method (Fetters, Curry, & Creswell, 2013). The combined analysis will allow for qualitative and quantitative data sources to be compared as they relate to each RQ to produce a more complete account of the results as a whole (Creswell & Plano Clark, 2011).
Theoretical Assumptions

Converging Theories

The fields of social and psychological sciences have become increasingly engaged in research from a relational developmental standpoint (Overton, 2014). The shift in perspective from learning and development as individualistic, linear, and mechanically based towards perspectives that consider culture, context, and variability in their framework is supported by three separate but complementary theoretical standpoints. Following the traditions of Vygotsky, SCT embraces the social influences present in development and traces the emergence of higher order mental functioning to social origins as culturally-historically situated.

Complex dynamical systems theory considers development as a series of interactions occurring across numerous variables over time to cause non-linear adaptations within the system to maintain order within the system. Each interaction within the system has the potential to drive development as some interactions cause the system to teeter into a chaotic, or far from equilibrium state, where the system is triggered to self-organize and emerge as a qualitatively new form in a new state.

Lastly, the ecological approach is closely linked to the works of Bakhtin and the dialogical view of language (Holquist, 2002; Kramsch, 2004). Through the dialogues of human interaction, the person, situation and culture merge, creating meaning in context. Each of these three views additionally offers a framework through which embodied cognition can be supported as an integral aspect of learning and developmental processes.

Mixed Methods Analysis

Mixed methods research involves the collection and merging of qualitative and quantitative data sources (Creswell & Plano Clark, 2011). Mixed methods research has become
increasingly articulated and attached to research practices and has received support and recognized as a major research paradigm (Johnson, Onwuegbuzie, & Turner, 2007). Several working definitions are currently available for what constitutes mixed methods research, including what is mixed, where the mixing takes place, why mixing is carried out, and the orientation and breadth of the mixing (Johnson et al., 2007). The definition provided by Johnson and Onwuegbuzie (2004) has been selected to apply to this dissertation: “mixed methods research is the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study or set of related studies” (p. 17). This dissertation involves both the mixing of data sources (qualitative and quantitative) with the mixing of worldviews by borrowing research techniques and language from SCT, CDS, and ecolinguistics.

The research approach in the current study follows a convergent design. With the convergent design, the researcher performs simultaneous data collection both quantitatively and qualitatively during the same phase of research. Equal, or nearly equal, emphasis is placed on the quantitative and qualitative strands (Creswell & Plano Clark, 2011). Though each RQ has either a primarily quantitative (RQ 1) or qualitative (RQ 2) focus, data mixing is embedded throughout. For example, synchronous movement findings are primarily presented as quantified data, but qualitative findings from the video data are included to provide context and for explanatory purposes to bring meaning to the quantitative findings. This data triangulation is achieved through collecting multiple sources of data, such as interviews, observations, and artifact collection. The purpose is to reinforce the consistency of a finding (Yin, 2014). Conclusions made about the analysis of movement as it relates to both research questions in the final discussion will be associated with contributions from both analytic techniques.
Qualitative Research Theory

Qualitative research approaches, broadly stated, are concerned with the study of social phenomena. Qualitative research typically takes place in naturalistic contexts, using multiple interactive methods with emergent and evolving research designs (Marshall & Rossman, 2014). Through “a set of interpretive, material practices that make the world visible…qualitative researchers study things in their natural settings, attempting to make sense of or to interpret, phenomena in terms of the meanings people bring to them” (Denzin & Lincoln, 2000, p. 4-5). The qualitative researcher seeks to represent reality through exploring, explaining, or describing a phenomenon (Marshall & Rossman, 2014).

Qualitative researchers who embrace constructivism and relativism in their research designs emphasize local and specific constructed realities intrinsic to the research context (Lincoln & Guba, 2016). Educational and language development research based on constructivism view the learner as an active agent in the construction of their own knowledge, including previous experiences and negotiations made during the developmental process (Collentine & Freed, 2004). Constructivist methodology considers joint contributions such as the individual/social, historical/contextual dialectics. It also aims to reconstruct previously held constructions as they exist in real time as expressed through the context of the study (Denzin & Lincoln, 2000).

In this dissertation, the qualitative approach will be used for inductive analysis, which seeks to actively discover patterns, themes, and categories in the data (Patton, 2002). Through an inductive, or grounded theory, approach, the researcher immerses themselves into the data drawing on different theoretical perspectives (Richards, 2009). Understanding the role movement plays in SLD has not been restricted to interpretation through one existing framework,
but instead is expected to draw upon multiple perspectives that view learning in a holistic and context-dependent manner. The interpretations made will rely on thick description that embraces complexity through data triangulation and member checking (Marshall & Rossman, 2014).

**Quantitative Research Theory**

Traditionally positivist quantitative research methods argue that social science need be objective, suggesting that the truth about the reality of a phenomenon exists independently of the time and context in which it is viewed (Johnson & Onwuegbuzie, 2004). The quantitative methods used in this dissertation, namely the non-linear dynamical modeling, reject traditional positivism and embrace the ability to quantify patterns of development among noisy data.

The purpose of a dynamical systems approach is to collect as much information as possible about the system in order to track change and development of the system. Thelen and Smith (2006) stress the importance of developmental research with CDS covering many domains and levels of analysis. In their strategic approach, they suggest the following steps to CDS research design: identify the collective variable of interest, characterize the behavioral attractor states, describe the dynamic trajectory of the collective variable, and identify points of transition (Thelen & Smith, 2006). As a relatively unknown method, the dynamical CRQA movement analysis will provide new evidence for expanding perspectives about quantitative theory and approaches in developmental research.

**Microgenetic Study Design**

The microgenetic approach taken in this study design highlights the importance of process-based inquiry. Microgenetic study designs follow the moment-by-moment developmental processes that occur over short periods of time (Lavelli, Pantoja, Hsu, Messinger, & Fogel, 2005). As opposed to outcome-based study designs which measure development based
on measurable learning outcomes, microgenetic approaches were developed to focus on the *why* and the *how* of development (Siegler & Crowley, 1991). Understanding development requires an understanding of how development actually occurs online, in real time, and can be observed across multiple levels of time scales (Granott & Parziale, 2002). Observing changes in understanding at the micro-level are fundamental to understanding changes on the macro-level of longer developmental scales (Lavelli et al., 2005).

Microgenetic approaches were developed as an alternative to traditional research approaches that use cross-sectional or longitudinal data (Kuhn, 1995). While longitudinal studies enhance the likelihood that stable and unstable developmental patterns can be observed within individuals over time (versus cross-sectional designs), they do so in a limited fashion. Longitudinal studies most often used a limited number of samples with lengthy time intervals between each measurement. By sampling more densely, microgenetic approaches can detail the patterns of intra-individual variability that would be lost between samplings of traditional longitudinal studies as associated with the genesis of learning (Calais, 2008).

Some key characteristics of the microgenetic method include: 1) observation of the changing individual in interaction with others as the fundamental unit of analysis, 2) observations of development before, during, and after a period of rapid transition occurs and until the behavior reaches a relatively stable state, 3) a sampling rate of elevated density that is high relative to the rate of change of the phenomenon, and 4) intensive data analysis using both qualitative and quantitative methods (Lavelli et al., 2005; Siegler & Crowley, 1991). Also, relevant to this dissertation, a relational-historical specific approach relies on the identification of patterns of communication of real time sequences via quantitative developmental trajectories.
combined with qualitative description of historical emergence of change and stability within dyadic communication (Lavelli et al., 2005).

Overall, the microgenetic approach is concerned with change processes, bringing forward the nature of transitional developmental states and allowing for identification of conditions under which change is likely to occur (Lavelli et al., 2005). Microgenetic study designs are amenable to being used with SCT and CDS perspectives. Within SCT research framework, the causal-genetic method offers a lens through which all activity is viewed as shared activity. To understand how intrapsychological functions form, the researcher must first observe the interpsychological space in which the learning activity takes place (Geist, 2008).

Observing the formation of abilities and knowledge as they are constituted but before they become automatic reflects Vygotskian theory specifically within the ZPD (Granott & Parziale, 2002; Lavelli et al., 2005). As has been discussed previously, frequent observation of developmental change has shed new light on development from several perspectives (Larsen-Freeman & Cameron, 2008; Thelen & Smith, 1994; van Geert, 1998). Both SCT and CDS perspectives utilize the microgenetic study tool to be able to demonstrate development after what appear to be learning failures, not only after successes (Siegler & Crowley, 1991). Microgenetic approaches are underutilized in educational research and their increased use has the potential to broaden current perspectives on learning and developmental patterns.

**Data Collection**

A flowchart of the overall study design is available in Appendix A as a visual supplement to the following sections on data collection and data analysis.
Participants

The participants in the study includes pairs of non-native English-speaking students (NNES) with ESL trained writing tutors selected from two institutions of higher education located in the Southwest United States (U.S.). The students and tutors were selected via stratified purposeful sampling to meet the study criteria. Purposive and criterion based sampling strategies are common in qualitative studies and are used to facilitate comparison between cases and regulate quality assurance (Marshall & Rossman, 2014).

The tutors were recruited by recommendation from the writing center director and were screened by the researcher through and informal interview and pre-participation questionnaire (Appendix B).

The first tutor, Abby, is a graduate student working on her master’s degree in TESL (teaching English as a second language). She holds a TESL certificate and has 20 years of experience working with English language learners (ELLs). Abby splits her time between teaching English language courses and tutoring with the writing center. She is passionate about working with ELLs and describes her approach as student-centered and communicative. When she can, Abby borrows from specific pedagogies to structure her teaching approach.

The second tutor, Bailey, is an undergraduate student who has worked as a writing consultant for 2.5 years. She completed training with the writing center for structured tutoring of various aspects of English writing. Bailey reported that she takes a holistic approach towards tutoring, working beyond grammar to develop writing skills as a whole by focusing on content and format. She was specifically recommended by the writing center director for her ability to work successfully with ELL students. Bailey is a native-English speaker and a conversational Spanish speaker. Bailey noted that she enjoys working with ELL students because of her
personal experience helping her parents (who are both native Spanish speakers) improve their English while she was growing up.

Students for the study were initially recruited through classroom visits to English 113 and 114 classes, which are required courses for international students. Despite encouragement from all the English 113 and 114 instructors, there was a low response rate to participate in the study. An additional round of recruitment went out to the university education department, which filled the additional recruitment needs.

Each student completed the student version of the pre-participation questionnaire (Appendix C) to confirm s/he met the following criteria: The student is at least 18 years old, identifies as NNESs, was not born in the United States, and completed formal schooling in their native language.

A total of 12 qualified students were observed for the study. Seven students met with Abby and five students met with Bailey. Because the nature of the analysis does not rely on traditional statistical methods, a large sample size was not required for the study. The quantitative analysis is largely exploratory and will be presented descriptively. The qualitative analysis is treated as a multiple case study with analysis of highlighted developmental events.

The purpose of the selected size of sample is to provide enough data to observe varied accounts of interaction, while also being able to establish patterns within the interactions for each tutor. Additionally, use of the microgenetic method allows for only one meeting per dyad. The emphasis is on collecting enough data to capture developmental events. Small sample sizes are common in microgenetic studies (Calais, 2008; Sun et al., 2016).
Task

Each dyad (one L2 student/one tutor) met for one 45-minute writing consultation session to discuss a writing sample that the L2 student provided. The length of the actual sessions varied based on the needs of the student and ranged from 21 to 53 minutes. The writing sample was any class paper or project that a student is working on for a course (referred to subsequently as the ‘writing sample’). The writing sample was not limited to any specific subject area, the only requirements were that the sample include a demonstration of the student’s use of the English language for academic purposes to express original thought. It was important that the student brought her/his own writing sample to provide meaningful context in which the student has a vested interest in the quality of the writing product.

The instruction was given to each pair to discuss freely the writing sample provided by the student. Because part of the purpose of this study is to observe natural patterns of interaction, an intervention was not a necessary component to include. During the discussion, the tutor reviewed the student’s writing and engaged the student in a discussion about lexical, syntactic, and semantic characteristics of the writing.

Equipment and Set-up. The student was asked to bring two copies of their writing sample so each person could have their own copy to write on. The pair sat side-by-side at a table each with their own copy of the writing sample place in front of them. A Canon D70 camera was placed approximately 8ft in front of the pair\(^2\) to mitigate obtrusiveness of the camera that might have affected the interaction.

\(^2\) A rear camera was also placed behind the pair to capture the writing but was not used for final data analysis.
All but one\textsuperscript{3} of the consultations were recorded in the same room under the same conditions. To control for the introduction of extraneous noise into the motion extraction data, there was no natural light entering the room, the pair were placed in front of a plain wall and were seated in chairs that could not roll or spin. Once the session began, the researcher left the room to eliminate any interference her presence may have had on the actions of the pair, returning when the pair had concluded the session. Due to recording limitations of the Canon D70, the researcher returned at the 30-minute mark to check the equipment and start a new recording clip.

\textbf{Additional data.} When available, original writing samples and follow-up writing samples completed after meeting with their tutor were collected as additional data to aid in analysis for RQ 2. The original writing sample served as a reference during the discourse analysis portion of the data analysis for RQ 2. The second draft of the writing sample was used for comparison with observed developmental events also identified in RQ 2.

Finally, informal member check interviews were conducted on an as-needed basis after the first round of qualitative data analysis. This gave the researcher an opportunity to confirm assumptions about any moments in the discourse and increases validity of the research (Creswell & Miller, 2000). Fossey, Harvey, McDermott, and Davidson (2002) describe that member checking is common in qualitative study designs given that a principle aim of the research is to involve the participants’ perspectives through her/his own interpretation of their responses, which eliminates researcher bias during analysis.

\textsuperscript{3} Due to a room scheduling conflict, participant Beau was moved to a different room and recorded under similar conditions.
Data Analysis

The data analysis took place in separate phases to provide qualitative and quantitative analyses for research questions two and one, respectively, with merged analysis embedded into the primary analysis when applicable (Appendix A).

Quantitative

To answer RQ 1, a multi-step analysis began with quantifying the movements produced by each tutor and each student using Optical Flow software for PC (Barbosa & Vatikiotis-Bateson, 2006). A region of interest was selected around each participant to produce individual movement time series for each member of the dyad. The regions of interest were drawn to capture all upper body movements produced. The Optical Flow software produces movement time series using optical flow algorithm (Horn & Schnuck, 1981) which measures velocities of pixilation change from one frame to the next. The software automatically produces an Excel spreadsheet with directional and magnitude vectors for each frame of the video. Movement magnitude vectors were retained and down sampled to 10 Hz following recommendations based on the literature (Paxton & Dale, 2013b; Tschacher, Rees, & Ramsayer, 2014).

Next, time series for each student were divided into 2-3 segments for analysis. Though the dividing of a single interaction has not been previously used in the literature, this step of the analysis was included for two main reasons. First, during initial data testing for the subsequent section of analysis, the length of the time series (e.g. 27,000 data points for a 45-minute consultation) caused the R software to crash. Further testing revealed that a time series of up to 6,000 data points (10 minutes) was the maximum amount of data points the software would

---

4 The lower body was excluded from analysis because some participants wore long skirts which introduced artefactual movement into the data stream.
analyze. Upon consulting similar examples in the literature, it was determined that a maximum length of 10 minutes for analysis is common practice (Duran & Fusaroli, 2017; Paxton & Dale, 2013a).

Second, the nature of the data was amenable to being divided into segments. Unlike previous studies which have captured topic-bound conversations in controlled settings (Duran & Fusaroli, 2017; Paxton & Dale, 2013), the present study placed less restriction on the interaction. As is expected in a natural setting, the observed interactions contained topic shifts and other conversational variabilities, especially given the length of time allowed for the interaction. Also, because the present data was collected in a natural context, there were other uncontrolled factors that lead to extraneous movement being introduced into the data. For example, occasional paper shuffling, drinking from a water bottle, or checking a cell phone were all instances of extraneous movement that occurred to differing degrees during each of the writing consultations.

Given the considerations listed above, the following criteria were developed to divide each writing consultation into individual segments:

1. The segment was no shorter than seven minutes and no longer than 10 minutes in length.
2. When possible, the segment started and ended during natural conversation breaks or topic shifts.
3. No segment was to contain more than three noticeable interruptions to natural movement patterns (e.g. excessive paper shuffling or handling of objects other than a pen/pencil).

After applying the listed criteria, between 1-3 segments were able to be identified for analysis for 11 of the 12 participants. Table 1 displays segment lengths for each participant included in the movement analysis. One dyad (tutor: Bailey with student: Mei) was unable to be included in the movement analysis because the participants were placed in chairs that swiveled,
causing extraneous movement in the data. Also, participants Juan and Jun only had one segment able to be included for analysis. In Juan’s case, numerous overlapping movements occurred between the dyad because Juan continuously reached to point at the copy of the paper in front of Abby. For Jun, movement measurement was interrupted when Bailey brought her laptop over to the table which then blocked the ability to view her movements.

Table 1

<table>
<thead>
<tr>
<th>Tutor</th>
<th>Student</th>
<th>Consultation Length</th>
<th>Segment 1 Length</th>
<th>Segment 2 Length</th>
<th>Segment 3 Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abby</td>
<td>Beau</td>
<td>53:00</td>
<td>8:51</td>
<td>9:32</td>
<td>7:33</td>
</tr>
<tr>
<td>Abby</td>
<td>Grace</td>
<td>33:00</td>
<td>8:51</td>
<td>8:10</td>
<td>──</td>
</tr>
<tr>
<td>Abby</td>
<td>Alex</td>
<td>29:00</td>
<td>7:18</td>
<td>8:36</td>
<td>──</td>
</tr>
<tr>
<td>Abby</td>
<td>Emma</td>
<td>45:00</td>
<td>8:55</td>
<td>9:05</td>
<td>──</td>
</tr>
<tr>
<td>Abby</td>
<td>Annie</td>
<td>48:00</td>
<td>7:45</td>
<td>7:19</td>
<td>8:44</td>
</tr>
<tr>
<td>Abby</td>
<td>Julia</td>
<td>47:00</td>
<td>9:15</td>
<td>9:38</td>
<td>8:31</td>
</tr>
<tr>
<td>Abby</td>
<td>Juan</td>
<td>27:00</td>
<td>9:05</td>
<td>──</td>
<td>──</td>
</tr>
<tr>
<td>Bailey</td>
<td>Cam</td>
<td>41:00</td>
<td>7:50</td>
<td>7:10</td>
<td>8:33</td>
</tr>
<tr>
<td>Bailey</td>
<td>Lily</td>
<td>52:00</td>
<td>8:39</td>
<td>7:09</td>
<td>8:52</td>
</tr>
<tr>
<td>Bailey</td>
<td>Mina</td>
<td>51:00</td>
<td>8:37</td>
<td>9:25</td>
<td>8:46</td>
</tr>
<tr>
<td>Bailey</td>
<td>Jun</td>
<td>21:00</td>
<td>8:37</td>
<td>──</td>
<td>──</td>
</tr>
</tbody>
</table>

*Note.* Consultations that could not be divided into three segments are indicated by a dash.

After the segment division was completed, each time series was plotted on a line chart for visual inspection of the movement patterns and to identify whether unexpected noise appeared in the data (See Chapter 4 for details).
CRQA

For the next portion of the analysis, time series for each member of the dyad were analyzed in R (package crqa) to obtain information about the characteristics of interactional synchrony between each dyad. The pattern of recurrent points present can reveal characteristics of the hidden structures within the shared dynamics of the pair of interlocutors such as, the overall coordination between the pair (RR), diagonal line profiles (DET, Lmax, L), and predictive strength of the model (rENTR) (Coco & Dale, 2014). This aspect of data analysis allowed specific focus on the complex nature of the reciprocal relationships among the developmental system (Marwan, Romano, Thiel, & Kurths, 2007). The goal of the analysis is to capture the dynamical nature of the behavior without overestimating stable or noisy periods (Sun et al. 2016). The duration of each tutoring session segment (7-10 minutes) provided an adequate duration of time to yield dense data with the possibility of displaying recurrent patterns.

Synchronous movement. The type of interactional synchrony measured by this portion of the analysis is specifically movement synchrony. The CRQA determines which movements are synchronous based on temporal and magnitude measures. Thus, recurrent synchronous behavior is not required to be matched in form, though it is possible that some synchronous movement may be form-matched. Seminal research in the field of coordinated movement by Bernieri (1988) defines movement synchrony as “precise timing and coordination of movements to coincide with the timing or rhythm of the movements of another” (p. 121). Synchronous movement can be thought of as ‘marching to the beat of the same drummer’ (Bernieri, 1988). More specifically, behavior matching (as mimicry or mirroring) focuses on the similarity of appearances (Chartrand & Lakin, 2013).
Therefore, throughout the analysis and discussion, I will use the term synchronous movement to refer to temporally coordinated movement that is matched by ratios of change in movement magnitude. I will use the terms mirroring or mimicking when qualitative data is available to confirm similarity of movement appearances. Though the terms mirroring and/or mimicking may be insinuated with the notion that one person is leading the movements, in the literature behavioral mimicry is defined as two people engaging in the same behavior at the same time (Chartrand & Lakin, 2013). Should it be visible that one member of the dyad leads mirrored/mimicked movement behavior, this will be specified.

