A Micro-level Analysis of Behavioral Dynamics in Parent-Child Synchrony

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A MICRO-LEVEL ANALYSIS OF BEHAVIORAL DYNAMICS IN PARENT-CHILD SYNCHRONY

by

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A THESIS

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This study investigates parent-child synchrony, a multilevel construct that has not been operationalized in a precise or standardized way. Synchrony is frequently discussed theoretically, yet there still lacks a clear means of measuring it, even on the behavioral level. When parent-child synchrony is operationalized in a study, it is rarely analyzed in such a way that reflects the dyadic dynamics that unfold as the parent and child are interacting. The aim of this study is to operationalize parent-child synchrony in terms of the dyadic behavior patterns. An overview of the current literature with regard to synchrony as a multilevel construct is included. The methodology for this study consists of video-recording four parent-child dyads while they are interacting in response to a series of prompts. Segments for synchrony and asynchrony were coded second by second by the primary researcher and an independent coder. Consensus codes were analyzed using a time series analysis, specifically, transitional probabilities, which allows behavior patterns to be identified. Significant results were found for two selected behavior patterns, one in synchronous segments and one in asynchronous segments. Transitional probabilities were significant for Collaboration (a dyadic code) to follow Parent Facilitation (an individual code) after a two second lag in the synchronous segments, and for Separate Attention (a dyadic code) to follow Parent Suppress (an
individual code) after a two second lag in asynchronous segments. Yule’s Q was calculated as an effect size measure, and most of the significant results also had large effect sizes. This study demonstrates that behavior patterns can be utilized to differentiate between synchronous and asynchronous interactions. Implications for future research and clinical interventions are extensive and potentially consequential for the field.
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# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>ii</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>iii</td>
</tr>
<tr>
<td>List of Figures</td>
<td>v</td>
</tr>
<tr>
<td>Chapter 1: Justification</td>
<td>1</td>
</tr>
<tr>
<td>Chapter 2: Literature Review</td>
<td>3</td>
</tr>
<tr>
<td>Chapter 3: Methods</td>
<td>28</td>
</tr>
<tr>
<td>Chapter 4: Analysis</td>
<td>46</td>
</tr>
<tr>
<td>Chapter 5: Results</td>
<td>49</td>
</tr>
<tr>
<td>Chapter 6: Discussion</td>
<td>61</td>
</tr>
<tr>
<td>References</td>
<td>73</td>
</tr>
</tbody>
</table>
List of Figures

Table 3.1 “Demographic Description of Sample Dyads” 30

Table 5.1 “Behavior Frequency and Segment Type Proportions” 50

Graph 5.1 “Behavior Code Graph for Synchrony 12 B” 52

Graph 5.2 “Behavior Code Graph for Synchrony 03 A” 53

Graph 5.3 “Behavior Code Graph for Asynchrony 05 B” 54

Table 5.2 “Transitional Probabilities of Collaboration following Parent Facilitation after Two Seconds” 57

Table 5.3 “Transitional Probabilities of Separate Attention following Parent Suppress after Two Seconds” 59
Chapter 1: Introduction

The concept of dyadic synchrony is essential to several current theoretical frameworks conceptualizing optimal parent-child relationships. Empirical research has established the influence of dyadic interactions on child outcomes, such as attachment research (Isabella & Belsky, 1991). Other lines of research on parent-child dyads demonstrate that the relationship between children and caregivers is bi-directional (Kochanska, 1997). Studies have described synchrony in various ways. Extant theoretical articles describe the benefits of parent-child interactions characterized by synchrony, yet few attempt to operationalize the definition of synchrony. Those teams who have empirically researched synchrony do not follow a standardized definition or method of operationalization. Even within a researcher’s program of research, there are often different operationalizations of synchrony (Feldman, 2003; Feldman, 2006; Feldman, Magori-Cohen, Galili, Singer, & Louzoun, 2011). Without an established operationalization of synchrony, findings of various studies are difficult to aggregate. At present, few studies measure synchrony in interactional terms, and this leads to the current problem of prevalence of a construct in theory, without a validated and reliable means of measuring the construct in research. This gap prevents scholars in the field from utilizing the construct of synchrony beyond the level of theory. Through operationalizing parent-child synchrony in terms of measurable dyadic interactions, this study presents an option for future studies to utilize.

Thus, the first aim of this study is to operationalize the construct of parent-child behavioral synchrony. The concept of parent-child synchrony on the behavioral level has been well-developed theoretically and conceptually and is central to clinical practice
(Bukatko & Daehler, 2001; Feldman, 2007b; Bowen, 1978); however, a standard means of operationalizing dyadic synchrony has yet to be established. Behavioral coding of video-recordings of interactions between preschool children and their parents is used to operationalize the construct of dyadic synchrony for the purpose of this study.