**Qualitative Analysis**

The qualitative data sources were primarily used to answer RQ 2. Qualitative data sources included: video recordings, writing samples, pre-participation questionnaires, member check interviews, and researcher notes taken during the first phase of video analysis. This portion of the analysis relied on the selection of developmental events that occurred during the writing consultations. A developmental event can be described as a series of interactions that produces a change in language use. Microgenetic development generally presents itself through problem solving activities such as making structural or grammatical corrections in the writing or rephrasing the writing. These developmental events are also referred to as **rich points** (Agar, 1994). The researcher is tasked with connecting, or translating, rich points from the data source to the target perspective (the study reader) for understanding. An important note on rich points is that the researcher does not know what the rich points are going to look like until data analysis begins (Agar, 1994).

First, the questionnaire data were assembled for descriptive purposes to provide context to understand the experiences and circumstances each person brings with them to the study.
Context is inherent to each of the theoretical perspectives considered in this study. Second, the video data from the front camera was viewed at least two times by the researcher to take observational notes about the interaction, with specific focus on identifying developmental events in the data. Developmental events were marked for follow-up analysis using ELAN 5.0.0-beta software application to complete gesture and speech transcription. Speech transcription notation symbols adapted from Atkinson and Heritage (1984) and Olsher (2008) were used in addition to McNeill’s (2005) extensive codebook for gesture transcription (see Table 4). The goal of the analysis was to fully capture the discourse events occurring in speech, gesture, and other bodily movements such as pauses, intonation, gesture type and positioning, etc. Transcription of the entire video feed was not necessary (Marshall & Rossman, 2014) and was limited to the developmental events of interest as demonstrated in previous studies (Lazaraton, 2004; McCafferty, 2002; Smotrova & Lantolf, 2013).

After the initial (phase 1) qualitative data analysis, an informal member check follow-up interview took place with student participants for the purpose of supplying ecological validity. By confirming assumptions drawn by the researcher about the contextual elements of the interaction, the researcher reduces the influence of their own biases on the data (Fossey et al., 2002). The member check can also serve as an additional layer of data if the participant is able to identify details within the data the researcher did not initially uncover.

**Merged Analysis**

Each research question was designed to capture different aspects of understanding how interactive movement patterns behave in the present dyadic interactive context. These research questions were designed with a broad approach to leave open multiple possibilities for the role of movement in an SLD event. By collecting and analyzing data qualitatively and quantitatively...
through multiple theoretical perspectives, a rich account of how movement behaves in this SLD context can emerge. For the merged analysis, characteristics observed in the dynamical movement analysis were compared to other characteristics observed in the gestural and affective patterns present in the qualitative and contextual analyses.

A common challenge with the merging of data in a mixed methods approach arises from attempting to combine the otherwise conflicting positivist versus constructivist theoretical viewpoints (Johnson & Onwuegbuzie, 2004). In this dissertation, the metatheoretical worldview of *relationism* (Overton, 2014) provides the foundation for both the qualitative and quantitative separate analyses, therefore making the mixing of the data more amenable to comparative analysis. The mixing of the data brought the qualitative perspective into RQ 1 by identifying specific events in from the video analysis that exemplified patterns observed in the quantitative findings. The mixing of data or RQ 2, however, was quite limited. Because the developmental events selected for analysis during RQ 2 were short in length, they could not be individually assessed with CRQA. Also, some of the developmental events occurred during parts of the interaction that were not measured with the original CRQA.

Overall, the merged data analysis contributed to providing a fuller account of the role of movement in SLD.
Chapter 4: Findings

Chapter Overview

This chapter is divided into two main sections to display findings for each research question separately. Part I reports findings for the synchronous movement analysis completed to answer RQ 1 and Part II reports findings for the embodied aspects of development completed to answer RQ 2. Each of the two main sections will include a section overview, findings, and a section summary.

Part I: Synchronous Movement Findings

Overview

The purpose of the synchronous movement analysis is to examine how two interlocutors (individuals in a conversation) grow to have similar behavior, cognition, and emotion over time (Paxton & Dale, 2017). Though a range of terminology has been used in the literature to approach the study of intrapersonal and interpersonal activities in tasks involving dyadic cooperation, I use the term *synchrony* to describe temporally matched movement behavior (Paxton & Dale, 2017). Synchronous movement behaviors may or may not be form matched (i.e. mimicked) as the measurement is based on magnitudes of movement.

It is important to note that while synchrony takes places on multiple levels (i.e. linguistic, embodied, and social), the results presented are focused on the aspects synchronous movement, specifically.

To answer RQ 1, quantitative and qualitative data analyses were completed. As stated previously, interactions for 11 of the 12 participants were divided into segments to eliminate extraneous movement events from the data and for observation of changing dynamics over the course of an interaction. First, quantified movement data for each participant were examined
visually by inspecting matched behavioral time series plotted per selected time segment. Next, the time series were time delayed and embedded into higher dimensional space to form CRPs. Individual measures of complexity were then extracted from the CRPs using CRQA to report on the patterned structures within the CRPs (see Chapter 2).

While it was expected that synchronous movement findings would be primarily informed by the quantified movement data, an additional qualitative layer of synchronous movement results were also identified from the video data. These results are included as visual evidence to complement the synchronous movement results provided by the quantified data and to provide a more comprehensive view of synchronous movement events that occur during the dyadic interaction.

Overall, the findings indicate that tutors and students synchronize their movements during a writing consultation. The patterns of synchrony that emerge from the noisy behavioral data vary in their degrees of complexity, such as the length and amount of shared movement patterns. Further, no clear influence of the tutor on the patterns of synchrony was noted, indicating that the interactions are highly individualized to each dyad.

The findings for Part I are presented in a descriptive manner, focusing on identifiable attributes and trends in the data. When applicable, trends are reported at the tutor-group and selected dyad levels, as well as for the study population as a whole. Additional details are provided in each section of the findings.

**Quantified Time Series Comparisons**

The first portion of analysis for the quantified movement time series involved visual inspection of time series for observation of interactive movement behavior trends and to identify the overall quality of the data before completing the CRQA. The visual inspection relied
primarily on plots of the time series and is supplemented with information about summed movement totals. The summed movement totals are presented first and are then referred back to during the presentation of the movement time series plotted data.

**Summed movement totals.** To assist with the descriptive data analysis of the visual plot characteristics, a table displaying summed movement totals for the members of each dyad is provided in Table 1. The summed movement totals are the sums of the movement magnitude measures for each participant per segment. Because the movement totals are sensitive to both movement frequency and movement size, a participant with higher summed movement totals is classified as having moved more than a participant with lower values. That is, the individual with a greater movement total may have either moved more frequently, produced larger gestures, or a combination of the two compared to their partner.
### Table 2

**Summed Movement Totals**

<table>
<thead>
<tr>
<th>Tutor</th>
<th>Student</th>
<th>Segment</th>
<th>S Movement Total</th>
<th>T Movement Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beau</td>
<td>1</td>
<td></td>
<td>1255.6</td>
<td>1722.4</td>
</tr>
<tr>
<td>Beau</td>
<td>2</td>
<td></td>
<td>883.7</td>
<td>1141.8</td>
</tr>
<tr>
<td>Beau</td>
<td>3</td>
<td></td>
<td>1280.5</td>
<td>1919.0</td>
</tr>
<tr>
<td>Grace</td>
<td>1</td>
<td></td>
<td>882.0</td>
<td>1076.1</td>
</tr>
<tr>
<td>Grace</td>
<td>2</td>
<td></td>
<td>886.5</td>
<td>1051.0</td>
</tr>
<tr>
<td>Alex</td>
<td>1</td>
<td></td>
<td>997.6</td>
<td>862.1</td>
</tr>
<tr>
<td>Alex</td>
<td>2</td>
<td></td>
<td>1669.8</td>
<td>1080.3</td>
</tr>
<tr>
<td>Emma</td>
<td>1</td>
<td></td>
<td>1130.3</td>
<td>1113.3</td>
</tr>
<tr>
<td>Emma</td>
<td>2</td>
<td></td>
<td>1269.6</td>
<td>1179.5</td>
</tr>
<tr>
<td>Annie</td>
<td>1</td>
<td></td>
<td>934.1</td>
<td>1131.3</td>
</tr>
<tr>
<td>Annie</td>
<td>2</td>
<td></td>
<td>816.5</td>
<td>1222.5</td>
</tr>
<tr>
<td>Annie</td>
<td>3</td>
<td></td>
<td>1201.4</td>
<td>1247.8</td>
</tr>
<tr>
<td>Julia</td>
<td>1</td>
<td></td>
<td>1545.4</td>
<td>1235.9</td>
</tr>
<tr>
<td>Julia</td>
<td>2</td>
<td></td>
<td>1348.7</td>
<td>1349.1</td>
</tr>
<tr>
<td>Julia</td>
<td>3</td>
<td></td>
<td>1249.5</td>
<td>1547.3</td>
</tr>
<tr>
<td>Juan</td>
<td>1</td>
<td></td>
<td>1138.6</td>
<td>1673.0</td>
</tr>
<tr>
<td>Cam</td>
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*Note.* The movement data is represented as magnitude of pixilation change per frame.
Because the lengths of the time series are different for each segment, the summed movement totals can only be discussed on a case by case basis for who moved more within a segment. In the absence of movement data normalized for time series length, it is not possible to say whether or not one tutor moved more than the other overall or whether certain students moved more than others. Instead, the primary use of the summed movement data is to confirm who moved more in a dyad per segment and as an indicator of movement trends from one segment to the next within a dyad. A closer analysis of individual segment totals will be presented in the following section for selected cases.

Presently, it is possible to compare one case to another in terms of which dyad member moved more in each segment. For example, Abby moved more in each measured segment for three of her pairings: Beau, Grace, Annie. Meaning, Abby moved more across the entire writing consultation than did Beau, Grace, or Annie. Abby also moved more than Juan, but the pair were only able to be measured for one time series segment during their consultation.

Conversely, Abby moved less in both segments with Alex and in both segments with Emma, though the differences in movement totals for Emma were small. The case of Julia with Abby was different from the others, with Julia moving more in the first part of the consultation, both of the dyad members moving equally (1348.7 for Julia and 1349.1 for Abby) in the middle of the consultation, and Abby moving more in the final measured segment of the consultation.

As a trend, Abby moved more overall than the students she was paired with, but not in every case. It was also observed that in five of the six cases where multiple segments were measured for an interaction, either Abby or the student moved more in each measured segment. Abby only had one pairing (Julia) where there was a trade-off between which person moved more and this trade-off evolved over time.
Bailey participated in four dyads included in the synchronous movement data. Three of Bailey’s dyads were able to be measured with multiple segments of interaction. For these three cases, Bailey moved more in all three segments with Lily and in all three segments with Mina. However, Bailey moved less that Cam in all three of their measured segments. These observations continue the trends noted from Abby’s data: the tutor more often moves more than the student, and this movement trend is observed for the duration of the consultation.

**Plotted time series.** Prior to running CRQA, it is recommended that time series data are plotted for visual inspection (Richardson, 2017). Because the CRQA is based on reconstruction of the time series data in a multi-dimensional phase space, it is important to have a general understanding of how the data behaves before submitting it to further analysis.

Quantified movement data time series plots were created for the members of each dyad by selected time series segments. Each plot displays movement magnitudes produced for each member of the dyad by video frame number using a sampling rate of 10 Hz. Given that each frame represents $1/10$th of a second, a time series of 5,000 points is equivalent to approximately 8 minutes, 20 seconds and a time series of 6,000 points is equivalent to 10 minutes.

**Outlier screening.** As displayed in Table 1, 26 total time segments were analyzed for 11 of the 12 dyads, which means 26 movement plots were created. First, for purposes of data quality screening, each plot was checked for outliers. As can be viewed in Figures 2-7, several instances of more individual isolated large movements occurred in the data. Time points were identified for these instances of sudden large movement spikes and revisited in the video data. For example, in Figure 4, Abby produced a large movement at time point 2426 (magnitude value = 1.545). In the video data, this movement occurred at minute 8:03 and was created by Abby moving both arms in a large, circular pattern gesture produced with the co-speech “category.”
As in, Abby was drawing a circle to represent a category. Additionally in Figure 4, at time series point 5169 (magnitude value = 1.411), Abby produced another movement of large magnitude. The video data was used to confirm that this spike in the data was again produced by large co-speech gestures and was not due to measurement error.

**General movement patterns.** Overall, each of the movement time series plots displays alternating fluctuations between periods of movements with greater magnitudes and periods of lower magnitudes. Most of the movement data is concentrated in a range of lower movement magnitudes, with all movement plot examples displaying several smaller bursts of momentary increased activity. Meaning, students and tutors were both prone to periodic isolated bursts of high magnitude movement activity. These proportionally larger movements were most often unmatched by the other member of the dyad (see Figures 4 and 5), though the movement plots alone are not enough evidence to conclude whether larger, isolated movements occur as part of movement synchronization or as a result of other interactions taking place in the context of the complex environment.

In the interest of identifying patterns of interactional movement synchrony, the movement plots provide early evidence that synchronized movements are likely shared movement patterns of smaller magnitudes. It is also evident that, as expected, the dense, behavioral data is noisy. While only a limited amount of information can be gained from visual inspection of noisy data, the plotted time series data provide an important screening tool and initial layer of evidence about interactional movement patterns.

**Selected time series plots.** Though all movement plots were checked during data analysis, only selected dyads are presented below as examples of the types of movement trends that were present. Figures 2-7 display two movement pattern time series for selected dyads:
Cam and Bailey, Grace and Abby, and Alex and Abby. By selecting three individual cases, a closer analysis of interactional movement patterns in the dyads is possible.

**Cam and Bailey.** The plots for Cam and Bailey were selected to show a comparison between a segment with a high recurrence rate\(^5\) (RR = 4.35) and a segment with a low recurrence rate (RR = 2.25). The summed movement totals for segment 2 are 1153.0 (Cam) and 1032.8 (Bailey). Summed totals for segment 3 are 969.5 (Cam) and 834.3 (Bailey). This provides evidence that movement patterns were increased for both participants in segment 2 over segment 3, and by similar amounts. Cam’s movement difference was 183.5; Bailey’s movement difference was 198.5 (Table 2).

Time series data figures for segments 2 and 3 of Cam and Bailey’s interaction show variable movement patterns cycling between brief periods of lower amounts of movement and higher amounts of movement. Comparing the paired displays of segment 2 (Figure 2) and segment 3 (Figure 3), it is observed that overall movement levels are increased in segment 2 compared to segment 3. For example, the largest movement spike in segment 3 has a value of 1.06 (Bailey), while all other movement spikes are below the 1.00 level. In segment 2, the largest movement spike has a value of 1.44 (Cam) and is produced during a burst of higher level activity. When revisiting the video data, it was observed that this cluster of higher movement occurred when Cam performed self-adaptor gestures including, raising both hands to brush back his hair, adjusting his glasses, and adjusting his clothing.

The patterned fluctuations between periods of high and low movement activity display shared characteristics in both segments. Clusters of high movements appear concurrently in sections such as from (approximately) time point 900 to time point 1700 in segment 2, and time

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\(^5\) Recurrence rate values are discussed in the CRQA Results section.
point 2000 to time point 2400 in segment 3. Clusters of concurrent movement activity bursts throughout the entire time series, appeared to be early evidence of turn taking. For example, the movement spikes do not overlap, but rather show a switching back and forth between movement spikes in similar regions. Refer to Figure 2 to see the movement spikes between time point 1759 and time point 2783 in segment 2.

*Figure 2.* Cam and Bailey: segment 2. The movement data is represented as magnitude of pixilation change per frame.
Figure 3. Cam and Bailey: segment 3. The movement data is represented as magnitude of pixilation change per frame.

**Grace and Abby.** Grace and Abby were selected as an example of a case with noticeable isolated movement outliers in the data. Upon first glance, the interactions between Grace and Abby also display greater variability than did the interactions between Cam and Bailey. In segment 1 (Figure 4) and segment 2 (Figure 5), less clustering of higher and lower pockets of movement occurred. Instead, individual movement spikes are displayed only by Abby.

The summed amounts of movement are consistent between the two segments. Also, Abby moved consistently more across both segments than did Grace. Abby’s summed movement totals are 1076.1 (segment 1) and 1051.0 (segment 2), and Grace’s summed movement totals are 881.9 (segment 1) and 886.5 (segment 2).
While more blue is visibly present (Abby) in the figures than gray (Grace), patterned movement clustering does appear. For example, in segment 1, between (approximately) time point 3000 and time point 3300, Grace displays a burst of movement activity immediately followed by a burst of movement activity by Abby. Also in segment 1, a cluster of activity for both participants appeared from (approximately) time point 4500 to time point 5000. Within this cluster, Grace and Abby both produce larger movements compared to the smaller movement pockets before and after this cluster, however Abby’s movements appear larger in magnitude.

In segment 2, an additional example of both participants shows a cluster of higher movement activity between (approximately) time point 1500 and time point 1900. Again, Abby’s movements appear higher in magnitude, though movement activity increased for both dyad members. This evidence suggests that despite Abby’s movements being larger in magnitude, both participants appear to phase through clusters of higher movement activity during the same periods of time.
Figure 4. Grace and Abby: segment 1. The movement data is represented as magnitude of pixilation change per frame.
Figure 5. Grace and Abby: segment 2. The movement data is represented as magnitude of pixilation change per frame.

Alex and Abby. Alex and Abby provide another example of how interactive movement patterns unfold over the course of a writing consultation. This dyad was selected to show an example of larger magnitude movement patterns forming clusters versus isolated spikes of larger movement activity. In Figures 6 and 7, Alex’s movements are visibly greater in magnitude over extended periods of time. In Figure 6, a period of shared movement patterns stems from series points ~700-1500 with two clusters of increased movements separated by a phase of lower movement activity. A phase of larger movements is visible for Alex from time points 1540-3016. Alex additionally has two main groups of increased movement activity followed by scattered increased movement after point 4000.
In Figure 7, both Abby and Alex increase their total movement produced in the segment. Alex increases his total movement activity by 672.2 between segment 1 and segment 2 and Abby increases her total movement activity by 218.2 between segments 1 and 2. In segment 2 (Figure 6), there are two main clusters of movement for Alex. The first cluster appears from time points ~400-1600, and the second cluster appears from time points ~2000-4000. Abby’s movements magnitudes stay well under those of Alex, though there is indication of some patterned movement magnitude variation between the two members of the dyad. Though their movement magnitudes are markedly different, both Abby and Alex appear to oscillate between periods of lower and higher magnitude movements.

*Figure 6. Alex and Abby: segment 1. The movement data is represented as magnitude of pixilation change per frame.*
Figure 7. Alex and Abby: segment 2. The movement data is represented as magnitude of pixilation change per frame.

Quantified Time Series Comparison Summary

The initial analysis of the quantified movement data demonstrated that the movement patterns are highly variable for all measured dyads, though a few patterns were identified across the data. First, while the tutors are more likely to move more than the students, in a few cases the student produced greater movement totals. Next, it was common to observe large, isolated movement magnitude values for either the student or the tutor, which could be traced back to the video data. Lastly, movement magnitude values generally fluctuated between cycles of small movements and cycles of larger movements. Evidence points to these cycles of movement that
show interaction between the student and the tutor, though the noise in the data makes this assumption somewhat speculative.

The next step in the analysis, performing CRQA, will transform these movement time series into a multidimensional phase space to systematically analyze recurrent patterns, i.e. interaction, between the two members of each dyad. This stage of the analysis will provide numerical representation of the measures of complex phenomena that characterize the nature of the interaction between each pair, thus providing a level of detail unable to be drawn from the unidimensional movement time series plots.

**CRQA Results**

**CRPs.** To begin the recurrence analysis, the two time series trajectories are plotted in a multidimensional phase space to compare shared recurrent behaviors between the two members of the dyad. In order to achieve the ability to compare the two independent systems within the same systems phase space, the series are time delayed and embedded by a given dimension, also called *delay embedding* (Marwan et al., 2007). Recurrence events are then extracted from the phase space trajectory plot and mapped on a cross-recurrence plot (CRP) to visualize shared recurrent behaviors between the two movement data streams. Constructing a CRP is a way of viewing synchronization as a “combined spatial and temporal behavior matching” (Louwerse et al., 2012, p. 1405). The CRP serves as an intermediate step in the process of transforming the behavioral time series into data that can be analyzed for cross-recurrence. The figures are primarily a reference tool used to represent recurrence in a less abstract manner than the CRQA output numbers alone.
Figures 8 and 9 were selected to display examples of CRPs for a higher recurrence interaction (Figure 8, RR = 4.31) and a lower recurrence interaction (Figure 9, RR = 2.14). In each CRP, time is displayed along the X and Y axes with respect to each of the compared time series. In both examples, time for the student’s movement series is placed on the X axis, while time for the tutor is placed on the Y axis. A blue dot indicates a time when a behavioral state of one system matched the behavioral state of the other measured system. For any given times $i$ and $j$, in which the behavioral states of the student and tutor did not match, the space is left white.

Visual inspection of Figure 8 and Figure 9 reveals two main structural features: diagonal lines and vertical bands. The diagonal lines indicate shared recurrent patterns that extend for some period of time. The imposed black lines on the figures represents the line of incidence (LOI) where behavioral patterns would be entrained, or matched, at the same time for each member of the dyad. The diagonal line structures which fall directly above the LOI indicate instances where the student initiated the matched movement pattern. Conversely, diagonal lines falling directly below the LOI indicate tutor-initiated recurrent behavior.

Vertical bands that appear on the CRPs represent movement patterns that were revisited over the course of the time series. The vertical line structures are visibly noticeable in Figure 8, which has the higher overall recurrence rate (RR). More white space appears in Figure 8 in between the diagonal and vertical line structures on the plot. In Figure 9, this white space is filled in with more diagonal line structures. Closer examination of specific measures of diagonal and vertical line segments in the following section will reveal that a higher percentage of points are falling along diagonal lines (40.39%) in Figure 8 than in Figure 9. This indicates that the diagonal lines are on average, longer in the higher recurrence example. This is confirmed by
referencing the longest max line measure (Lmax), which is only 11 in Figure 9, but is 69 in Figure 8. The measures of complexity thus far indicate varying levels of complexity between two compared movement segments. Individual measures of recurrence, diagonal lines and vertical lines will continue in the following section.

Figure 8. Lily and Bailey: segment 2. Cross-recurrence plot (CRP) with RR = 4.31. The CRP is a matrix indicating synchronized movement patterns between the student (x-axis) and the tutor (y-axis). A blue dot indicates matched movement patterns for any two times \((i, j)\) on the matrix. Time is represented on the x-axis and the y-axis as \(1/10^{th}\) of a second per unit. This matrix represents 7 minutes 09 seconds.
Figure 9. Cam and Bailey: segment 1. Cross-recurrence plot (CRP) with RR = 2.14. The CRP is a matrix indicating synchronized movement patterns between the student (x-axis) and the tutor (y-axis). A blue dot indicates matched movement patterns for any two times $(i, j)$ on the matrix. Time is represented on the x-axis and the y-axis as $1/10^{th}$ of a second per unit. This matrix represents 7 minutes 50 seconds.
Measures of complexity. Cross-recurrence quantification analysis was used to examine recurrent structures between the time series for the student and the tutor during each interaction. Each reported measure quantifies the visible structures in the CRPs based on recurrence point density and the diagonal and vertical line structures of the CRP (Marwan et al., 2007). The analyses presented below report on the trends present across the data for each of the CRQA measures.

Measures of recurrence density. Recurrence Rate (RR) is the percentage of recurrent, or behavior matched, points falling within a specified range called a radius. Recurrence is a measure of the density of recurrent points in a recurrence plot, or more specifically the probability that a point will return to its designated neighborhood in phase space (Marwan et al., 2007). The range of the RR is set to return a recurrence model fit between 2% and 5% (Coco & Dale, 2014). Because data for complex systems is inherently noisy, the RR is set to a low percentage as an acceptable threshold to eliminate noise from being included in the model.

RR’s in for this study ranged from 2.14 to 4.85 with seven of the segments falling in the 2% range, 11 of the segments falling in the 3% range, and eight of the segments falling in the 4% range (Table 3). All of the segments in the 3% range occurred in interactions where Abby was the tutor. Bailey’s segments were either in the higher recurrence range (six segments in the 4% range) or in the lower range (5 segments in the 2% range).

Examining the range of recurrence rates within individual interactions is possible for nine of the 11 participants. Since Abby’s interactions primarily fell in the 3% RR range, there was less variability within individual interactions. On the other hand, each of Bailey’s three participants (Cam, Lily, and Mina) experienced RR’s in the 2% range and also in the 4%. This
demonstrates that behaviors of basic recurrence can change over the course of a single interaction.

**Measures based on diagonal lines.** Diagonal line structures in the CRP reflect shared recurrent patterns that extend for some period of time. Measures based on the diagonal line structures include DET, Lmax, and ENTR (Marwan et al., 2007):

- DET, or percent determinism, measures the percentage of recurrence points that form diagonal line in the recurrence plot. Determinism is considered a measure of predictability of the system. Deterministic processes, as opposed to uncorrelated or chaotic behavior, exhibit longer diagonal structures with less isolated recurrence points.

- Lmax reports the length of the longest diagonal line in the segment. The shorter the Lmax, the more chaotic the signal (Webber & Zbliut, 2005).

- ENTR measures the Shannon entropy of the probability of finding a diagonal line of a given length \( l \) in the CRP. Entropy serves as a measure of complexity with respect to the diagonal line lengths. A simple system will have entropy levels approaching 0.0; a low entropy indicates that model fits the data with a high level of predictability (Gates & Liu, 2016).

Looking across the data for all the dyads, the percentage of recurrence points occurring along diagonal lines (DET) ranged from 27.67% (Mina with Bailey) to 65.07% (Annie with Abby). The range of values was not evenly distributed: 17 of the 26 segments had DET values below 50%, and 9 had DET values above 50%. The longest individual diagonal lines per segment ranged from 11 (1.1 seconds) to 192 (19.2) of recurrent matched behavior patterns. There is no relationship between the DET and the Lmax. For example a segment with an overall low DET will not necessarily have a single long period of recurrence within the segment. The
longest Lmax of 192 was observed during a segment of 44.81% DET. Similarly, a shorter Lmax of 16 was observed during a segment of 65.07% DET. One way to interpret this is to argue that segments fit with a lower predictability model along the diagonal lines can still contain valuable information in regard to the longest single matched behavior pattern within that segment.

Further, entropy values (ENTR) examine complexity as it relates to the variation in diagonal line lengths distributed throughout the measured segment. ENTR values range from 0.65 to 1.63. There are no set values listed in the literature for what constitutes a low versus high entropy for psychological behavior data, so these ENTR values will be interpreted in relation to one another. Given the stated range of observed ENTR values, there is evidence to suggest that the complexity of the diagonal line structures does vary across the segments.

**Measures based on vertical lines.** Vertical line structures display information for the tendency of the system to return to a given neighborhood\(^6\) within the system’s phase space. Whereas diagonal line structures measure recurrence points with respect to unfolding time, vertical line structures measure how similar recurrence points are revisited over time. Vertical line structures can be imagined as attractor states where behaviors tend to get ‘trapped.’

Laminarity (LAM) is the deterministic measure of vertical line structures. The LAM values in this data set range from 41.75% to 80.64%. The LAM values exhibit similar patterns to the DET values for diagonal line structures. There is a tendency for lower LAM values to match with lower DET values, and vice versa. For example, in segment 2 of Mina and Bailey’s interaction there was a 41.75% LAM with a 27.67% DET. Also, segment 3 of Cam and Bailey’s interaction has a 43.39% LAM with a 32.23% DET. On the higher end, Lily and Bailey’s

\(^6\) See Figure 1, p. 62 for a description.
segment 3 has respective LAM and DET values of 79.63% and 60.45%. Julia and Abby’s segment 1 additionally has values of 80.64% and 60.41% for LAM and DET, respectively.

Trapping time (TT) estimates the mean length of vertical line structures. A threshold of 2 was selected as the minimum accepted length for a line (Coco & Dale, 2014). The observed TTs ranged from 2.55 to 5.31. A total of 13 of the segments have observed TTs in the 2 range, while 10 of the segments have TTs in the 3 range. Only three of the segments have a TT of 4 or greater.

Evidence suggests a relationship between TT and LAM. Segments with a smaller percentage of recurrence points falling into vertical line structures (LAM) also tend to have smaller observed TTs. The two shortest TTs (2.55 and 2.58) co-occur with LAM values of 42.48 and 45.96, respectively. The two longest TTs of 4.71 and 5.31 co-occur with LAM values of 79.63 and 80.64, respectively.
Table 3

_CRQA Results_

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110
Variability among the CRQA Findings. Findings indicate that recurrence varies from one dyad to the next, and also within individual dyads. No clear influence of the tutor appears in the CRQA results. Instead, a range of recurrence complexities are observed across all measures and all cases. To understand recurrent movement behavior in the dyads, each recurrence measure must be interpreted in relation to the other measures. I will structure the findings of synchronous movement variability around the global measure of recurrence rate (RR). In previous studies, the RR has been used as a primary measure of synchrony, with differences in RR attributed to experimental conditions (Duran & Fusaroli, 2017; Paxton & Dale, 2013a; 2017). Presently, I seek to understand variability in RR by 1) comparing how RR variability relates to variability in the other measures of complexity, and 2) comparing RR’s to observable movements and other information in the video data and the movement charts. The movement synchrony variability will be discussed across and within the dyads.

Cross-case Comparison. Using the global measure of RR as a starting point for comparison, it was observed that high and low recurrence events occurred across multiple dyads. There were no dyads that coordinated exclusively in the low range nor exclusively in the high range, and the time point during the conversation did not influence the RR. Additionally, English proficiency did not appear related to RR considering there were low and high RR values observed among speakers of different English ability levels. Low RR segments occurred in the 2 range and the high RR occurred in the 4 range. Observed RRs do vary in the literature depending on the type of data collected and the parameters chosen for modeling the systems, similar studies have described interactions with lower coordination in the 2 or lower range and higher coordination in the 3 or higher range (Shockley, Santana, & Fowler, 2003).
The three low RR segments are Cam with Bailey (segment 1, RR = 2.14), Lily with Bailey (segment 3, RR = 2.23), and Grace with Abby (segment 2, RR = 2.27). The three high RR segments are Lily with Bailey (segment 1, RR = 4.60), Annie with Abby (segment 2, RR = 4.67), and Mina with Bailey (segment 3, RR = 4.85). Closer examination of RR as compared to other complexity measures can uncover relationships between the RR and the structures in the CRPs, which can help account for RR variability. For example, I will first compare measures of DET, ENTR and Lmax with the low and high RR groups, respectively.

The percent of points falling into diagonal line structures (DET) does vary in the set of low RR segments (35%-60%). Additionally, the entropy measures (ENTR) observed included the lowest ENTR of the entire data set (0.65) and the highest ENTR of the entire set (1.63). The low DET and low ENTR both occurred with Cam and Bailey’s segment 1 and also included the lowest diagonal max line (Lmax) of the entire data set. This is a strong indication that there was a lower incidence of synchrony during this portion of Cam and Bailey’s interaction.

Alternatively, during Lily and Bailey’s low RR segment (3), the DET and ENTR were both the highest of the entire data set (60% and 1.63). Though the Lmax for Lily’s segment 3 was only 34 (3.4 seconds) in duration, the average diagonal length (L) (3.44) was the second longest L in the entire data set. This relationship indicates that there were a number of synchronized movement patterns that occurred in shorter, but still meaningful, durations of time. Unlike with Cam, the additional measures of complexity for Lily’s segment 3 do not indicate a low incidence of overall synchrony. In fact, all of Lily’s segment 3 measures were some of the highest in the whole data set.

Considering the final low RR event from the selected examples (Grace and Abby, segment 2), Grace’s other complexity measures do not provide any further substantial evidence
for a clear relationship between the RR and the other measures of complexity. From these three examples, it has been demonstrated that relying on the RR as the only measure of complexity may lead to a weak characterization of the interactional synchrony present. A low RR measure can occur in conjunction with other low complexity measures, but also a low RR measure can occur in conjunction with additional high complexity measures.

Similarly, in the higher RR segments, there was a range of DETs (40%-60%). This suggests that the ratio of recurrent points falling into diagonal line structures is not alone informative about the quality of the diagonal lines themselves, or more generally about the amount of meaningful synchrony. Because the threshold for what constitutes a diagonal line was set at a value of 2 (per Coco & Dale, 2014), there is a possibility that the DET measures could have been influenced by brief, stochastic movement couplings. As an alternative to DET, I can compare the length of the longest shared synchrony to the RR. For example, the Lmax of 106 (10.6 seconds) observed during Mina and Bailey’s segment 3 (RR = 4.85) coincided with a lower DET (40%). Though the complexity of Mina’s diagonal line structures was moderate (L = 2.42), this could be a relationship present between multiple longer diagonal structures and the higher observed RR.

This postulation is strengthened by the observation of a similar co-occurrence between Bailey and Lily’s segment 1 between the Lmax (105) and a higher RR (4.6), though the DET in this case was also higher (57%). Interestingly, in the final high RR example, Annie and Abby’s Lmax was shorter (36) with a higher DET (60%), which counters the previous argument for a relationship between the Lmax and the RR but doesn’t rule it out completely.

Further insight into possible relationships between the low RR segments and the high RR segments was explored by returning to the video footage. During the low RR events, all three
dyads were discussing argumentative essays provided by the students. In Cam and Lily’s lower RR segments, the dyads were engaged read-aloud activities. Bailey read Cam’s essay, while Lily read her essay. However, in Grace’s low RR segment, she and Abby were reviewing an outline of Grace’s essay. The pair had already completed reading the outline and the discussion during their segment was addressing the content of one of Graces’ proposed counter-arguments for her essay. Specifically, Abby spent time explaining to Grace that while the counter-argument was a strong argument, it did not fit the topic she presented in the paper’s introduction.

During each of the low RR segments, the tutors were speaking more and had more co-speech gesture activity. Cam/Bailey (1) and Lily/Bailey (3) each had pencils in their hands and were writing notes during the interactions, while Grace and Abby (2) had set their pencils down on the table. Because Grace and Abby were engaged in a more conventional style conversation (not reading through a document), their bodies were oriented towards each other and there were longer turns between which member of the dyad was speaking.

Lily and Bailey’s interaction also had a high RR segment in which they were engaged in a read-aloud with a different argumentative essay Lily brought to the session. The topics of discussion for the other two high RR segments were different in nature. In Annie and Abby’s high RR segment, the pair had just finished reviewing the outline Annie brought to the session when Annie asked Abby if she could explain the difference between a colon and a semi-colon. The focus of this segment became primarily instruction focused with interaction from Annie who frequently checked her understanding out loud. Also, in Mina’s high RR interaction with Bailey, the pair had finished reading through the document Mina brought with her and were engaged in reviewing Bailey’s recommendations for the strategy Mina should use to continue editing her document on her own after the session ends.
Comparing the information from the video content, there are varied conditions leading to both low recurrence interactions and high recurrence interactions. In each of the low RR and high RR examples, the tutor does contribute more spontaneous utterances (utterances that are not from reading the content of the paper) and therefore more co-speech gesturing. This is not unexpected considering the role of the tutor is to offer their feedback and suggestions. Though the traditional roles of tutor and student are observed in the exchanges, the stronger verbal presence of the tutor does not appear to affect the ability of the pair to synchronize their movements. Also, the students are not purely observing the tutors but are actively engaged in the sessions as well. The students exhibit physical behaviors such as following along the paper with their pencils, alternating their gaze between the paper and the tutor, and turning their body towards the tutor during longer turns in the conversation. The level of engagement from the students does not vary between the low and high recurrence examples.

Additional inspection of the movement charts reveals no further evidence for differentiating the low RR examples from the high RR examples. Each of these six movement charts exhibit cycles of lower movement activity and higher movement activity, including a few occasional large jumps in the movement data. Further, there was no relationship between movement total values and the RRs. In fact, during Annie and Abby’s segment 2 - where the largest movement total difference was observed from across all measured segments – a high RR was measured.

From this exploration of low and high RRs observed across the 26 movement segments analyzed, there was no clear association between the additional complexity measures from the CRQA, the video data, nor the movement charts. Interactional synchrony measures such as RR were not affected by tutoring activity, e.g. reading the paper aloud versus more conversationally
oriented dialogue. RR as a global measure of synchrony also appears unperturbed by large spikes in the data caused by brief, larger movement patterns produced. RR instead appears more sensitive to the smaller, nuanced movements that may be otherwise undetectable through other qualitative data analysis.

**Within-case comparison.** Dividing the interactions of each dyad into smaller segments provides an opportunity to examine how CRQA measures vary over the course of a single interaction. Some dyads exhibited more stable measures across their segments while other dyads showed greater variability across segments. Previous studies have evaluated how RR evolves over the course of an interaction (Richardson & Dale, 2005, Richardson, Dale, Tomlinson, & Clark, 2008), however there are no studies I am aware of that have compared other recurrence measures variation over time. Individual case analysis allows for these observations to be made over the time course of the interaction.

**Cases with less variability.** The cases of students Julia and Beau exhibited the least variability in CRQA measures across each of their three segments compared to the rest of the dyads. This indicates that the interpersonal synchrony between the dyads of Julia/Abby and Beau/Abby remained at more constant levels throughout their interaction.

Each of Beau and Abby’s measures did increase slightly as the interaction unfolded, which suggests an increased synchronization of body movements as the dyad interacted. Though the CRQA measures appear to be detecting the movement synchrony less visible through qualitative analysis, there was a noticeable change in movement patterns during the course of Beau and Abby’s interaction. For example, Beau repeatedly performed self-adaptor gestures. Most frequently, he turned to rub his chin on his shoulder. During the first half of their interaction, Beau did this 16 times, but then he ceased performing the action during the second
half of the consultation. This may be an indicator of how their shared synchrony increased over
time.

Julia and Abby’s measures were more variable than Beau and Abby’s, but more stable
than other dyads. Their interaction started with higher coordination in the first segment,
specifically a higher RR, more overall diagonal lines, and a higher complexity of line lengths.
The RR, DET, and Lmax dropped during the second segment and remained about the same
during the third segment though their max synchronized movement pattern increased to 16
seconds in the last segment (up from 7.6 seconds and 6.3 seconds in the first two segments). The
focus of conversation during segment 1 was different from the other two segments.

In segment 1, Abby asked Julia a few questions about the essay Julia brought with her
and what Julia wanted from the session. Julia provided lengthy answers to these questions and
therefore the pair didn’t begin reading through the document until the start of segment 2 (at
minute 9:45 of the session). During segment 1, Julia faced Abby and placed one or both hands
above the table where she frequently gestured in a large gesture box. Abby’s body was oriented
towards the table where she periodically wrote notes on her paper. However, Abby’s gaze
remained on Julia. To contrast, the pair spent most of their time reading during segments 2 and
3. This caused their bodies and gaze to be oriented towards their papers more than towards each
other. The difference in body orientation and movements produced during the different
conversational topics may have influenced the levels of movement synchrony.

*Cases with more variability.* All three of Bailey’s cases that were able to be measured
over multiple segments returned RR values in either the 2’s or the 4’s, with each dyad having at
least one of each. Individual segments for Cam, Lily, and Mina were previously discussed
during the low and high recurrence segments section and will be revisited briefly to expand.
Cam and Bailey’s interaction began with a lower RR, jumped to a higher RR, and the returned to the lower RR. Their measures of DET, L, and ENTR remained more stable, however. Additionally, Cam and Bailey’s Lmax values increased considerably from 1.1 seconds, to 5.4 seconds, and 17.7 seconds, over time. While the RR suggests a changing level of complexity over the segments, other measures suggest more stable synchrony. The suggestion of more stable synchrony is further reinforced by the lack of movement pattern differences observed in the video analysis. Therefore, using a group of measures to characterize synchrony provides evidence that though the RR increased during segment 2, the higher recurrence detected was likely due to an increase in random recurrence during that segment.

An argument on similar grounds can be made for Lily and Bailey’s third segment. Their first two interactions returned RR’s of 4.60 and 4.31, while their third was 2.23. However, the low RR segment had the highest DET, L, and ENTR values of all three segments. Here, there is evidence to support the claim that though the RR was low, the increased complexity present in the diagonal line structures indicated more interactional synchrony. For Cam/Bailey, the high RR segment contained more recurrent points not in diagonal line structures which suggests an over-estimated RR due to increased chaotic behavior. For Lily/Bailey, the opposite appears to be the case. Their low RR segment is underestimated because there were less chaotic recurrences and more complexity represented in the diagonal line structures.

The video data shows that Lily and Bailey did switch from reviewing one essay to a different essay in the third segment. The movement patterns observed also show that there was a longer period of silent reading where Lily placed both her hands under the table, blocking her arms from being measured. The more typical movement pattern observed during silent reading was having both members of the dyad following along their papers with a pencil in hand.
Though Lily did pick up her hand to make a correction and then resumed following along with her pencil, the ~26 seconds she placed her hand under the table may have lowered the RR. Once the pair resumed more verbal interaction and produced more body movement, the interactional movements (as reflected by higher diagonal recurrence measures) were synchronized.

Lastly, Mina and Bailey’s RRs were low in the first two segments (2.50 and 2.91) but increased to the highest RR out of all 26 measured segments (4.85). Though Mina’s DET measure was higher in segment 3 over segments 1 and 2, there were still a relatively low proportion of recurrence points forming diagonal structures (41%). There were no other recurrence measures indicating an expected high RR, therefore the evidence suggests that the 4.85 RR was overestimated similarly to Cam and Bailey’s increased RR in segment 2.

**Qualitative Synchronous Movement Findings**

RQ 1 was originally designed as a quantitative analysis of synchronous movement patterns between the dyads. However, while watching the video recordings of the writing consultations, examples of synchronous movement presented themselves occasionally as brief shared movement patterns caught by the naked eye. To demonstrate, two examples have been selected from the video data to provide a visual account of synchronous movement patterns that took place during the writing consultations. Both examples are very brief, lasting no more than five seconds. These brief interactions were analyzed frame-by-frame (30 Hz) to inspect the pair’s coordinated movements down to the 30th of a second. Each example is presented with screenshots of the coordinated movements and descriptions of the context in which the movement events took place.