Not only are current studies on behavioral synchrony lacking a standard operationalization of the construct, they also typically analyze the observed behavior from a global or an aggregated approach rather than a micro-analytic approach. A global approach to behavior observation is when, during the determined time segment or interaction event, the behavior was measured as present or not present. The behavior under investigation is sometimes scaled, but even with scaling, the patterns of interaction are lost in the global assessment (Bakeman & Gottman, 1997). When behavioral data are aggregated, the behaviors are reported in terms of frequency through the segment or event. Further analyses are often conducted with these frequency data, but the interaction pattern is not maintained through this type of analysis, either (Bakeman & Gottman, 1997). Micro-analytic approaches record observed behaviors with their respective onset and offset as they occur, and they are analyzed using methods that represent the patterns of behavior (Bakeman & Gottman, 1997). This is a critical distinction to make with studies on synchrony because as a dyadic construct, synchrony unfolds through time with contributions from both parent and child (Feldman, 2007a). These contributions from both individuals can include behaviors that are alternating or continuous, perhaps occurring simultaneously (Butkatko & Daehler, 2001). To accurately capture the precise nature of parent-child synchrony, the investigation must be on a micro-analytic level.
Chapter 2: Literature Review

This review addresses the definition of synchrony as well as empirical research on this construct. Before examining the research precedents for synchrony, discussion of the concept of synchrony is necessary. Thus, defining synchrony as a multilevel construct, establishing a theoretical framework, and exploring systemic implications will be addressed first. This study addresses behavioral synchrony, but any in-depth discussion of synchrony would be remiss if it did not include the multilevel and systemic nature of parent-child synchrony. Next, instances of multilevel synchrony in the extant literature is introduced. Following are several examples of single-level synchrony studies, which are more prevalent in the research literature than investigations of multilevel synchrony (e.g., physiological and behavioral synchrony). Next is a discussion of constructs that are related to synchrony conceptually. Finally, the gap in the extant literature is defined, as well as the role of this study within that gap.

Synchrony in Concept

There are few contemporary models of child development that do not include some aspect of dyadic parent-child synchrony. Human relational synchrony, however, has been somewhat neglected over the past few decades, particularly on physiological levels (Feldman, Magori-Cohen, Galili, Singer, & Louzoun, 2011). Synchrony is, in essence, the matching of processes between individuals where the movement of one person in the system impacts the movement of the other, and vice versa, often in a recursive pattern. Recent research has indicated synchrony can be found in multiple systems between human parents and children, such as communicative behavior, attention,
heart rhythm, hypothalamic-pituitary-adrenal (HPA) axis arousal, affective state, and possibly neural processes (Feldman, 2012a).

While the presence of synchrony in the parent-child dyad is considered an indicator of healthy interactions, synchrony is not continuous, even in highly synchronous dyads (Tronick & Cohn, 1989). Synchrony is associated with positive affective states and with dyadic flexibility, whereas rigid interaction patterns are characterized by negative affective states (Lunkenheimer, Olson, Hollenstein, Sameroff, & Winter, 2011). Conflict, negative affect, and rigid interaction patterns are all associated with asynchrony, while flexibility and positive affect characterize interactions that are synchronous. Parents and children are at times uncoordinated in their interactions, but dyads with optimal interaction patterns are able to move into synchrony, out of synchrony, and back into synchrony. These periods of synchrony are often marked by high arousal, positive affect, and playful interactions (Feldman, 2007a). Several factors have been found to interfere with synchrony between parents and children, such as maternal anxiety and depression, post-partum depression, premature birth, autism spectrum disorders, father attachment insecurity, and multiple births (Feldman, 2007b; Feldman, 2003; Feldman, 2012a; Feldman & Eidelman, 2004).

Through the matching of processes in dyadic synchrony, several developmental capabilities are fostered in the child (Feldman, 2007b). Longitudinal research has demonstrated that the degree of mother-infant synchrony during infancy predicted outcomes such as self-regulation (in terms of compliance with maternal requests and prohibitions), intelligence quotient (IQ), symbolic expressions, and internal state
language such as, “happy,” “want,” and “think” (Feldman & Greenbaum, 1997, p. 12). Synchrony with both parents was related to secure attachment behavior and fewer behavior problems during toddlerhood, and with more empathy for others during early adolescence (Feldman, 2007b). Thus, this construct of synchrony as rhythmic and matching behavioral, emotional, and physiological processes between parent and child seems to capture the optimal relationship state that has been posited as beneficial for development in decades of child development and family science models. As a child develops, the specific behaviors a child needs from a parent change, and synchrony refers to the ability of the parent to meet the child’s need through developmental changes.