**Lily and Bailey.** The following example takes place during minutes 39:01-39:06 of their writing consultation. Lily and Bailey have completed reviewing one of Lily’s essays and are
transitioning to read her second essay. In Figure 10, Bailey has just asked Lily if she is comfortable with reading her essay out loud again. Lily replies “sure” and lifts her left arm off the table (Figure 10, image a), rolls her left shoulder back (Figure 10, image b), and circles her body back down to the table. Bailey reacts by also forming a fist with her left hand and picking up her left arm of the table (Figure 10, image b) saying “okay!” Here, Bailey has mimicked Lily’s arm motion, both with hand shape formation and direction of the movement. The pair also share mirrored body positioning: each has their gaze fixed on their paper, their right forearm on the table with their pen/pencil in their hand. Both have lifted their torso extended up in image 2 and then lower their postures back down towards the table in Figure 10, image c.

After this brief movement pattern lead by Lily, Lily then pulls both elbows to the table, giggles and drops her head. The pair lock gazes as Bailey adds, “if you don’t…” and Lily interrupts, “I like reading!” (Figure 11, image a). Bailey replies, “oh!” at which point the two both immediately sit up together (Figure 11, image b) and pause briefly as Bailey says, “then good!” and sits her torso back up (Figure 11, image b). Lily’s body reacts immediately by also sitting up. Her reaction is so quick, the two complete the sitting up action together and, at this point, Bailey has completed her statement with “that’s good!” The two then turn their heads (Figure 11, image c) back to their papers, Lily’s left arm tucks back (Figure 11, image d) and lowers to her lap (Figure 11, image e). By Figure 11, image f, both of their torsos have assumed
mirrored postures, sitting up at approximately the same angle, with the left shoulder dipped down. Also, between Figure 11, images e and f, both women synchronize their right arm movement beginning with each of their right elbows pulling back slightly and then sliding diagonally in front of them (Figure 11, image g) as their torsos lean forward. The shared movement sequence finishes (Figure 11, image h) with their torsos leaning forward and their left shoulders still lowered.

*Figure 11. Lily and Bailey’s synchronous movement example (part 2)*
Figure 12 shows an additional detailed view of the mirrored body positioning the two share in the final image of the sequence including the angles of their shoulders, their gaze, left arms pulled back and right arms placed diagonally in front of them. Note that although Lily has her right arm under the table, the two still synchronized the motion of moving the arm across their bodies to settle at similar angles.

Figure 12. Lily and Bailey’s synchronous movement example (part 3)

**Cam and Bailey.** The following example between Cam and Bailey takes place at the beginning of their interaction (minute 1:26-1:30) just as Bailey has finished reading Cam’s assignment instructions from his phone. Bailey indicates that she is done reading by saying “yeah,” sitting up and flipping her head to the right to get her bangs out of her eyes (Figure 13, images a-d). About half a second after Bailey begins to sit up, Cam also starts to sit up (Figure 13, image c). As they are sitting up, the two both rotate their gaze off of the phone (lying on the table between them) and towards their own papers (Figure 13, images d-f). Also during this time, Bailey picks up her right hand off the table and turns it palm down to one corner of the paper. Cam follows this action by turning his right palm down. Cam also lifts his left arm off the table and shifts it back to match the angle at which Bailey has her arm placed on the table as well.
(Figure 13, image f). The two both briefly lift the corner of the page where their right hand is hovering, though Cam lifts his corner just before Bailey lifts hers.

The two both slightly adjust the papers in front of them (Figure 13, image f), and as Bailey begins to say “so…” they both shift their gaze towards each other and Cam crosses his left arm back in front of him to open up his posture towards Bailey (Figure 13, images g-h). Bailey completes her statement “…you’ve been to the writing center before” and also pulls her left arm back to open up her posture towards Cam. By the final image (Figure 13, image h), the two have mirrored body postures as if the posture of one of the bodies is reflecting the other.
Figure 13. Cam and Bailey’s synchronous movement example (part 1)

Figure 14 shows a detailed view of the mirrored body postures Cam and Bailey displayed in the final image of the previous sequence, including the positioning of the gaze, the angle of the shoulder, the outside arm placed diagonally in front of the body, and the inside arm retracted back to open the posture towards the partner.
Qualitative Findings Comparison

Some similarities and differences between the two qualitative synchronous movement events are presented. The similarities are: both events lasted about the same amount of time (4-5 seconds), both events demonstrated synchronized movement during a transition from one activity to the next, and both events demonstrated that members of a dyad do not need to be looking at each other in order to synchronize movement. The first difference between the two examples is that Cam and Bailey’s synchronized movement event occurred right at the beginning of their writing consultation (the second minute) and Lily and Bailey’s event occurred towards the end of their writing consultation (the 40th minute). The next difference is that the student (Lily) was more of the leader in her event, while the tutor (Bailey) was more of the leader in Cam’s event. Also, while both of the pairs ended up with synchronized body positions at the end of their events, Lily and Bailey’s postures were shared but Cam and Bailey’s postures were mirrored.

Merged Synchronous Movement Findings Summary

Part I of the findings presented quantitative and qualitative accounts of synchronous movement patterns that emerged during the writing consultations. Both levels of the analysis found that dyads consisting of a tutor and a student synchronized their movements during their interactions. Evidence from the video analysis and the CRQA measures (specifically the average
length of diagonal line structures) suggests that synchrony is brief, occurring over a few seconds at a time. These synchronous events, though brief, are visible when analyzed closely through video data.

Findings also indicated that the tutors more often moved more than their student counterparts, but some of the students moved more than the tutors. Also, whoever moved more was likely to do so consistently throughout the writing consultation. Despite this consistency, the measures of recurrence showed levels of recurrence complexity evolving throughout the consultation, which means that the characteristics of the shared movement patterns were unlikely to be related to overall movement amounts displayed by either participant. Synchronous movement is, perhaps, related to what is occurring during different time points in the interaction. For example, synchronous movements appeared during a topic shift. The discussion section will elaborate further on the complexities of the synchronous movement patterns.

Comparison of different cross-recurrence indices indicated that there is a high amount of variability in synchronous movement complexity both across and within the dyads, none of which can be attributed to a particular trend in any single measure. Rather, by comparing the measures in relation to one another, and to qualitative aspects from the video data, some trends did appear. Importantly, there was no identifiable impact of the tutor, the student’s level of English, or the topic of discussion on movement synchrony. This suggests that synchrony arises as a result of the joint activity between students and tutors and can be achieved within different contexts.
Part II: Developmental Events Findings

Overview

The second half of the study findings is dedicated to answering RQ 2: how do embodied aspects of interaction, as determined through analysis of movement, relate to SLD? I analyzed SLD through identification of key developmental events in the data. A developmental event was classified as a series of interactions that produces a change in language use. This analysis relied primarily on the 8 hours and 17 minutes of video data from the writing consultations, but also included collected writing samples, pre-participation questionnaires, member check interviews, and researcher notes.

Four examples of developmental events have been selected to present in the findings. These four examples were selected to highlight four different aspects of language development observed during the consultations which provides a range of developmental possibilities. First, student Beau resolves a grammatical issue with his tutor, Abby. Second, student Alex overcomes a verbal hindrance while discussing the activity of writing itself with his tutor, also Abby. Next, student Lily resolves a lexical error in her writing by restructuring a phrase with assistance from tutor Bailey. Last, student Julia assesses how clearly she has expressed her ideas during a section of her essay with tutor Abby.

Although it would have been desirable to represent each of the tutors equally (Abby is the tutor for three of the four examples), the chosen examples were primarily motivated by the development taking place on the part of the student. This provided me the ability to present a range of developmental events as well as examples with students who have differing degrees of
English proficiency. The examples are ordered by English proficiency level starting with Beau (pre-intermediate), then Alex (upper intermediate), Lily (advanced), and Julia (proficient)\(^7\).

Overall, the results indicate that bodily movement plays a role during a range of SLD events. The ways in which movement is incorporated into development varies by student proficiency level, language task, level of involvement of the tutor, and environmental affordances. The following examples also provide evidence that movement plays a role in development specifically at the microgentic level. By analyzing the movements made during developmental events, an observer can “see” development unfolding.

To help the reader grasp the reporting of the developmental events, the data are presented using transcription analysis using verbal and gestural transcription (Table 4). Screenshots from the video data are interwoven into the transcriptions for pictorial representation of bodily movements. The reader should attend to movement details such as body positioning, gaze, pencil placement, and gestures. Also, due the long length of transcriptions for the entirety of each developmental event, only sections of transcription are included with each example in this chapter. Full transcriptions of each event can be found in Appendices D-G.

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\(^7\) Levels are based on a combination of researcher observation and student reported levels of English proficiency and are researcher estimates of proficiency levels. Proficiency levels were selected using the English level overview guide at https://www.embassyenglish.com/resources/english-levels
Table 4

Transcription Legend

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<th>Symbol</th>
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<tr>
<td>text</td>
<td>dog</td>
<td>Speech with gesture</td>
</tr>
<tr>
<td>text</td>
<td>dog</td>
<td>Speech with other body motion (with or without gesture)</td>
</tr>
<tr>
<td>()</td>
<td>((smiling))</td>
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<td>( )</td>
<td>(dog)</td>
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<td>( )</td>
<td>(dog/dock)</td>
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<td>: do:g</td>
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<td>. dog.</td>
<td>Falling intonation</td>
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<td>, dog.</td>
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<td>? dog?</td>
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<td>(CAPs) DOG</td>
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<tr>
<td>= dog=gone</td>
<td>Continuation with no stress</td>
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<tr>
<td>[ ] [dog] gone</td>
<td>Overlap with other speaker</td>
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</tr>
<tr>
<td>&lt; &gt; &lt;um&gt;</td>
<td>Filled speech pause</td>
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Abbreviations

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<tr>
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<tr>
<td>LH</td>
<td>Left hand</td>
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<tr>
<td>RH</td>
<td>Right hand</td>
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<td>BH</td>
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Note. Transcription symbols adapted from Atkinson & Heritage (1984), McNeill (2005), and Olsher (2008).

Example 1: Beau’s Event

Beau was an 18-year-old freshman studying graphic design. He only began studying English when he arrived in the U.S. with his family 2 years and 6 months prior to participating in
this study. He reported that on the average day he still speaks “mostly Thai language and often English.” Beau has used the writing center before upon recommendation from his teachers, but this was the first time he worked with Abby.

For this writing consultation, Beau brought with him a copy of an essay he was writing for his English class about his friends. He and Abby worked through the draft with a read-aloud by Abby, pausing when she found errors. Though Beau was supposed to bring two copies of his essay to the consultation, he only brought one, so the two shared his copy.

In this selected developmental event, Beau corrects an error he made in his essay with verb form agreement. Understanding his mistake requires much help from Abby, who approaches her explanation from a few different angles to help Beau understand the grammar mistake. The developmental event spans two minutes, starting from the time when Abby identifies the error until Beau completes the correction and the pair transition to a new topic.

The intervention begins when Abby identifies an error that Beau has made regarding parallel structure in his paper. The error comes from the following sentence: “it is a good thing that we have friends or a best friend because they can talk play and having fun with us.” After reading this sentence aloud, Abby proceeds by providing some instruction to help Beau understand the source of his error. She first describes that items in a list need to be in matching form and then asks Beau to identify which verb is different from the other two verbs in his list. He identifies that ‘having’ is different from ‘talk’ and ‘play,’ but is unable to tell Abby which form ‘having’ should be in. Abby continues by explaining to Beau that he has used two base form verbs and one gerund. She identifies that Beau used the modal verb ‘can’ in his sentence and after a short set of exchanges, Beau is able to correct his grammar to the form ‘have fun.’
During the interaction, Beau’s movements keep him engaged with the activity as an active listener. He seeks an alert, but comfortable posture, nods frequently, and follows Abby’s instructional movements with his gaze, an important aspect of which involves the use of her pencil as an instructional tool, incorporating the movement of her pencil into every aspect of her explanations. In the following section, Abby’s movements with the pencil will be analyzed first, followed by an analysis of Beau’s movements both reacting to and independent of Abby’s pencil movement.

**Abby’s movement.** The first movement Abby makes after reading the sentence from Beau’s paper is turning her body to a blank piece of paper on her left. She begins her instructional intervention by writing on the paper as she speaks. First, she writes a list on the blank paper (lines 8, 12, 14).

The following transcription is the initial exchange:

7. Abby: Whenever you have a list of things one thing (.) two things (.) and third thing (.hh They have to be the same form.) (.)

8. writes out a list

9. gazes towards Beau and back to the paper on the left

10. Beau: [nods, swerves head toward right shoulder, nods again]

11. Abby: it-they either need to be all nouns (.) or all verbs (.) or all adjectives (.) whatever. they can be any kind of word but they have to be the same [(1.0)]

12. continues writing on the list

13. tilts head to side and shrugs right shoulder

14. continues writing on the list

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8 The complete transcription of Beau’s developmental event is available in Appendix D.
15. pulls pencil off paper and nods in Beau’s direction

16. Beau: [nods once in agreement]

17. Abby: .hhh ((slowly)) So we have a list here (.5) o[f

18. leans body towards shared paper

19. Beau: [wipes face on right shoulder]

20. Abby: “can, talk, play, and having” which one is different?

21. traces pencil on shared copy ((as she reads the words))

22. pulls pencil off paper and hangs head to the left, leans into her left elbow

   After Beau is unable to answer what form ‘having’ should be changed to, Abby reaches
   back to the essay then to her paper to continue writing.

29. Abby: .hh well, I- ah ok so right now w-we have all verbs (.5) [but you have a]

30. sits up and shifts back to the left

31. draws three circles the pencil above the shared paper and then retracts RH

32. shifts body to the paper on the left

33. Beau: [cocks head right]

34. Abby: ((slowly)) base form verb, a base form verb, and an i-n-g verb [(5)]

35. writes on the paper ((Figure 15))

Figure 15. Beau’s event.
For the remainder of her instruction, each time Abby mentions either the indexed words on the essay or her written examples, she moves the pencil over the items she is referring to verbally. Once Beau has stated the grammar correction, Abby confirms that he is correct and briefly reiterates why while continuing the movements of her pencil (lines 95, 99, 103).

93. Abby: that’s right so you [i-n-g verb]
94. nods ((small))
95. points pencil once on the shared paper
96. retracts RH
97. Beau: [picks up pencil and writes on the shared paper]
98. Abby: needs to be base form just like these two
99. points pencil to the shared paper twice and ((quickly)) retracts RH
100. Beau: ((whispers)) okay
101. nods ((exaggerated)), retracts RH
102. Abby: that is always true with a list
103. draws a circle above the paper on her left
104. leans body left and places head into her LH

As observed in the selected excerpts from the transcription, Abby’s movement of her pencil between the two papers is concurrent with her verbal instruction. The pencil is used first to write parallel structure examples on her paper that will become a teaching tool. Then, the pencil is used to guide Beau’s attention back and forth between the two papers. Abby uses the pencil to create pointing, circling, or underlining gestures over each of the papers. With each gesture she makes, Abby explicates the details in her verbal instruction. Further, when Abby pauses her instruction, she retracts her pencil away from the papers, thus removing it from the
instructional space. Abby’s movements with the pencil between the two papers stays active through the end of the intervention.

**Beau’s movements.** To analyze Beau’s movements during the event, attention will be drawn to his posture, gaze, nodding, and self-adaptor gestures.

**Posture.** As the intervention begins (when Abby reads the sentence), Beau has his left hand on his chin, leans towards the paper with his gaze on the paper and has his pencil in his right hand hovering over the paper (Figure 16, image a). Once Abby identifies there is an error, Beau alters his body position. He sits up, sets down the pencil, crosses his arms and leans back down, now with his gaze on the paper in front of Abby (Figure 16, image b).

![Figure 16. Beau’s event.](image)

Beau’s changes in body position demonstrates a switching of activities. His initial position shows him in a relaxed but ‘thinking’ posture. He comfortably follows along the paper and is ready to make edits on the paper with pencil in hand. When Abby moves away from the shared paper and over to the paper where she is going to give instructions, Beau transitions from editing to listening. He sits up higher, no longer has his pencil in his hand, and tucks his arms into a crossed position. Beau’s left arm remains crossed in front of him for the remainder of the event and he does not pick his pencil back up until after he corrects his verb form.
**Gaze.** Beau’s gaze follows the movement of Abby’s pencil. When Abby retracts her pencil away from the papers, Beau keeps his gaze on the last location of her pencil. Beau removes his gaze from the direction of the pencil a few times to make quick glances towards Abby. One reason Beau shifted his gaze was after he answered one of Abby’s questions. In Figure 17, Beau shifts his gaze towards Abby for reaction to his answer (Figure 17, image b). However, as he answers, the intonation in his voice rises as if asking a question. This section of the event is as follows:

60. Abby: *should it be [‘can talk?’ O]r ‘can talking’?*

61. *points to the shared paper*

62. *shifts gaze towards Beau, nods ((once))*

63. Beau: *[gaze shifts to Abby and back to shared paper] ((Figure 17, image a))*

64. Beau: *((slowly)) can- (. ) I think ‘can talking’?*

65. *gaze shifts to Abby ((Figure 17, image b))*

---

**Figure 17. Beau’s event.**

66. Abby: *((gasps)) [.hh ‘can talking?’ ahhhhh oh, no!]*

67. *shifts gaze to paper on the left*

68. *pulls pencil towards paper on the left*
**Nodding.** Beau speaks little during the intervention, however he nods frequently in response to each point made in Abby’s instruction. For example, here are three instances of Beau nodding:

*Example 1.*

11. Abby: *it-they either need to be all nouns (.) or all verbs (.) or all adjectives (.) wha:tever, they can be any kind of word but they have to be the same [(1.0)]*

…

16. Beau: *nods*

*Example 2.*

29. Abby: *hh well, I- ah ok so right now w-we have all verbs (.) [but you have a]*

…

34. Abby: *((slowly)) base form verb, a base form verb, and an i-n-g verb [(,.5)]*

…

16. Beau: *nods*

*Example 3.*

81. Abby: *(1.5) So you- and you knew that here (.) “can talk”*

…

83. Beau: *yeah*

84. *nods*

While these are only three examples of Beau nodding, each example shows how Beau follows Abby’s instruction with his nodding. Despite his nodding in response to most of Abby’s instructions, his actions do not necessarily mean that he has comprehended what Abby is telling
him. This is evident as Beau requires further instruction following each of these examples. Instead, Beau’s nodding may be a cultural habit, a regulatory behavior, or both.

**Self-adaptors.** Finally, Beau exhibits three examples of self-adaptor gestures during the event. A self-adaptor generally involves self-touch but can include other movements made for regulatory purposes (Neff, Toothman, Bowman, Fox Tree, & Walker, 2011). Here are the three examples of Beau, displaying adaptor gestures:

*Example 1.*

10. Beau: *[nods, swerves head toward right shoulder, nods again]*

*Example 2.*

19. Beau: *[wipes face on right shoulder]*

*Example 3.*

45. Beau: *[tucks RH up behind right ear, scratches his neck, nods]*

Each of Beau’s self-adaptors were exhibited during one of Abby’s instructional component. Beau’s first self-adaptor occurred during Abby’s first line of instruction about parallel structure. His second self-adaptor happened when Abby made her first shift between her paper and his essay. His third self-adaptor occurred as she explained further that ‘talk,’ ‘play,’ and ‘having’ were not all in the same form.

On a final note, I read the version of Beau’s essay that he completed after the consultation to check for examples of parallel structure in his writing. He made several structural changes to his essay and the example he and Abby discussed was removed from his final paper. However, he did include another list which required applying the parallel structure rule. In his new example, Beau used the correct verb form agreement.
Example 2: Alex’s Event

Alex was a 21-year-old with freshman class standing who was still exploring majors, though he was interested in Biology. He is Cuban and is a native Spanish speaker. Alex never studied nor spoke English until arriving in the U.S. 2 years and 6 months prior to participating in this study. For comparison, Alex has been in the U.S. the same amount of time as Beau and also had not spoken English prior to arriving, yet his English conversational abilities were much higher than Beau’s.

This writing consultation was Alex’s first visit to the writing center. He participated in the study to help his English but also out of a desire to help with the study. Alex received high marks on the essay outline he brought in to review during the consultation, so his review of the outline with Abby lasted about 16 minutes. After they were done with the outline review, the pair stayed at the table and continued on with an open discussion about writing. In this developmental event, Alex is trying to convey something verbally to Abby, but is not able to immediately vocalize his thought. The development occurs as Alex progresses from thought to utterance. Unlike with Beau in the first example, the second event is short, spanning 30 seconds, and demonstrates oral language development occurring during a writing consultation and not as associated with the written product.

The event begins when Abby asks Alex about a previous assignment he completed for his English class called a ‘source evaluation.’ Alex remembers the assignment and starts to tell Abby about something his teacher gave to the class to help them complete their source evaluation. He calls this activity the ‘crab list.’ Before Alex can complete his statement about the crab list to Abby, he breaks from the thought to make two side statements. Then, he pauses
for a few seconds before completing his thought, which was to state that the purpose of the crab list was to “analyze each single point and see which one’s strong…”.

During this example, Alex displays constant co-speech gesturing as well as gesturing during pauses in his speech. His gesture patterns create a physical space for him to depict the crab list. This space is active from before he mentions the crab list through the time he completes his thought verbally. Each instance of Alex using the space to his left during the event is presented below.

**Alex’s gestures.** The first sign of the gesture begins during Alex’s first statement when he responds to Abby’s question if he had to do the source evaluation. His speech is broken as first, but he then responds as follows:

13. Alex: \_\_hh oh but=but <ah> I: I: \[I (. ) she\textsuperscript{9} \_\_ya- (. )\]  

\[...\]

16. Alex: *moves LH up but stops and places elbow on table*  
17. Abby: ((quietly)) \[did she ((inaudible))\]  
18. Alex: \_\_yeah she gave us-  
19. *LH still elevated, drops index finger in a straight line down*

In line 16, Alex first initiates the motion of his left hand moving upward (instance 1). Next, in line 19, Alex picks his elbow up off the table and makes a downward motion with his index finger (instance 2). Alex then interrupts his statement to mention to Abby that he got a good grade on the source evaluation. As Alex finishes his statement, he deictically indicates to the space on his left where he previously placed his left hand (instance 3).

\textsuperscript{9} Referring to his teacher
Next, Alex names the activity, first calling it the ‘crab list,’ then the ‘crab points.’ As he names the activity, he creates the shape of the letter ‘c’ and moves it towards Abby (Figure 18) (instance 4). When he renames the activity, he flattens his hand, but builds on the motion with two circular movements (Figure 19) (instance 5).

![Figure 18. Alex’s event.](image)

![Figure 19. Alex’s event.](image)

Alex then breaks from his thought to clarify that he knows the crab list is a metaphor, pointing to Abby, and then he returns to the gesture space. Next (Figure 20), he pauses his speech, making larger circling motions (instance 6) than previously. During this pause in his speech, Alex flicks his left wrist and momentarily makes a quick shift over to a new space on his right (Figure 21).
This shift is short-lived:

45. Alex: I analyze each single point. (. )

46. lifts LH back up, palm down

47. beats three times with pointer finger and thumb pinched close together ( (Figure 22 ))

48. drops LH to table
On line 45, he immediately turns to his left and performs beat gestures with his left hand as he finally describes the activity (lines 45-48, Figure 22). He then flicks his left wrist as he completes the thought and returns his hands to the table (lines 52-53).

During the event, Alex used gesture to create a physical space to depict the ‘crab points’ activity. He returned to the gesture space seven times over 20 seconds using it to materialize his thoughts in conjunctions with speech production, successively adding the needed gesture components each time he returned to the gesture space, as mirrored in his speech. The first three times he used the gesture space occurred before he mentioned the name of the ‘crab points.’ Specifically, during the first instance, Alex held his left hand, index finger raised, towards the space. In the second instance, he lifted the elbow up off the table and dropped his index finger downward. In context, the second gesture appears to be his finger running down the list that he is soon to mention.
After Alex introduces the ‘crab points,’ he returned to the space (instance 3) after making a side comment. In instance 4, he made his hand into a ‘c’ shape, perhaps to represent ‘crab’ as he first mentions the ‘crab list.’ In instance 5, he flattened the hand back out and added a circular motion which he repeated with larger circles during the sixth instance. Finally, during the seventh instance, the fingers closed to accentuate “each single point” of the crab list.

Importantly, during the larger circle motions (instance 6), Alex’s normal speech was paused. He had just completed a side comment and used filler speech (e.g., um) before he told Abby what he did during the activity. The circle motions of his hand were paired with this pause where he seemed to be thinking about what he was going to say. Then, when he turned his body briefly to the right (still during the pause), he moved his hands as if wanting to change his explanation. However, without saying anything, he returned to the original space on the left during the final statement of his thought. Thus, utilizing gesture space in his initial utterance through to his final statement. Once he completed the thought out loud, he rested his hands to the table.

**Example 3: Lily’s Event**

Lily was a 19-year-old freshman studying hospitality. She lived in the U.S. for one year prior to participating in the study, is a native speaker of Chinese and a self-reported advanced English-speaker. Lily has frequently visited the writing center and has worked with her tutor, Bailey, before. For this consultation, Lily brought with her two essay drafts, mostly in outline form. In the event, Bailey worked with Lily to restructure an argument Lily proposed placing in her essay. Lily’s event is the longest of the four examples, spanning 3 minutes and 20 seconds. There are several aspects of movement to draw attention to in relation to the transpiring of the event. First, I analyze how Bailey used co-speech gesture as a teaching tool. Next, I identify
patterns in Lily’s gaze shifting patterns that coincide with particular types of exchanges. Last, I provide examples of Bailey displaying other types of movements that are salient features of the interaction.

**Bailey’s teaching gestures.** At the start of the event, Bailey is reading a list of arguments Lily has proposed to include in her essay. She stops reading and asks Lily what she means by the phrase “make easily discernable from real life.” For context, here is transcription of the speech only for the initial part of the exchange:

1. Bailey: so this point “make easily discernable from real life” could you explain what you **meant by that**?

   …

4. Lily: [mmm] (1.5) you know maybe in the **not real life** <um>

   …

8. Bailey: **Ohhh** .hhh

   …

10. Lily: In the, (.) live in the video game (.5)

Next, Bailey begins to explain what the word ‘discernable’ means:

12. Bailey: Yeah <um> but discernable [(.) me]ans like it’s (1.0)

13. *shifts body up to face Lily, retracts hands to center*

   …

16. Bailey: **separating** [(.) you] know

17. *opens both hands up, palms facing each other*

   …

20. Bailey: no[w when you say “make easily sss- discernable” it’s like]
21. lowers RH to paper and draws a circle

... 

26. Bailey: it’s easily t- it’s easy to separate those things

27. pulls hands back to center, about chin level, as gaze shifts up

28. begins to stroke hands away from each other, and retracts (Figure 23)

29. completes the motion of the hands separating as gaze shifts to Lily

30. retracts and repeats the gesture one more time

During her explanation, Bailey uses co-speech gestures to illustrate actions associated with the word. Her first explanation, “it’s like separating” is paired with a gesture where her hands separate from each other on the horizontal plane with the palms facing each other (line 17). Next, she repeats the gesture once more as she says “separate” (as a verb). This time, her palms face down as she completes the stroke.

Next, Bailey completes her explanation:

33. Bailey: and to distinguish one from the other

34. pushes RH out in front of her ((Figure 24, image a))

35. pushes LH out in opposite direction ((Figure 24, image b))
Initially, Bailey uses gestures to illustrate the concept that if two things are easily discernable, they are easily separated. Her first explanation, “it’s like separating” is paired with a gesture where her hands separate from each other on the horizontal plane with the palms facing each other (Figure 23). Next, she repeats the gesture once more with the word “separate.” This time, however, her palms face down as she completes the stroke, changing the function of her hands to now represent metaphorical containers (for holding ideas). These containers then come to represent the “one” and the “other” as Bailey explains “to distinguish one from the other.”

At first, Bailey’s gesture emphasized an action, e.g. the act of separating. This gesture evolved to convey that the two things which separated are easy to distinguish from one another (lines 34-35, Figure 24). Later in the transcript, Bailey still uses her hands to represent the ‘two things’ when she says, “making these two things hard to separate” (Appendix F, lines 68, 74). This time, her hands are placed closely together, thus reiterating that they are hard to separate.

**Lily’s movements.** Throughout the event, Lily exhibits a gaze shift pattern where she looks forward, followed by looking either at her paper or at Bailey. This pattern takes place during moments where Lily appears to be thinking. In this first example, Bailey has just asked Lily what she meant by the phrase “make easily discernable from real life.” During a silent pause, Lily looks forward and answers:
4. Lily:  [mmm] (1.5) you know maybe in the not real life <um>

5. *looks up from paper straight ahead*

6. *looks back at Bailey*

   In this next example, Bailey has just finished her explanation of what the word ‘discernable’ means. Lily responds:

36. Lily:  ohhh [ok .] I got it*

37. *shifts gaze forward*

38. *shifts gaze to her paper*

   At the conclusion of the event, Lily rephrases her argument orally:

77. Lily:  oh yes (.5) I got it <um> .hh make children (.5) <um> ((slowly)) make real world

and virtual world (.5) ((quietly)) indistinguishable?

78. *shifts shoulders and looks straight ahead ((Figure 25, image a))*

79. *begins to turn head slowly towards Bailey*

80. *locks gaze with Bailey*

81. Bailey:  hhh yes! nice!

82. *((smiling)) lifts body and opens palms out to either side ((Figure 25, image b))*

83. *releases hands back to table and picks up her pen*

Figure 25. Lily’s event.
In the first and third examples, Lily’s gaze patterns are the same. She looks forward first, then to Bailey. Also in the first and third examples, Lily pauses, then delivers information to Bailey. When she pauses, she looks forward. Then, while still looking forward, she begins her statement. As she speaks, she turns her head and looks at Bailey while she finishes her statement.

The difference between Lily’s gaze patterns in the first/third examples and the second example is that Lily looks at her paper after looking forward. The conditions where Lily looks forward appear the same in all three examples; Lily is pausing to think. However, unlike the other two examples, in the second example, Lily doesn’t answer a question after she looks forward. And instead of looking at Bailey, she looks down. Therefore, looking down may suggest that Lily is still thinking. Otherwise, if she has delivered an answer, she looks at Bailey.

I will also comment on Bailey’s movements as she first listens to Lily’s answer and then reacts. In Figure 25, image a, Bailey has her hands folded across each other with her right forearm resting on the table. Her head leans forward and she is smiling with her eyebrows raised. When Lily completes her statement, Bailey sits up and opens both hands out to the side in approval of Lily’s answer (Figure 25, image b). Bailey’s first posture demonstrates her interest in what Lily is saying; she pauses her hand movements and clasps them near her body in a display of patience. When Bailey reacts to Lily’s answer, her movements are an enthusiastic demonstration of her support for Lily’s answer.

Example 4: Julia’s Event

Julia was a 32-year-old graduate student studying clinical mental health counseling at the master’s level. She is Bulgarian and a native speaker of the Bulgarian language. Julia started studying English at the age of seven and also speaks French at the intermediate level. At the
time of the study she reported spending almost all her time communicating in English and only spoke Bulgarian when communicating with her family members, none of whom lived in the U.S.

Julia completed her undergraduate degree in the U.S. and then returned to Europe (Greece, France, and Bulgaria) for eight years. At the time of the study she had been living in the U.S. again for about 2 years. This was not her first visit to the writing center, but it was her first time working with Abby. Julia brought an essay about family relationships across the lifespan. Her assignment involved interviewing family members about how her family life growing up affected her development to the present day. During Julia’s event, she explained to Abby ideas that she wanted to convey in a paragraph from her essay. She told Abby how she believes close personal relationships impacted her life during high school. As she explained this to Abby, she performed iconic and metaphoric co-speech gestures which illuminated her speech. Julia’s movements will be the focus of this analysis. Primary attention is given to co-speech gestures, but the analysis also includes gaze and self-adaptors.

To begin, Abby has just read the following passage from Julia’s paper:

In my opinion, it is a privilege to have been born and raised in a nuclear family as it teaches values of loyalty, commitment, support, understanding and acceptance. I feel privilege for having such a strong bond created and maintained within my nuclear family which allowed me to resist all the social pressures posed by the high school experience. Thrown amongst parents’ expectations, school assignments, achievement requirements, heartbreaks, friends’ rejections and immoral propositions, it is quite understandable that the struggling teenager will act out and display and [sic] attitude issues.
Both women have their pencils in their hands and are focused on their papers. There is a
brief pause as Abby quietly reads back to herself what she has just read aloud. Julia opens the
discussion as follows:

1. Julia: <um> basically here I was trying to say that <umm> in high school
2. *looks forward and then to Abby*
3. Abby: all these things happened ((small laugh))
4. *nods*
5. Julia: yes and I resisted them and I had a pretty (.5) good experience
6. *looks down to her paper*
7. LH is rubbing across her collarbone ((Figure 26))
8. *flicks wrist of RH forward*
9. *looks forward, dips head and swoops RH forward in a U-shaped motion*

*Figure 26. Julia’s event*

As Julia starts to speak, she looks forward to Abby, then down to her paper again. Her
body remains in a closed position as she performs a self-adaptor gesture, rubbing her collarbone
as she begins her explanation. She continues:

10. Julia: like I- I can honestly say that my high school experience was fun because
11. *sits back in her chair*
While Julia reminisces that high school was a “good experience,” she shifts her body position to an upright posture, which opens up space around for gesturing. Julia’s left hand extends in front of her, palm up, forming a container gesture. This gesture represents the metaphorical space for ‘holding’ the idea she will continue to talk about (her high school experience).

Julia next explains how she felt about relationships with her best friend and her parents during high school:

15. Julia:  because of my best friend at the time and because of (.)
16. *pulls RH towards her as LH shifts towards Abby*
17. *tucks BH, palms up to her R side ((Figure 27))*
18. *shifts BH hands back to center and opens fingers*
19. *places RH on table and LH on lap*

20. Julia:  the strong bond I had with my mom and my dad because I didn’t need to look
21. *pinches fingers together and points towards self*

22. *releases BH forward*

23. *for what they were giving me (.) out there*

24. *pinches fingers together and closes BH to center ((Figure 28))*

25. *beats BH rhythmically and shifts gaze to Abby*

26. *presents BH forward, palms up*

---

Figure 28. Julia’s event.

As Julia mentions her best friend, she places her hands directly on her right side, which represents her friend as having been physically ‘by her side’ (Figure 27). Next, she pinches her fingers and closes them towards her while speaking about her “strong bond” with her parents. This gesture represents the connectedness and closeness she associates with this relationship.

Julia continues to talk about how she believes her relationships kept her from making poor decisions in high school and how she thinks that “nowadays” teenagers do not have these types of relationships with their parents. Then, she mentions her relationship with her parents again:

53. Julia: *(.) it felt good if I- I was really happy to be home and like*

54. *shrugs shoulders*

55. *nods head forward and lifts BH up*
sets down pencil on table

have my mom here and my dad here and just you know

places LH on chest, extends RH out to the side ((Figure 29, image a))

extends RH out to the side and brings LH towards chest ((Figure 29, image b))

closes BH towards center and then throws BH up ((Figure 29, image c))

rests LH in lap and RH on table as gaze shifts to Abby

Figure 29. Julia’s event.

Abby: mmm

nods ((exaggerated))

Julia: ((quietly)) have dinner yeah

eyes look R and eyebrows raise

This time, when she mentions her relationship with her parents, Julia uses an extended
gesture box to create wrapping motions with each arm on either side of her body. Like with her
description of her best friend, Julia’s gesturing depicts a physical closeness with her parents. She
then completes her explanation:

Julia: so that’s what I was trying to convey here I don’t know if if I got my point across

flips both palms up and circles BH away from each other over paper ((Figure 30))

pulls BH back together over paper then places BH on lap
For Julia’s final co-speech gesture, she returns to the container position she initially used to represent the idea she wanted to convey in her explanation. She opens the container and tips her hands towards her paper, indicating where her ideas need to be expressed.

Next, Abby responds to Julia that she thinks the message Julia just verbally conveyed does come across in the paper, and Abby suggests that Julia doesn’t need to make any changes. However, after the consultation, Julia rephrased her paragraph for her final draft. She keeps the thought the same in the opening sentence then edits and condenses the second sentence:

On one hand, I see it as a privilege to have been born and raised in a nuclear family as it teaches values of loyalty, commitment, support, understanding, and acceptance.

Furthermore, having such a strong bond with my nuclear family provided me with the strength and confidence to resist all the social pressures growing up.

The thought is more complete in the final version, now including details about what this strong bond did for her character and how that helped her resist outside social pressures. The third sentence of her paragraph remains the same, and she includes a new concluding sentence to summarize her argument:

For example, it is quite understandable that the struggling teenager will act out and display attitude issues when thrown amongst parents’ expectations, school assignments, achievement requirements, heart-breaks, friends’ rejections and immoral propositions. A
strong family foundation is required to allow the future adult to handle these challenges by making moral and rational decisions.

**Developmental Events Findings Summary**

In Part II of the study findings, four examples of SLD that occurred during the writing consultations were presented. In each of the four examples, movement played an identifiable role in the developmental event. The type of movements displayed varied between the examples and also between the student and the tutor. Movement played a role in developmental events for students ranging across English proficiency levels, from the pre-intermediate to the proficient. Additionally, developmental events were observed for various aspects of language from lexical and grammatical, to conveying ideas on a larger scale, and even verbal communication about writing. Movements varied based on the type of language development taking place and the proficiency level.

For example, Beau, the student with the lowest proficiency level, displayed movements as indicators of his active engagement in the task. Beau’s tutor, Abby, used movement as a teaching tool to connect her example to Beau’s writing by using her pencil. Lily’s tutor, Bailey, also used movement as a teaching tool in the form of co-speech gesture. Bailey’s gestures were used for illustrative purposes to explain a word’s meaning. Like Beau, Lily’s postures and gaze indicated she was engaged in the activity during her tutor’s explanation.

Alex and Julia performed numerous co-speech gestures during their events. Julia used gestures to demonstrate a physical sense of security she felt when describing the impact of her family life on her development. Alex used gesture to materialize thoughts in conjunction with speech. Alex’s example also demonstrated how language development during a writing-oriented activity can be unassociated with the writing product itself.
The following chapter will present a discussion of the findings from Parts I and II of this chapter as related to the theoretical perspectives introduced in the literature review. This includes sociocultural theory, complex dynamical systems theory, and ecolinguistics. A comprehensive discussion concerning the main theme of movement, as related to the coordinative task presented in this study will also be included as a capstone.
Chapter 5: Discussion

Overview

In this chapter, the findings from Chapter 4 will be discussed using the theoretical framework introduced in the literature review. Following the format from Chapter 4, the discussion is separated into sections to address the types of movements observed by each research question independently. The two research questions are:

1. What synchronous movement patterns emerge during dyadic interaction between a non-native English-speaking student and an ESL trained writing tutor?
2. How do embodied aspects of interaction, as determined through analysis of movement, relate to second language development?

RQ 1 measured synchronous movement patterns using a three-step approach. RQ 2 involved identification of individual developmental events that occurred during the writing consultations.

Two main theories guided the design of each research question and the methods of analysis. Complex dynamical systems theory guided the design and analysis of RQ 1, while sociocultural theory based on the works of Vygotsky guided RQ 2 design and analysis. A third theory, ecolinguistics, relates to both SCT and CDS and offers additional insight into the unique roles of the dyad members within environmental contexts across timescales.

The discussion of RQ 1 is presented as a discussion of synchronous movement including, the complex, dynamical characteristics of synchronous movement and a discussion of the role synchronous movement played in the writing consultations. The discussion of RQ 2 is presented as related to the role of synergistic movement as a mediator in the ZPD with distinct ecological and discourse regulating functions. The discussion concludes by addressing how embodied
interactions are situated within discrete contexts across timescales, further contributing to the understanding of the role of movement in learning and development in L2 tutoring activity.

**Part I: Synchronous Movement**

RQ 1 was designed as an exploratory analysis to examine synchronous movement patterns that emerged between students and tutors interacting in a writing consultation. Overall, the results from the present study indicate that students and tutors in a semi-structured writing consultation synchronized their movements. However, the complexity of the synchronized movements varied across the dyads and also across individual interactions. These findings are congruent with previous research studies which have demonstrated that interacting individuals synchronize their nonverbal activity with different degrees of complexity depending on the context (Duran & Fusaroli, 2017; Paxton & Dale, 2013a; 2017).

Before discussing further connections between the present study and previous research on dyadic synchronization, I will address the main differences between this study and other examples in the literature. For example, this study used a reduced sample size to focus the analysis on the underlying complexity characteristics present across individual interactions (Webber & Zbliut, 2005). Whereas previous research has used larger sample sizes and grouped dyads into categories to measure whether amount of synchrony can be statistically associated with outcomes such as rapport, creativity and memory (see Lumsden, Miles, Richardson, Smith, & McRae, 2012 for a review), I instead considered synchrony as the outcome and used a **retrodictive** approach by revisiting patterns in the data to explain variation among the synchronous movement patterns (Dörnyei, 2014).

Also, dyads were observed in a natural setting as opposed to under experimental conditions. Therefore, the emergent synchronous movement patterns observed can be related to
organically occurring coordinative structures of interaction versus placing participants in interactive settings manipulated to produce different synchronous behaviors.

By directing individualized attention to each dyad as an independent case, I was able to form deeper connections between each interaction and the prevalence of synchronous movement patterns within each individualized context. This allowed me to consider multiple levels of interaction including: English language proficiency, which tutor was present, the type of assignment being discussed, time point (beginning, middle, or end of the interaction), and the types of activities unfolding during different time points. From this, it is possible to discuss synchronous movement behavior in terms of the complex, dynamical systems principles of holism, variability and self-organized emergence.

**Complex, Dynamical Features of Synchronous Movements**

**Holism.** Following the same guiding principle that causal patterns within a complex system are irreducible to single components, the complex characteristic of synchrony should also be viewed as irreducible to only a single type of behavior. The findings indicated that taking a singular view of synchrony, such as considering only the measure of global recurrence rate (RR), provides a limited view of synchronous movement behavior. For example, there were measured segments with a low RR which also co-occurred with a larger ratio of points falling into recurrent (diagonal) structures (DET). This indicates that in the data there were a number of synchronized movement patterns which occurred in shorter, but still meaningful, durations of time.

Additionally, RR was not consistently related to the length of the longest shared recurrent pattern (Lmax). This means that a low overall recurrence did not imply that the segment was absent of any longer recurrent shared patterns. The same is also true for the reverse: the data
showed that a high RR could be measured within a segment which had no individual longer shared recurrent observations.

These types of patterns are important to note because this study design provided the opportunity to individually investigate the relationships between these measures on a case by case basis, which is not commonly how synchrony studies have been designed. The present findings support the case that synchrony itself is a complex phenomenon, exhibiting changing relationships between measurement indices throughout an interaction. The role of synchrony is multiple in social activity (Dale, Fusaroli, Duran, & Richardson, 2013). As this data reflects, synchronous movement engagement may emerge in different ways throughout an interaction to serve different purposes. Without the ability to know where particular synchronized movements were measured, I am not able to speak to the qualitative differences between (for example) high RRs with shorter lengths or low RRs with longer lengths, though it can be expected that the presence of altering synchronous characteristics is not a random occurrence. There is likely a reason for a longer shared recurrent pattern emerging during a period of otherwise low recurrence. Perhaps, a longer spontaneous shared recurrent pattern acts as a trigger which affects other coordinative structures of the interaction.

What is evident from this data is that taking a reductionist approach by relying on trends within a single measure, rather than across multiple measures per measurement removes the ability to view behavioral synchrony as an emergent measure. It is a reminder of the influence that the interactions themselves have on the reported measures of complexity.

**Variability.** To continue the discussion of synchronous movement variability, I will consider the fluctuations in synchrony over the individual interactions and relate them to the role of variability in complex, dynamical systems. In previous SLD studies using a CDS framework,
the prevalence of variability across language measures is a prominently discussed theme as related to language development (Larsen-Freeman, 2006; Polat & Kim, 2014; Rosmawati, 2014; Spoelman & Verspoor, 2010). Dynamic characteristics such as sudden jumps, competitive relationships, and non-linearity are all examples of the type of variability observed in interaction-based systems, which makes it possible for the system to transition into a new state.

The variability observed in the movement synchrony can be viewed as another aspect of the complex developmental system. Each of the observed synchronous relationships varied over time, increasing and decreasing across the recurrence indices with patterns unique to each dyad. While interactional synchrony has been conceptualized as the study of how two systems come to behave similarly over time, this is not the case in the current findings. However, the patterns observed in the current findings are not surprising given the nature of the task. If the task were directed towards a common goal in which both members of the dyad were expected to jointly contribute equally to achieve a specific outcome, then the assertion that they would need to behave in an increasingly similar manner is theoretically sound. For example, if the pair needed to solve a puzzle together or maneuver and object together then synchrony would be expected.

The conditions in the present task, though, are distinctly different because the outcome of the task is different. It is expected that a dyad engaged in a tutoring task should act in a coordinated fashion to achieve the goal of addressing language issues in the writing sample. The role of each member of the dyad, though, is distinctly different. Therefore, the movements performed by each member must diverge at certain points for the purposes of them fulfilling their own role. As observed in the data, the tutors were likely to be engaged in movements that accompanied a teaching event and the students exhibited unique movement patterns during their turns in the conversations, especially during focused developmental events. Therefore, the
movement patterns are expected to vary between synchronized and unsynchronized movements over the course of the interaction. If the dyad grew to synchronize too much, then likely there would be a heightened level of mimicry and a loss of independent contributions from one of the dyad members. Sustained development does not occur from mimicry alone and in this type of dyadic interaction would not be beneficial to the student’s development. Instead, as this data demonstrates, the synchrony varies over time showing that each pair fluctuated their movement synchrony throughout the task to maintain a balance between staying synchronized enough to jointly complete the task and independent enough to foster development.

**Self-organization and emergence.** Complex, dynamical systems express development through cycles of self-organization and emergence as the system seeks stability though the constantly changing interactive influences on the system. The spontaneous synchronization of movements in the present data provides an example of observable emergent system phenomena that occur when two individuals come together to participate in a tutoring activity. The two selected examples of synchronized movement patterns that were observed in the video data are strong indicators that emergent synchronized movement patterns are automatic and biologically primed. In both examples, the dyads synchronized their movements and body positioning, even as their gazes were not focused on each other. Thus, when two individuals (as individual systems) form a dyad, the two systems are able to automatically connect though a movement-based self-organized interaction which allows the pair to emerge in a new shared joint activity space.

As systems seek stability, they converge around sets of strong and weak attractors (Deboeck, 2013). These attractor states are pervasive in the movement data. In the movement charts, fluctuations were observed between periods of high movement activity or low movement
activity, demonstrating the cyclical nature of movement behaviors. When movement data was displayed as recurrent behaviors, attractor states were observed in the diagonal and vertical line structures demonstrating that as a joint system the pair gravitated towards matched movement patterns and returned over time to similar movement pattern states.

Also, the synchronization of movement itself can be thought of as an attractor state: the student and the tutor vary their movements between states of synchronized movement and unsynchronized movement. As was discussed previously, it is important for there to be a certain level of variability in the synchronized movement data to promote development. In some cases, though, an increasing emergent level of synchronized movement may be beneficial. The case of student Beau provides an example.

In the beginning of Beau’s session, he repeatedly performed the self-adaptor gesture of rubbing his chin on his shoulder. Each time Beau performed these self-adaptors, he was being pulled into a particular attractor state. Initially, there were a set of conditions present that caused him to repeatedly perform these actions. His self-adaptor actions were not supportive of his presence in the shared activity space, meaning his actions were not contributing to his ability to coordinate with Abby in either a synchronized or unsynchronized manner. Because the success of the activity is dependent on the ability of the pair to coordinate, a correction needed to be made in order to reduce this aspect of Beau’s movement behavior. It appears from the data that the automatic synchronization of Beau’s movements with Abby’s movements encouraged the pair to soft assemble into a state that favored increasing levels of synchronized movement in order to detract Beau from his self-adaptor movement state because over time Beau’s self-adaptors decreased and synchrony increased.
The Role of Synchronized Movement

Due to the exploratory nature of the study, no specific variables were included to measure whether levels of synchrony were statistically related to other outcomes of the tutoring sessions. However, previous research has established differences between synchronous and asynchronous dyads and in dyads who shared mimicked movements. Though synchronized movements encompass broad range of similar movement patterns, mimicked movements are a subset of synchronized movements and are also considered because they were observed in the qualitative component of the analysis. Specifically, movement synchrony has been associated with positive rapport and social affiliation (Bernieri, 1988; Lakens & Stel, 2011; Cacioppo et al., 2014; Hove & Risen, 2009), fostering relationship formation (Vacharkulksemsuk & Frederickson, 2012), encouraging cooperation (Wiltermuth & Heath, 2009), boosting creativity (Won, Bailenson, Stathotos, & Dai, 2014), and influencing memory (Miles, Nind, Henderson, & McRae, 2010).

Given that it is important for each of these aspects of interaction to be present in order to accomplish the goals of the writing consultation, the synchrony observed in this study can be associated as contributing to a multitude of positive effects on the writing consultation. It has also been suggested that synchrony goes beyond simply encouraging social cohesion, but rather synchrony directly influences the ability of the dyad to pursue shared goals (Valdesolo, Ouyang, & DeSteno, 2010). This further strengthens the argument that the synchrony observed plays an integral role in creating the conditions necessary for completing the writing consultation task.

When considering the specific synchronous behavior of mirrored movement as being associated with increased cognitive processing (van Baaren, Janssen, Chartrand, & Dijkmans, 2009) and convergent thinking (Ashton-James & Chartrand, 2009), additional benefits of reflective movement behaviors emerge. Notably, the conditions under which such movements
were observed can be linked to each of these outcomes. Both of the reflective movement events occurred during transition periods during the interaction, meaning each dyad was task switching, with the reflective synchronous movement patterns leading the transition into a shared reading task. In other words, the synchronized movement events that were also confirmed to be reflective movements showed how both dyads prepared to initiate a joint reading task by mirroring each other. The reflective synchronous movements can be thought of as a priming for the next phase of the joint activity where the pair needed to follow the same pace when reading through the student’s paper, processing the text together, and converging their thinking, and agreeing on edits to be made.

**Synchronous Movement Summary**

Whether reflective or not, synchronized movement patterns promote social affiliation through many channels. Though the present data cannot be directly related to any particular aspect of increased social affiliation, as a whole, the synchronous movement data combined with the known outcomes from the writing consultations align with findings from previous studies and suggest positive social outcomes. Synchronized movements are observable aspects of the complex, dynamical system that is formed when two individuals join to complete a developmental task together. Synchronized movements varied throughout an interaction with different degrees of influence as a result of participants constantly adjusting to task needs and exhibiting emergent system behaviors known to either influence or create the conditions needed to achieve the social goals associated with the writing consultation task, although each consultation remains its own activity at the same time.

**Part II: Synergistic Movement**
RQ 2 analyzed the role of movement during L2 developmental events observed in the video data and was supplemented by member check interviews and/or collected writing samples when needed. The findings indicated that movement was incorporated into each development event, and the types of movements performed were as distinct as the events themselves. While the previous section of discussion emphasized movement synchrony as shared movement patterns, this section will highlight how movement incorporated into the developmental events through what I will call *synergistic movement exchange*. Physiologically speaking, synergy describes how bodily processes, such as moto-neural or endocrine, cooperate to create an action or an effect. According to Geary (2013), the “simplest quantitative definition of synergy is that it reflects an increase in effect over the agents alone” (p. E247). The resulting outcome is *supra-additive* (Geary, 2013) and akin to the CDS principle of emergence.

Synergy has been described interpersonally within the scope of interpersonal coordination research, but as related to aligned movement patterns such as rhythmic movement synergies (Riley, Richardson, Shockley, & Ramenzoni, 2011). I propose synergistic movement be described in a more general sense and expand the concept of interpersonal synergistic movements to entail movements performed independently by each interlocutor for the purposes of cooperative interaction. In effect, this will permit exploration of how movements or actions performed independently (not detectable as synchronized) contribute to the coordinated interaction at large.

Synergistic movement will be described in the context of the developmental events analyzed in the findings. The four examples selected from the video data each represent a discrete account of development. Lily’s event was the restructuring of a phrase due to inaccurate word choice, Beau’s event was learning how to apply the rule of parallel structure to a list,
Alex’s event was materializing a thought into speech, and Julia’s event was restructuring a passage of her writing.

**Mediation in the ZPD**

Perhaps the most distinct difference between each of the four cases was the second language issue being resolved during the developmental events. Each selected developmental event demanded a different level of English proficiency, and each of the event levels corresponded to the English proficiency of the student it occurred for. For example, Beau had the least English experience of the four students and completed a correction of a more beginning level mistake while Lily, an advanced English speaker, corrected a single phrase involving a more advanced lexical selection.

Ultimately, each student made developmental advances, in conjunction with the tutor, within the student’s zone of proximal development (ZPD) (Vygotsky, 1986). The errors presented in each example demonstrated the student’s actual performance level with their corrections reflecting their potential development achieved in the presence of the tutor (Chaiklin, 2003). The students were each willing participants in the activity, interacting with their tutors in a coordinated, collaborative manner to make corrections with their English language usage. The observed types of exchanges made between the students and the tutors have been previously shown to increase the incidences of the student making their own self-initiated repairs in the future (Mirzaei & Eslami, 2015).

The level of assistance required from the tutor also varied by example. When comparing the three examples that occurred related directly to the writing assignments (Beau, Lily, and Julia), the lower the English proficiency level, the more assistance was required from the tutor. Beau required the most assistance, or scaffolding, to work through his grammatical issue. Abby
scaffolded his development with verbal instruction, visual information, and her movement between the two documents on the table to connect her example to his written product. Lily also required multi-modal scaffolding by Bailey to make her language correction. While it took multiple attempts from Abby to help Beau make the connection between the verb forms he chose and the correct verb forms, Bailey only had to instruct Lily once to help Lily progress through her ZPD.

In both of these examples, the role of movement was most prominent on the part of the tutors. Both of the tutors used movement to lead the conversations, which began with the tutors identifying the language errors and explaining why the language usage was incorrect. During this part of the exchange, the students were in a listening mode, following their tutor’s movements. Beau tracked Abby’s movements between the two papers and Lily watched Bailey enact visual representation of the word ‘discernable.’ Here, it is observed that movement is a salient factor in engaging the student to the examples presented by the tutors. The movement-rich explanations served the students in a holistic manner, invoking multiple channels of perception from which they could, in turn, act upon (Hanna & Maiese, 2009).

The role of movement in Julia’s example differed from Beau and Lily’s examples because there was very little scaffolding required on the part of her tutor, Abby. The developmental event was triggered by a pause in Abby’s speech, which opened up the opportunity for Julia to reflect on a passage in her writing. Julia’s quick action resulted in her leading her own developmental event. Julia, to an extent, scaffolded her own development, using movement to reenact the physical presences of friends and family members and how those presences impacted her high school experience.
The trend in these three examples indicates that movement is a catalyst in ZPD-activated collaboration and that the development-triggering movements are performed by the leader of the exchange. As previously observed with regard specifically to gesture (Lantolf & Aljaafreh, 1995; McCafferty & Ahmed, 2000), but now extended to the role of movement, during tutor-led activity, movement served as a mediator bridging the knowledge of the tutor to the intersubjective space to be interpreted and possibly internalized by the student.

Notably, the activity leader was not always the tutor. As the English proficiency level of the student increased, the reliance on the tutor for scaffolding decreased (Mirzaei & Eslami, 2015). However, movement remained a powerful mediator. In Julia’s example, the presence of the tutor provided the environmental circumstances that encouraged Julia to explain her thinking in the manner that she did. This is to say that Julia was placed in a scenario that encouraged her to reflect on her writing in an interactive setting which created the opportunity for her to engage in an embodiment-rich reflection. Regardless of the direction of communication (tutor to student versus student to tutor), movement still mediated the interaction.

The movement-as-mediator can be extended to Alex’s example as well, though his developmental event was categorically discrete from the other three examples because his event was related to a language issue which emerged in the context of the tutoring activity, not in the writing assignment. The quick resolution of Alex’s communication challenge involved gesture-rich activity in which he mapped his concept of ‘crab list’ in space for Abby to watch. Alex’s event, though, is better explained using the concept of a growth point. McNeill (1992; 2005) refers to the growth point as the minimal psychological unit of thought. The growth point is the unpacking of inner speech to create a verbal idea unit.
In Alex’s developmental example, the growth point was reached through a progressive building of his thought through gesture and speech. His thought emerged first through gesture when he created a space to the left side of his body that in turn became a physical space for his idea to exist. He successively built his gestures within this space, which acted as a canvas he returned to repeatedly during his event (Gullberg, 1998). It was while moving within this gesture space that Alex was able to develop his thought into a communicable unit of speech. Just as the other examples demonstrated movement as a catalyst for development, understanding how Alex transitioned from thought to utterance requires consideration of language development as a holistic thinking/action unit.

**Ecological Function**

According to Gibson (1979), learning and development are understood only when the integration of the individual and their eco-social environment is considered. Development is a result of action possibilities one has within their environment based on their perceptions of affordances at their disposal. These affordances can be likened to Vygotsky’s concept of tools. Students and tutors both mediated the developmental activity through action-oriented use of tools. Aside from language being used as a cultural tool, the examples presented in this study demonstrate how the members of each dyad used their bodies to navigate the activity with affordances such as their pencils and papers.

In the parallel structure example, Abby could have simply told Beau that he needed to remove the gerund from one his verbs to make the forms all match in his list. Instead, she created an instructional space using the pencil and paper she had available to her. She used her pencil to illustrate and then motioned back and forth between her example and his essay to connect the content between the two papers. Abby’s movements directed Beau to what he
should be paying attention to and helped him identify how information on her paper related to information on his paper. Abby enriched Beau’s learning experience by taking action with the available environmental affordances to create a multimodal developmental space.

Movement additionally helped define the boundaries of the environment. Tutoring is a unique type of dyadic interaction due to the fact that the student and the tutor must coordinate as a unit to stay aligned with the task, but at the same time, the student must retain their own ‘space’ in which they can work independently. If the student is too dependent on the condition of the dyad, they will not be able to perform independently once the dyadic element has been removed.

In the developmental events, it was observed that gaze is a powerful indicator of transition between the dyad/self systems present. The students used gaze shifting patterns to switch their orientation between the shared cognitive space and their own independent thinking space during problem solving activities. For example, Lily looked away from her shared space with Bailey while she finalized her responses, then turned to Bailey as she completed her utterance. The movement of her head indicated whether her orientation was directed towards the dyad, or away from it. Her movement showed that a boundary needed to be defined for her to shift between the dyad-zone and the self-zone and displayed how these constructs are physically manifested.

McCafferty (2004) used the phrase ‘space for cognition’ to describe how gestures function within a dyadic context to enact meaning through representational imagery, among other purposes. The present findings can expand on this idea by demonstrating how gaze, as an additional aspect of movement, also creates a ‘space for cognition.’ Like Lily, Beau also shifted his gaze away from the dyad while pausing to think. Each student formulated their answer
while focusing away from the dyad and then returned to the dyad-zone to lock eyes with their
tutor for approval of their response. Lily and Beau began verbalizing their answers while
looking outwardly, then began turning towards their tutor as they completed their utterance,
which demonstrates that each student actively brought their thought with them back into the
shared space.

The tutor’s gaze was also important to observe during the student’s gaze shift pattern.
The tutors both kept their focus on the student as the student looked away from the instructor and
were ready to make eye contact as the student turned back towards them. The tutors essentially
held the shared space open and available for when the student reengaged with the space.
Considering the activity of the problem solving is a developmental task for the student, the
observer can see the student’s use of gaze as reflecting the need to move in and out of the shared
space as their development internalizes.

**Discourse Regulation**

Synergistic movement can also be considered in terms of the enacted identities on display
in the discursive activity. The nature of the task placed pre-defined roles on each member of the
dyad (Kramsch, 2008). Historically, in relation to activity, the role of the tutor is to act as the
teacher. A tutor is expected to be the expert on the topic whose primary role it is to identify
shortcomings in the student’s writing and offer guidance for correcting these issues. The student
is expected to approach the writing consultation ready to listen to the suggestions made by the
tutor and to engage as an active participant in the correction making process.

In this study, the tutors and the students provided many indications of adhering to their
culturally/historically defined roles, specifically though their movements. First, the students
approached the task looking for guidance from a more-knowledgeable ‘other’ and demonstrated
with their movements that they were interested and engaged in the session. The students positioned their bodies towards their tutors as they listened to instruction, or towards their paper actively reading along with their tutor. Beau, as the student with the lowest English-proficiency level, especially embodied the actions of a ‘good student.’ He set down his pencil when he wanted to show he was listening to Abby, nodded to show understanding while Abby explained his grammar mistake, and leaned towards their shared space.

Bucholtz and Hall (2005) described a sociolinguistic linguistic approach to identities expressed during interaction. As part of a multi-tiered approach, the authors addressed how identities are the product of linguistic and other semiotic practices, but they situated their argument solely around linguistic influences. Specifically, “identities may be linguistically indexed through labels, implicatures, stances, styles, or linguistic structures and systems” (Bucholtz & Hall, 2005, p. 585). I argue that additionally, identity may also be indexed through embodied actions, such as posture, hand placement, nodding, and gaze. Considering embodiment as a unit of analysis is helpful to understand enacted identities in cases where little is expressed linguistically (i.e. Beau’s case).

Embodiment is also prevalent in understanding the role of the tutors. During teaching moments, Abby and Bailey incorporated illustrative gestures into their explanations, such as with Bailey’s explanation of the physical separating action that related to the explanation of the word discernable. Though Abby’s use of illustrative gestures in the examples presented in the findings was limited, she incorporated numerous other examples throughout her consultations. Across all of the tutoring interactions, both of the tutors used illustrative gestures as a way to tie physicality to their explanations and depended on these movements as teaching tools. Their use
of gestures incorporated into their performative role as a teacher, captivating the attention of their student counterpart.

Additionally, the tutors used movement as a way to establish rapport and express support for their students’ efforts. As they listened, tutors turned their bodies towards their students, fixed their gaze on them, and tilted their heads slightly to show curiosity in what the student had to say. Abby often acknowledged her students with a large smile and exaggerated nodding, while Bailey frequently leaned in towards her students, folded her hands while listening, which was followed by lifting her hands out to the side to show approval of the student’s answer.

Another notable embodied expression displayed by Bailey in particular occurred when she imitated a gesture performed by Lily. At one point during the developmental event, Lily flipped up the palm of her right hand as she checked whether Bailey understood her. Bailey immediately reacted by mirroring Lily and expressed her agreement by flipping her left palm up (see Appendix F, Figure F4, p. 210). This particular gesture expressed a tone of informality within the exchange, which was furthered by the fact that the mirrored gesture was initiated by the student. Tociamaza-Hatch (2016) suggests that learner orientation sets the tone for tutoring interactions, while Benwell and Stokoe (2002) observed increasing levels of informality during peer-tutor interactions. Both of these findings support why the type of gesture and leader of the gesture sequence were observed during this exchange.

However, I will also consider Bailey’s negotiation of conflicting identities present during the interaction to address another layer of this complex phenomena. Because Bailey was concurrently an undergraduate student and in the position of tutoring her peers, she needed to reconcile these conflicting identities during her writing consultations. Especially with Lily, whom Bailey had worked with on multiple prior occasions, there was an expressed level of
friendship between what would otherwise be two undergraduate peers. Bailey used multiple opportunities\textsuperscript{10} to establish rapport with Lily in a friendly manner by mirroring Lily’s causally expressed gestures.

**Synergistic Movement Summary**

The synergistic movement analysis revealed emergent properties of how the dualistic presence of the self/other creates a functioning intersubjective space. When independent actions of each dyad member coordinate in a meaningful way, synergy emerges. The students and tutors aligned their movement patterns to concurrently meet their own needs and the needs of the other during the interaction. Without the dyadic context, the independent actions (as movements) would not have produced a meaningful outcome. Each interlocutor simultaneously acts upon and reacts to the relational feedback loops created by the social interaction. Therefore, meaning is created through the relational presence between independent actors (Overton, 2014).

**Part III: Movement in Context**

This dissertation study design provided an opportunity to understand complex aspects of dyadic interaction at the movement level. Consequently, I was able to compound numerous examples demonstrating the different roles movement takes within an L2 writing context. Overall, the results indicated that language development occurs within a movement rich context through negotiated interaction which depends on a combination of synchronized and synergistic movements. To conclude this discussion, I will address two other pertinent factors contributing to the meaning-making ability of movement-driven development. These contextual factors include the immediate environment and the timescales across which the interaction unfolds.

\textsuperscript{10} See also the synchronous movement data qualitative findings.
Initial Conditions

The environment of the tutoring setting, along with the two individuals involved, determine the initial conditions for the interaction, and subsequently, the types of movements that can be made within that environment. The physical space was the most fixed condition, especially due to the need to control the research setting to measure the movements. The side-by-side arrangement gave each person their own space at the table while also placing them in a position to inhabit a shared psychosocial space. Each dyad was focused on one task with a central goal: to assist the student with a sample of their writing. The tutors were trained professionals and were expected to adhere to a set of standard practices during the session. The physical arrangement of the meeting space provided optimal conditions for engaging in a coordinated activity. I say this in comparison to developing English writing skills in a traditional classroom, where movement coordination or synchrony would be difficult, if not implausible, to achieve with a ratio of one teacher to many students.

Next, the personal factors each student brought to the interaction could have affected movement synchrony or synergy. This could include personal histories, emotions, needs, expectations, etc. Factors measured in this study included language experiences, reasons for attending the session, and prior experience(s) using the writing center. The students attended for various reasons, with varied amounts of previous visits to the writing center, and at varied levels of English proficiency. Importantly, none of these factors interrupted their ability to have meaningful movement interactions with their tutor. Though it is relevant to acknowledge that all the students participated because they genuinely wanted assistance with their writing.

Finally, the students and the tutors each arrived at the consultation with preconceived notions of how the activity would transpire. For the tutors, perceptions were based on their
training and previous experiences, and for some of the students, this included perceptions from previous tutoring experience. Whether the students had received one-on-one tutoring before, each also brought to the session knowledge of cultural expectations developed over history about the respective roles a tutor and a student are expected to assume during the interaction.

**Action Orientation**

Considering the actions that took place within the provided context, it was observed that the students and tutors performed movements for many different purposes. Movements were used as teaching tools, thinking tools, and for regulatory purposes. Pertinently, movement also related to the student’s emotional/historical orientation to the activity. For example, Julia’s writing assignment was distinct from other examples in that her assignment required her to connect to past experiences in a reflective manner. The level of personal importance Julia placed on the activity guided the way she proceeded with her explanation. She used the consultation to revisit social events in her history that had a lasting impact on her personal development, thus reflecting the effects of the events as Perezhivanie (Vygotsky, 1994). Specifically, Julia utilized a large gesture space around her to relive the feelings she had towards her friends and family while growing up.

The impact of emotional memory prevailed during Julia’s demonstration, and her gestures acted as a means to regenerate feelings experienced by her during her adolescence (Dafermos, 2018). The way that Julia enacted her gestures showed how protected she felt by the physical closeness of her friends and family to the effect that she was able to overcome influences of negative social pressures. Julia’s lived experience created the context for her development in the writing consultation. She integrated her past experience with the present situation to imagine the impact of these experiences on her future career as a mental health
counselor. Her movements (as gestures) represented the mobilization of a complex psychological reaction chain: a gesture evoked an emotional perception, leading to a thought which evoked new emotion and carried forward to create meaningful, emergent thoughts (González Rey, 2016). Julia’s previously inchoate argument matured through a movement-driven performance in a dyadic context that depended on the perceived importance of her past experiences.

**Movement Across Timescales**

The emphasis on interaction has thus far been focused on the emergentic properties of movement interactions on the micro-timescale from synchronized movement patterns undetectable by the human eye to synergistic movements observed over the course of isolated developmental events. The analytic timescale expanded with Julia’s example to demonstrate how movement mediated her connection between her own past, present, and future. Observed movements can be further extended to the macro level historical contexts within which the interactions take place.

Consider first the observation of automatically synchronized movements on the microgenetic timescale. The ability of two individuals to align their actions, which enables moment to moment social relations, is dependent on longer evolutionary biological timescale processes. Next, the cultural precedence, which has carved expectations for student/teacher relations, furthers the impact of macro-timescales on localized interactions. These higher-level processes running on the macro-timescale set constraints for what is possible (Lemke, 2006). However, to the benefit of the interaction, these constraints regulate what would otherwise be chaotic activity between the dyad.
Lemke (2000) argues that long-term processes and shorter-term events are linked through a network of material and semiotic artifacts. Also, “a new level in the scale hierarchy of dynamic organization emerges if and only if a new level in the hierarchy of semiotic interpretance emerges” (Lemke, 2000, p. 106). As per the analysis of this study, embodied actions provide the semiotic functions which supply meaning to the interaction. Biologically and socioculturally engrained movement practices initiate predictable behaviors which interact with unpredictable context-related movements unique to each interaction. It is at the intersection of these higher- and lower-level timescale activities where meaning emerges at a new level (Lemke, 2000). Once a new level has been established, the dyad (as a system) has interactive possibilities to further the localized development of the system, and potentially, longer-term development outside the confines of the dyadic interaction.

**Movement and SLD Summary**

Overall, it can be concluded that the movements of the tutor and the student were not arbitrary. The dyads demonstrated that movements are performed for various purposes such as, teaching, thinking, regulating, enacting roles, and coordinating the activity. Movements are connected, within the immediate context and across timescales in synchronized and synergistic manners as a source of mediation in the process of meaning-making. Movements in the dyadic context are self- and socially-driven, feeding a complex, dynamical system of reciprocal causality from which development can occur. The students and tutors coordinated their movements as a manifestation of the shared psychological coordination necessary for the goals of the shared activity to be realized.
Chapter 6: Conclusions and Implications

Conclusions

This dissertation study provided an opportunity to investigate coordinated movement during a writing consultation for ESL students at the undergraduate and graduate levels. Two research questions were designed to explore different aspects of movement coordination during the interaction. First, I sought to identify patterns of synchronized movement between the tutor and the student during their interaction. Second, I attempted to analyze the role of interactive movement during developmental events that occurred.

The study design began with the foundational assumptions that development is an individualized and non-linear activity rooted in complex interactions with one’s ecosocial environment. To satisfy these assumptions, I relied on combined perspectives from SCT and CDS theories, with additional insight from the field of ecolinguistics. For RQ 1, a dynamical modeling technique for non-linear time series (CRQA) was used to measure movement synchrony. For RQ 2, analysis of speech, gesture, and other bodily movement was carried out in the tradition of SCT. RQ 1 relied primarily on quantified movement data extracted from the video recordings, while RQ 2 used a combination of the raw video data, pre-participation questionnaires, writing samples, and follow-up interviews. However, all data sources were considered for use whenever deemed applicable to answering a research question.

Two tutors and twelve students volunteered to participate in the study. The tutors were both recommended by the writing center director for their experience working with ESL students. The students were all foreign-born and introduced to English as a second or third language at various times during their childhood. The study population was small enough to investigate cases individually, but large enough to establish emergent patterns across tutor...
groups and the study population as a whole. Additionally, the range of English speaking abilities among the students enabled a comparison across proficiency levels.

Sociocultural theory is a well-established method for studying SLD as socially and contextually situated and is especially applicable for studying embodied aspects of language learning. Though numerous research studies have used SCT to study gesture during SLD activities, the method has not been widely used to address other elements of embodiment in language development, such as coordination of movement, gaze, or body posture. This study extended on previous SCT literature findings by considering additional embodied factors contributing to the coordinative structure of the developmental interaction. By incorporating CDS theory into the study design, additional analysis of communicative coordination was possible.

The findings from the merged qualitative and quantitative data sources indicated that movement plays an integral role in the writing consultation activity. Specifically, as related to the synchronous movement analysis, students and tutors were found to synchronize their movements while engaged in dyadic interaction. The CRQA provided several measures of complexity to characterize the nature of recurrence across the interaction. Overall, measures of recurrent movement behavior suggest that synchrony is brief, occurring over a few seconds at a time. Cross-comparison of the video data confirmed the presence of synchronized movement patterns occurring over these brief time periods.

Closer examination of recurrent movement behaviors revealed that movement synchrony was highly individualized. It was therefore difficult to identify specific trends across the study population. Also, relying on individual measures of recurrence, such as global recurrence rate, may mislead the assumptions made about the complexity of the synchrony. For example, a low
global recurrence is not an indicator of recurrence quality, such as average length of diagonal lines or the length of the longest recurrent line during the interaction. Since the CRQA measures are considered measures of the complexity of the system, the smaller number of measures one relies on to understand the nature of the interaction, the less ability they have to capture complexity. Whereas a reductionist standpoint would seek to single out unique identifiers to explain some phenomena, a systems-based standpoint pursues understanding of how interactions produce emergent phenomena.

This study showed that measures of recurrence varied across individual interactions as well. In contrast to previous studies which only measured recurrence characteristics once per dyadic interaction, this study compared how measures of recurrence evolved over the span of an interaction. The information gained from this portion of the analysis demonstrated that recurrence measures do change over the course of an interaction in a natural setting and serve as evidence for future studies to consider what influences recurrence complexity changes for individual dyads.

For RQ 2, developmental events were successfully identified on the microgenetic scale. The nature of the development varied by linguistic task and by English proficiency level, yet in each of the examples, movement played an identifiable role in the developmental event. The role movement played was discussed in terms of mediation within the ZPD, with movement having distinct ecological and discourse regulating functions. This additional qualitative analysis of movement during developmental events extended the scope of the movement analysis by identifying how unsynchronized movements contribute to the interaction. The synergistic movement analysis revealed how independent movement streams coordinated during meaning-
making activity. In some cases, synergistic and synchronized movements alike contributed to similar prosocial functions, such as building rapport.

Specifically, the qualitative analysis found that independent movements occur in a complementary manner. The individual movement streams reflected turn-taking and gave each member of the dyad influence over the interaction when necessary. Because all of the movements occurred within the dyadic context, it can be concluded that the environment created the conditions from which independent actions were performed with the function of serving the self and the dyad concurrently. The use of movements varied between dyads, largely based on the individual needs of the student and the type of writing errors that needed to be addressed. Movements also varied by role of the dyad member.

As a final consideration, movement in SLD was placed within the larger context of the eco-social environment, which revealed how the environment influenced the types of movements that could occur. The environment both provides affordances for movement patterns to emerge, while also constraining the types of movements that could be produced. These seemingly contradicting roles of environment keep the interaction in balance by imposing top-down control and providing opportunity for bottom-up emergence.

**Implications**

Many aspects of this dissertation can inform future studies for educational research, as well as other fields of research studying interpersonal coordination. Beginning with the framework for this study, it was demonstrated that interactions occurring at the microgenetic level are able to provide meaningful information about the interaction while the interaction is taking place. Often, educational research is outcome-based, measuring development using single points of data across time, such as a school year or a semester. Instead, this study showed that
development can be observed as it is happening and understood on a much smaller timescale. For studies on language development specifically, this type of study design allows the researcher to see the context and activity that created the space for development to occur.

In regard to the nature of the task chosen, observation of writing consultations between a student and a tutor was both practical and informative. In the absence of a study intervention, development was able to be measured in a natural setting, thus informing the researcher about the nature of development itself. While the tutors were trained in certain theories and given a structure to guide the consultations, they were still able to work with each student as they saw fit. As a result, no two sessions were run the same. This provides implications to call for increased research studying individual learning interactions and allowing for the analysis of single cases within, perhaps, a larger group of cases. As the data from this study showed, group trends in the synchronous movement analysis were difficult to identify. Had these numbers been reduced to means with ranges, important information would have been lost about the fluctuations that occurred, even within single cases.

For other researchers studying interpersonal coordination in other social science fields, similar recommendations can be made. Generally, studies that have measured interpersonal coordination during dyadic interactions have done so using some kind of intervention on the conversation (Duran & Fusaroli, 2017; Paxton & Dale, 2013a; 2017). While informative for understanding how coordination changes based on different contexts, there is still room in the literature for understanding the complexities of conversations that occur in natural settings. In this study, I was able to show that movement synchrony can be measured in a naturally occurring context with topic shifts in the conversation as well as interaction with physical objects incorporated into their movements.
Finally, by concurrently analyzing two separate types of coordinated movement, I was able to apply knowledge of both synchronized and synergistic movements to broaden the understanding of the multiple roles movement plays during interactive activity. To the best of my knowledge, this study is the first instance of such a combined analysis. While informative, synchronized movement patterns are limited as to how much they reveal about the broader role of movement during dyadic interaction, stemming from the fact that only a maximum of 5% of the total movements produced are expected to be recurrent. In order to fully capture the true nature of embodiment dyadic interaction, multiple aspects of movement must be attended to.

**Future Research**

In this section, I offer several ways to expand on the findings from this exploratory study. The suggestion can first be made to keep research individualized and focused on naturally occurring developmental interactions. For those interested in continuing this line of work within an SLD context and interested in further exploration with recurrence analysis methods, future studies could use CRQA to measure other interactive activities occurring. For example, the language used during the interactions may have shared recurrent properties or the acoustics of the voices. Also, interaction can be measured across different tasks, with different members present in the dyads. If two students were engaged in an activity with the task of writing a paper together, they may exhibit different movement synchrony patterns than were observed in the current study.

Future studies could also benefit from relying on multiple levels of data to enhance understanding of movement synchrony patterns during the interaction. In this study, I based synchronous movement pattern findings from quantitative and qualitative data sources to address limitations to translate between the synchronous movement numbers and what the actual
synchronous movements looked like. One modification a future study could make to bridge the more abstract with the physical is to collect categorical data. Because the structures of the recurrence plots are different from continuous data streams, different measures can be extracted from the CRPs by the CRQA. For example, one can identify the time point at which the longest shared recurrent movement pattern took place (see Sun et al., 2016). From there, the researcher could visit the data and see what type of movement patterns are actually producing the recurrence.

Future studies interested in the more qualitative aspects of interaction, movement, and development could examine movement patterns across the entirety of the interaction. This study limited the qualitative movement analysis to the selected periods of data which included developmental events. Future research could also look at events where failures to correct language mistakes occurred, or they could also contrast similar learning events. For example, in this study there were two cases where students brought similar writing assignments that required them to write about past events in their lives. I was not able to include this comparison in the present analysis, but in the future could expand on the different ways in which their activities unfolded.

I am hopeful that the research begun in this dissertation will inspire continued research studies which value the importance of understanding development as a highly-individual, complex, and eco-socially coordinated activity. Further, I hope more educational research will embrace the embodied aspects of cognition, learning, and development.
Appendix A: Study Design

Recruitment
- Tutors: Pre-questionnaire for tutor screening
- Students: Recruiting through the English Language Center

Data Collection
- QUAN (RQ. 1): Data Sources: Front angle video recordings
- QUAL (RQ. 2): Data Sources: Front and back angle video recordings, pre-participation questionnaires, student writing sample

Data Analysis
- Procedure: 1) Quantify data via Optical Flow, 2) select segments for analysis, 3) plot data in Excel, 4) model interaction using CRQA in R
- Procedure: 1) Assemble questionnaire data into table, 2) Watch raw video & make notes, 3) Identify developmental events and perform gesture analysis, 4) Create member check questions

Data Collection (Phase 2)
- Data Sources: notes from member check, collect follow-up writing sample

Data Analysis (Phase 2)
- Procedure: 1) Follow-up initial findings with member check data and second writing sample

Merged Analysis
- RQ. 1: Identify examples from video data that exemplify patterns from the QUAN analysis, add in comments about synchronous movement patterns from notes and interview data
- RQ. 2: With initial QUAL data findings, compare identified developmental events to what the QUAN synchronous movement data displayed

Discussion
- 1) Interpret QUAL and QUAN data independent findings as they relate to their respective RQs, 2) Discuss when and how merged data findings either converge or diverge to produce a more complete account of the overall results
Appendix B: Pre-Participation Questionnaire – Tutor Version

Thank you for your participation in our research study. Please answer the following questions to confirm that you qualify for the study. If at any time you become uncomfortable answering these questions, you may decline to continue participation in the study. Please inform the researcher if you need clarification for any of the items on this questionnaire.

Tutor Information
1. How long have you been tutoring ESL students?

2. Do you have a certification and/or a degree in English teaching? If so, please specify.

3. In a few sentences describe your approach to tutoring/teaching English.

4. Do you have any other information about your career or English teaching experience you’d like to share?
Appendix C: Pre-Participation Questionnaire – Student Version

Thank you for your participation in our research study. Please answer the following questions to confirm that you qualify for the study. If at any time you become uncomfortable answering these questions, you may decline to continue participation in the study. Please inform the researcher if you need clarification for any of the items on this questionnaire.

Demographic Information

<table>
<thead>
<tr>
<th>What is your gender?</th>
<th>What is your age?</th>
<th>What is your major?</th>
<th>What is your class standing?</th>
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</thead>
<tbody>
<tr>
<td>___ Female</td>
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<td>___ Freshman</td>
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<td>___ Male</td>
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<td>___ Sophomore</td>
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<tr>
<td>___ Other</td>
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<td></td>
<td>___ Junior</td>
</tr>
<tr>
<td>___ Prefer not to say</td>
<td></td>
<td></td>
<td>___ Senior</td>
</tr>
</tbody>
</table>

Language Background

1. What is your native (first) language? Or, if you grew up bilingually, what languages did you grow up speaking?

2. What is your home country (or countries if more than one)?

3. How long have you lived in the United States in years and months?

4. Have you lived in other countries besides your home country and the United States? If so, list the countries and length of time you lived in each (years and months).

5. Please list any other language(s) you speak, at what age you began speaking the language(s), and your proficiency level for each (beginning, intermediate, advanced).

6. What languages were spoken in your home during childhood? If more than one, indicate the overall percentage of each language spoken.
7. At the present time, which languages do you speak during an average day, and approximately how much time do you spend speaking each?

8. How did you hear about the English Language Center (ELC)? Check all that apply:
   a. ___ Another student
   b. ___ Teacher
   c. ___ Advisor
   d. ___ Office of International Students
   e. ___ Advertisement
   f. ___ I already use the ELC
   g. ___ Other (please indicate in the space below)

9. What influenced you to come in today? Check all that apply:
   a. ___ Teacher
   b. ___ To help my grades
   c. ___ Because I want to improve my English
   d. ___ Other (please indicate in the space below)

10. Have you worked with this tutor before?

11. In one or two sentences describe the writing assignment you brought with you today.
Appendix D: Beau’s Developmental Event Transcription

Event start time: 11:43

1. Abby: “it is a good thing that we have friends or a best friend because they can talk play and having fun with us” (.5) .hhh okay! if [we were in the writing center I would go get a handout about parallel structure](.5)

2. follows the words on the paper with her pencil as she is reading

3. sits up and turns her attention over to a piece of paper on her left

4. leans body back towards the shared copy

5. sits up and returns attention to the paper on the left

6. [Beau glances twice at Abby and then coordinates his lean in (line 4) and a lean out (line 5) with Abby followed by setting down his pencil and folding his arms]

7. Abby: Whenever you have a list of things one thing (.), two things (.), and third thing (.). hh They have to be the same form (.). (.)

8. writes out a list

9. gazes towards Beau and back to the paper on the left

10. Beau: [nods, swerves head toward right shoulder, nods again]

11. Abby: it-they either need to be all nouns (.), or all verbs (.), or all adjectives (.), whatever, they can be any kind of word but they have to be the same [(1.0)]

12. continues writing on the list
13. tilts head to side and shrugs right shoulder

14. continues writing on the list

15. pulls pencil off paper and nods in Beau’s direction

16. Beau: [nods ]

17. .hhh ((slowly)) So we have a list here ([5] o)f

18. leans body towards shared paper

19. Beau: [wipes face on right shoulder]

20. Abby: “can, talk, play, and having” which one is different?

21. traces pencil on shared copy ((as she reads the words))

22. pulls pencil off paper and hangs head to the left, leans into her left elbow

23. Beau: Having

24. Abby: Yes, so what form should that be?

25. sits up and nods ((gaze stays towards the shared paper))

26. Beau: (3.5) [It’s n]oun right

27. sits body up and reaches right pointer finger to the shared paper ((Figure D1))
28. Abby: [glances towards Beau and then back towards paper]

29. Abby: .hh well, I- ah ok so right now w-we have all verbs (. ) [but you have a]

30. sits up and shifts back to the left

31. draws three circles the pencil above the shared paper and then retracts RH

32. shifts body to the paper on the left

33. Beau: [cocks head right]

34. Abby: ((slowly)) base form verb, a base form verb, and an i-n-g verb [(.] .5]

35. writes on the paper ((Figure D2))

36. tucks RH towards self and shifts gaze towards Beau

37. Beau: [nods]
38. Abby: You can see that having is a different form than talk and play (.5)
39. shrugs right shoulder and nods as gaze shifts towards shared paper
40. picks RH up and tilts once each to the right and left
41. hh [so we need to make them all the same form] (1.0)
42. shrugs right shoulder and nods head to right
43. points three times to paper on her left
44. shifts body up and back towards center
45. Beau: [tucks RH up behind right ear, scratches his neck, nods]
46. Because you’re using ‘can’, (.5) what [form should it be?]
47. points once to the shared paper
48. sit sup
49. shifts gaze towards Beau, head tilts to the right
50. Beau: [shifts gaze towards Abby and then to shared paper]
51. ((4 seconds of silence))

52. Abby: \(\.h[hh]\)

53. *draws her pencil back to the shared paper, then retracts RH* ((when Beau begins a vocalization))

54. Beau: \([wu-]\)

55. Abby: \(w-[we have] \text{‘can talk’}\)

56. *points to the shared paper*

57. Beau: \([drops RH forward]\)

58. Beau: \(,5\)

59. *nods* ((small))

60. Abby: \(\text{should it be [‘can talk?’ O]r ‘can talking’?}\)

61. *points to the shared paper*

62. *shifts gaze towards Beau, nods* ((once))

63. Beau: \([gaze shifts to Abby and back to shared paper]\) ((Figure D3, image a))

64. ((slowly)) \(\text{can- (. I think ‘can talking’?}\)

65. *gaze shifts to Abby* ((Figure D3, image b))
66. Abby: ((gasps)) [.hh ‘can talking?’ ahhhhh oh, no!]

67. shifts gaze to paper on the left

68. pulls pencil towards paper on the left

69. Beau: ((smiling)) [places LH in face, lifts head back up] ((Figure D4))

70. can talk

71. drops right hand out forward

72. Abby: yes

73. nods ((exaggerated))
Beau: ((quietly, smiling)) yeah, can talk

Beau: drops RH forward and tucks behind head, leans head into RH

Abby: if [you have] any mod[al,] any modal verb [(1.0) .hh] it’s followed by a base form

Abby: writes on paper on her left ((also nodding))

Beau: [crosses right arm over left and leans body towards Abby]

[uh-huh]

[arms still crossed, shifts body up and to center]

Abby: (1.5) So you- and you knew that here (.) “can talk”

Abby: makes underlining motions on the shared paper

Beau: yeah

Beau: nods

Abby: right- “we have friends because they can talk, we have friends because they can

play, we have friends because they can- (2.5)

Abby: makes underlining motions on the shared paper

Abby: drops head forward ((Figure D5))
88. Beau: have-. (.5)

89. Abby: have [fun]

90. retracts RH

91. nods ((exaggerated))

92. Beau: [fun]

93. Abby: that’s right so yo[ur i-n-g verb]

94. nods ((small))

95. points pencil once on the shared paper

96. retracts RH

97. Beau: [picks up pencil and writes on the shared paper]

98. Abby: needs to be base form just like these two

99. points pencil to the shared paper twice and ((quickly)) retracts RH
100. Beau: ((whispers)) okay

101. nods ((exaggerated)), retracts RH

102. Abby: that is always true with a list

103. draws a circle above the paper on her left

104. leans body left and places head into her LH

105. ((segment concludes with Beau nodding in agreement. He sits up to stretch and
leans back forward with arms crossed on the table as Abby resumes reading through the essay
(Figure D6)))

Event end time: 13:41

Figure D6. Beau’s event.
Appendix E: Alex’s Developmental Event Transcription

Event start time: 18:54

1. Abby: you had to do the <um>

2. pulls LH towards face with pointer finger and thumb in a U-shape

3. source (. ) evaluation?
   with fingers still in U-shape, drops wrist forward with two beat motions

4. Alex: [mm]:hmm

5. nods

6. Abby: .hhh and that was maybe difficult?

7. places LH palm-down with fingers spread

8. flips palm up

9. because you’ve never done that before?

10. flips palm down

11. shakes head side to side ((as in a “no” motion))

12. sets hand on table

13. Alex: .hh oh but=but <ah>I: I: [I (.) she11 ya-. (.)]

14. RH ((holding pencil)) points to Abby

---

11 Referring to his teacher
15. *looks down then looks at Abby*

16. *moves LH up but stops and places elbow on table*

17. Abby: ((quietly)) [did she ((inaudible))]

18. Alex: *yeah she gave us-

19. *LH still elevated, drops index finger in a straight line down*

20. *I really got a=a good grade on that one*

21. *points both hands towards Abby*

22. *shifts hands back the opposite direction with LH pointer finger elevated*

23. Abby: *ni:ce*

24. *((smiling)) nods ((exaggerated))*

25. Alex: <um> a:nd she gave us the crab list? ((pauses for Abby to acknowledge she understands what he is referring to))

26. *looks up towards LH as LA lifts straight up*

27. *looks back towards Abby as LH cups into a C-shape ((Figure E1))*

28. *fingers still in C-shape, draws hand toward Abby*
29. Abby: _hh yes_

30. ((smiling and emphatic)) *exaggerated nodding*

31. Alex: the crab points

32. *LH palm facing down, makes two circular motions downward* ((Figure E2))

33. Abby: yes

34. *nods* ((small))

35. Alex: not like (. ) do=you know it’s it’s (. ) like a metaphor like [you kn-]

36. *RH* ((holding pencil)) *points towards Abby and makes small circles*

37. *picks LH up off table, pulls RH towards it and back away*
38. both hands out, palms facing each other, shifts hands back and forth

39. ((smiling)) nods and, RH palm up, makes a presenting motion with both hands towards Abby

40. Abby: [((laughing)) It is] a metaphor yes

41. nods ((exaggerated))

42. Alex: and (.5) <um> I (.) ((inaudible sound))

43. lifts RH back up to the C-shape gesture and circles forearm towards himself three times ((Figure E3))

44. flicks R wrist behind him and sets on table as his RH initiates a writing motion

((Figure E4))
I analyze each single point. (. )

lifts RH up, palm down

beats three times with index finger and thumb pinched close together ((Figure E5))

drops RH to table

Abby:  nods

Alex:  a:and see which one’s strong or which one or. ((trails off))
picks up both hands and shifts them back and forth
flicks up L wrist
drops both hands ((to table))
Event end time: 19:24
Appendix F: Lily’s Developmental Event Transcription

Event start time: 16:36

1. Bailey: so this point “make easily discernable from real li[fe]” co]uld you explain what you meant by that?

2. underlines text on her paper

3. shifts her gaze up from the paper to Lily

4. Lily: [mmm] (1.5) you know maybe in the not real life <um>

5. looks up from paper straight ahead ((Figure F1))

6. looks back at Bailey

7. ((Bailey shifts gaze back to her paper))

Figure F1. Lily’s event.

8. Bailey: Ohhh .hhh

9. picks up pen and underlines something on the paper

10. Lily: In the, (.) live in the video game (.5)

11. lowers gaze to Bailey’s pencil on her paper
12. Bailey: Yeah <um> but discernable [(.) me]ans like it’s (1.0)

13. shifts body up to face Lily, retracts hands to center

14. Lily: [<mmm>]

15. ((during pause on line 12)) looks up at Bailey

16. Bailey: separating [(.) you] know

17. opens both hands up, palms facing each other

18. Lily: [<mmm>]

19. nods

20. Bailey: no[w when you say “make easily sss- discernable” it’s like]

21. lowers RH to paper and circles a word

22. Lily: [.hhhh ((whispers)) separating ohhhh]

23. opens mouth ((as she gasps in))

24. looks down to Bailey’s pencil

25. opens mouth again and looks towards Bailey

26. Bailey: it’s easily t- it’s easy to separate those things

27. pulls hands back to center, about chin level, as gaze shifts up

28. begins to stroke hands away from each other, and retracts ((Figure F2))
29. completes the motion of the hands separating as gaze shifts to Lily
30. retracts and repeats the gesture one more time

Figure F2. Lily’s event.

31. Lily: <mmm>
32. nods

33. Bailey: and to distinguish one from the other
34. pushes RH out in front of her ((Figure F3))
35. pushes LH out in opposite direction

Figure F3. Lily’s event.

36. Lily: ohhh [ok .) I got it]
37. shifts gaze forward
shifts gaze down to her paper ((Bailey does as well))

Bailey: [sooo] (.5) ((mouths something to herself))

holds one finger out towards Lily

Lily: can I check the word?

looks up towards Bailey and reaches RH for her pocket

Bailey: yeah! go for it

presents LH out to Lily, palm up

Time: 17:15

((Lily retrieves her phone from her pocket and attempts to look up synonyms for the idea she is trying to convey. She offers up the word “visional” but Bailey is confused by this. There are several pauses as Lily continues to search on her phone and Bailey tries for her own solution))

Time: 18:06

Lily: ah, fantasy world- oh no .hh you know like in the [(.) not] real world [(fantasy world) ((inaudible))]

looks up and Bailey and lowers phone  ((Bailey’s gaze meets hers))

shrugs as she lifts RH out behind her and flips palm up

shifts gaze back to phone
50. Bailey: [yeah] [yeah yeah <umm>]

51. Nodding

52. Lifts her LH out behind her and flips palm up ((mirrors Lily)) ((Figure F4))

53. fantasy wil- .hhh works (. it’s just like make easily is the: (.5) the part that throws it off- from real life- so maybe (. ) instead of saying discernable you could say (2.0) <umm> (2.0) ((quietly)) reduce decrease (3.0) make?

54. moves pen back and forth on her paper

55. leans head into her right hand ((Figure F5))

Figure F4. Lily’s event.

Figure F5. Lily’s event.
56. ((Lily stays focused on her phone until Bailey sits up and now offers the word “virtual” and explains the difference between virtual and fantasy.))

Time: 19:11

57. Bailey: so <um> I think vi[rtual,] (.)

58. *picks up pencil, shifts gaze to her paper*

59. Lily: ((quietly)) [virtual world]

60. *picks up pencil, shifts gaze to her paper*

61. Bailey: so maybe you could even say make (3.5)

62. Lily: make children live in the virtual ((small laugh)) world?

63. Bailey: but how bout instead of saying like make them live in one world you could say (. you could still even use the word (.5)

64. *shifts body to center and claps hands together* ((Lily looks up at her, but Bailey’s focus is still down to the paper))

65. *drops both hands towards Lily*

66. *makes a small circular motion in Lily’s direction and then shifts BH to opposite direction*

67. *gaze shifts to Lily* ((Figure F6))
68. discern just like indiscernible? or indistinguishable (.5) so like mak[ing (.5)
69. clasps hands back to center
70. lifts eyebrows and body slightly ((as punctuation))
71. opens hands slightly to Lily

72. Lily: [.hhh ohh yesss] (.5)
73. shifts gaze to her paper ((Bailey continues to look at her for the remainder of the excerpt))

74. Bailey: these two things] hard to separate
75. presses BH together
76. opens BH and tips up and down in opposite directions

77. Lily: oh yes (. ) I got it <um> .hh make children (.5) <um> ((slowly)) make real world and virtual world (.5) ((quietly)) indistinguishable?
78. shifts shoulders and looks straight ahead ((Figure F7, image a))
79. begins to turn head slowly towards Bailey
80. locks gaze with Bailey
81. Bailey: *huh yes! nice!*

82. ((smiling)) lifts body and opens palms out to either side ((Figure F7, image b))

83. releases hands back to table and picks up her pen

84. Lily: *mmm*

85. releases gaze back to paper and begins to write

Event end time: 19:51
Appendix G: Julia’s Developmental Event Transcription

Event start time: 19:29

1. Julia: <um> basically here I was trying to say that <umm> in **high school**

2. *looks forward and then to Abby*

3. Abby: *all these things happened ((small laugh))*

4. *nods*

5. Julia: *yes and I resisted them and I had a pretty (.5) good experience*

6. *looks down to her paper*

7. *LH is rubbing across her collarbone ((Figure G1))*

8. *flicks wrist of RH forward ((as punctuation))*

9. *looks forward, dips head and swoops RH forward in a U-shaped motion*

10. like I- I can honestly say that my high school experience was fun because

11. *sits back in chair*

12. *presents LH out palm up*

13. *shifts RH forward ((as punctuation))*

*Figure G1. Julia’s event.*
14. ((during line 12 Julia’s gaze shifts L to Abby and then back forward with her eyes more focused down. Abby is gently nodding and smiling at Julia))

15. because of my best friend at the time and because of (.)

16. pulls RH towards her as LH shifts towards Abby

17. tucks BH, palms up to her R side ((Figure G2))

18. shifts BH hands back to center and opens fingers

19. places RH on table and LH on lap

Figure G2. Julia’s event.

20. the strong bond I had with my mom and my dad because I didn’t need to look

21. pinches fingers together and points towards self

22. releases BH forward

23. for what they were giving me (.) out there

24. pinches fingers together and closes BH to center ((Figure G3))

25. beats BH rhythmically and shifts gaze to Abby

26. presents BH forward, palms up
27. Abby: got ‘cha

28. nods

29. Julia: because I think that that’s what’s happening with teenagers nowadays that

30. beats RH out in front of her

31. their parents are not available for them so they are looking for that

32. points BH in towards herself

33. opens hands up with RH in front of LH

34. acceptance and the that support and that love (.) in all in the wrong places

35. rolls RH out three times

36. tucks BH in and shrugs body forward

37. throws out BH, palms up ((Figure G4))
38. ((Abby is nodding in agreement))

39. so it’s it’s either hanging out with the wrong people or doing the wrong substances and I’ve never done that I’ve-

40. rolls BH out, palms up

41. nods head to either side ((as punctuation))

42. shrugs and presents LH out towards Abby then rests on lap

43. ((Julia’s gaze remains forward with her eyes focused down))

44. and I don’t think I lacked or missed out on anything

45. shifts eyes up ahead and sits up slightly

46. beats LH

47. shifts gaze towards Abby

48. Abby: right

49. nods
50. Julia: it- and I was happy to come home and have dinner with my [parents and it was.]

51. punctuates with her body and shoulders

52. Abby: [nodding]

53. Julia: (_) it felt good? if I- I was really happy to be home and like

54. shrugs shoulders

55. nods head forward and lifts BH up

56. punctuates with body and sets down pencil on table

57. have my mom here and my dad here and just you know

58. places LH on chest, extends RH all the way out to the side ((Figure G5, image a))

59. extends RH out to the side and brings LH towards chest ((Figure G5, image b))

60. closes BH towards center and then throws BH up ((Figure G5, image c))

61. rests LH in lap and RH on table as gaze shifts to Abby

a.  
b.  
c.  

Figure G5. Julia’s event.

62. Abby: mmm

63. nods ((exaggerated))
64. Julia: ((quietly)) have dinner yeah
65. *eyes look R and eyebrows raise*

66. Abby: *mm hmm*

67. ((Abby and Julia simultaneously shift gaze to their papers))

68. Julia: so that’s what I was trying to *convey here* I don’t know if if I got *my point across*
69. *flips both palms up and circles BH away from each other over paper* ((Figure G6))
70. *pulls BH back together over paper then places BH on lap*
71. *tips chin and looks L at Abby, then gazes down*
72. *picks up pencil, then looks at Abby*

*Figure G6. Julia’s event.*

73. Abby: I actually think that the way that you said it just now is slightly more (.5) <um>
74. *circles hands in front of herself*
75. *looks straight ahead and presents BH out, palms up*
76. academic or generalized than the way than the way you say it here (.5)
77. shifts gaze to Julia and externally rotates BH ((Figure G7))
78. turns back down and points BH on paper

Figure G7. Julia’s event.

79. but I get that what you’re saying here is what you just said
80. taps pencil on paper with RH
81. turns and points RH to Julia
82. turns back and points RH to paper

83. like your point is- is clear
84. shifts hands back and forth
85. points RH to paper twice
86. makes an underlining motion
87. flips both palms up and makes small circles

Event end time: 21:15
References


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Curriculum Vitae

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EDUCATION

Doctor of Philosophy, Educational Psychology | December 2018 | University of Nevada, Las Vegas | Dissertation title: “Conversational movement dynamics and nonverbal indicators of second language development: A microgenetic approach.” | Advisor: Steven G. McCafferty, Ph.D.

Master of Science, Kinesiology | December 2009 | University of Nevada, Las Vegas | Concentration in Motor Control and Learning | Thesis title: “Focus of attention on movement technique acquisition of a Pilates roll-up.” | Advisor: Gabriele Wulf, Ph.D.

Bachelor of Science, Exercise and Sport Science | June 2007 | Western Washington University | Concentration in Pre-Physical Therapy | Advisor: Gordon Chalmers, Ph.D.

RESEARCH EXPERIENCE

Research Associate | 2018 |
Center for Research Evaluation and Assessment, University of Nevada, Las Vegas
Designed and conducted evaluation and assessment of the National Institute of General Medical Sciences (NIGMS) Center of Biomedical Research Excellence (COBRE) grant Number P20GM109025. Evaluation topics included longitudinal assessment of community outreach activity, mentoring relationships, and social network analyses of collaborative scientific translational research networks. Research dissemination included manuscript publication and presentations of findings at regional and national conferences and annual reporting to the NIGMS.

Graduate Assistant | 2016-2018 |
Assisted with data collection and evaluation practices for consultation projects with Gwen Marchand, Ph.D. Evaluation topics included longitudinal assessment of mentoring relationships and building social network analyses for collaborative scientific translational research networks. Research dissemination included presentations of findings at regional and national conferences and annual reporting to the NIGMS.
Graduate Assistant | 2015-2016 |
Department of Educational Psychology and Higher Education, University of Nevada, Las Vegas
Collaborated on research development, data collection, and manuscript composition of studies on English Language Learners with Tiberio Garza, Ph.D.

Graduate Assistant | 2015 |
Department of Educational Psychology and Higher Education, University of Nevada, Las Vegas
Performed research assistance by completing systematic literature reviews for studies on higher education and health related issues with Nancy Lough, Ph.D.

Graduate Assistant | 2014-2015 |
Department of Educational Psychology and Higher Education, University of Nevada, Las Vegas
Assisted with grant management for the “Write to College” Summer Bridge Program with Stefani Relles, Ph.D.

Graduate Assistant | 2008-2009 |
Department of Kinesiology and Nutrition Sciences, University of Nevada Las Vegas
Scheduled and consented participants, collected data and prepared data files for statistical analyses in the Motor Performance and Learning Laboratory with Gabriele Wulf, Ph.D.

COLLEGIATE TEACHING EXPERIENCE

Instructor of Record | 2016 |
Department of Educational Psychology and Higher Education, University of Nevada, Las Vegas
Instructor for EPY 303: Foundations of Educational Psychology. Designed class assignments, prepared exams and lectures for 35 students, managed online class activities through Blackboard.

Teaching Assistant | 2014-2015 |
Department of Educational Psychology and Higher Education, University of Nevada, Las Vegas
Handled teaching assistant responsibilities including coursework organization and classroom technology management with Blackboard for EPY 718: Qualitative Research, EPY 719: Advanced Qualitative Research and EDH 738: Public Policy in Higher Education for Stefani Relles, Ph.D.

Teaching Assistant | 2009 |
Department of Kinesiology and Nutrition Sciences, University of Nevada, Las Vegas
Handled teaching assistant responsibilities for the organization and grading of homework and exams for KIN 250: Social Psychology of Physical Activity, KIN: 316: Motor Development Across the Lifespan, and KIN 462: Adult Development in Aging for Mark Guadagnoli, Ph.D.

Instructor of Record | 2009 |
Department of Kinesiology and Nutrition Sciences, University of Nevada, Las Vegas
Instructed SIM 150: Management of Sport Trauma and Illness laboratory section.
SCHOLARLY PUBLICATIONS & PRESENTATIONS

Manuscripts:


Refereed Conference Presentations:


EVALUATION CONTRACTS

*Center for Biomedical Research Excellence (COBRE) Assessment Project* | 2016-Present | National Institutes of Health, Grant Number P20GM109025 | PI: Dr. Jeffrey Cummings, CREA PI: Gwen Marchand | CREA Subaward, $97,651.


AWARDS

Conference Travel Grants awarded from the *Graduate Student Professional Association at the University of Nevada, Las Vegas* in May 2009, May 2015, May 2016, and May 2017.
Research Forum Award from the Graduate Student Professional Association at the University of Nevada, Las Vegas in February 2018.

**ACADEMIC SERVICE**

Graduate Student Council Member | 2016-2017 | University of Nevada, Las Vegas Graduate and Professional Student Association | Las Vegas, NV | Department of Educational Psychology and Higher Education representative at student council meetings, coordinated department communication and student development events.

Community Service Chair | 2014-2015 | University of Nevada, Las Vegas Student Affiliates in School Psychology (SASP) | Las Vegas, NV | Coordinated community outreach with local elementary schools and coordinated SASP fundraising activities.

ESL Tutor | 2006-2007 | Bellingham School District | Bellingham, WA | Volunteered 80 hours of tutoring services to non-native English-speaking elementary school students in math and science.