As one of the premier researchers in the field of synchrony, Feldman describes synchrony as “the matching of behavior, affective states, and biological rhythms between parent and child that together form a single relational unit” (2007a, p. 329). Another definition for parent-child synchrony that Feldman put forth is “a process that coordinates the ongoing exchanges of sensory, hormonal, and physiological stimuli between parent and child during social interactions” (2007b, p. 340). Family Systems Theory has long posited that family members function as a relational unit, and that a pattern of organized, flexible, and positive exchanges between individuals in the relational unit leads to optimal relational and emotional health (Bowen, 1978). When children are not able to develop within a sensitive caregiving system, there are often devastating outcomes for the child (Bowlby, 1988). Both of these definitions highlight the inclusion of the multiple components of physiological and behavioral synchrony. This is essential to the understanding of dyadic synchrony because the various modes of synchrony are
hypothesized to impact each other, and further evidence supporting this hypothesis is discussed later in this chapter. As a multi-faceted, systemic phenomenon, synchrony in one level of the system increases the likelihood of the presence of synchrony in another level of the system (Feldman, 2012a).

Feldman also emphasizes the temporal aspect of parent-child synchrony, positing that the experience of synchrony through time co-creates between parent and child a relational connection as well as shared biology (2007a). Temporal analysis of parent-child interactions is essential to understand synchrony because the rhythm of alternating interaction patterns is dependent on the “timeliness” of the individuals’ responses to each other (Feldman, 2007a). Thus, micro-analytic research approaches are well-suited to examine parent-child synchrony as it unfolds through time.

In Feldman’s model of bio-behavioral synchrony, behavioral interactions are the mode of contact between the parent and the child that regulate the biological functions involved in synchrony (2012a). This linear relationship, proposed by Feldman, wherein social behaviors are the mechanism by which multiple physiological processes synchronize is explained in the results of a study on heart rhythm synchronization between mothers and infants (Feldman, et al., 2011). Mothers and infants were recorded as they freely interacted together while the infants were secured in an infant seat and the mothers stood in front of them. During the interaction, the mother and infant did not touch, however, their interactions were coded for the aspects of behavioral synchrony of affect, vocal, and gaze synchrony (Feldman, et al., 2011). Heart rate variability (HRV) was measured using electrocardiograms (ECG) connected to each member of the mother-
infant dyad during the interactions. The HRV data between mothers and their infants while interacting were compared to each other, and the mothers’ HRV data were compared to the HRV patterns of other infants. Infants only interacted with their own mothers, so the comparison data were from an infant interacting with her own mother and then analyzed against a different mother who had been interacting with her own infant during the recording (Feldman, et al., 2011). Mothers and their infants showed more concordance in their heart rhythms than analytical comparisons between the mothers’ recorded HRV pattern and the recorded HRV of non-related infants (Feldman et al., 2011). The synchrony in HRV in mother-infant dyads was greater than what might be found according to chance, established by using non-dyad pairs as a comparison for HRV patterns (Feldman, et al., 2011). This can be considered evidence for synchrony on the physiological level. The research team also examined the relationship between HRV synchrony and behavioral synchrony traits. The researchers found that the more synchronous behaviors in the mother-infant dyads correlated positively with dyadic HRV synchrony, which can be considered evidence for multilevel synchrony (Feldman, et al, 2011). This study is also important because it utilized time-series analysis for the behavioral data, which maintains the behavioral patterns of the dyad members (Feldman, et al, 2011; Bakeman & Gottman, 1997).

While this study is very exciting in terms of multilevel synchrony research, it does not determine causality between behavior and physiology. Feldman and colleagues acknowledge that the results of this study readily lend themselves to the conclusion that social behavior synchrony causes physiological synchrony, so they present this option in
the discussion section, and Feldman built her bio-behavioral synchrony model on this proposition (Feldman, et al, 2011; Feldman, 2012a). This linear, causal relationship is posited as the result of a theoretical process of elimination to explain the correlational findings: the mothers and infants were not in physical contact, thus the researchers hypothesized that mechanism for synchronization was social. While this assumption is built into Feldman’s theoretical model, it is important to note that research has yet to support that aspect of the bio-behavioral synchrony model (2012a; 2012b).

Other studies demonstrate synchrony in conditions where this causal relationship between behavioral interactions and physiological synchronization is unlikely to have caused the physiological synchrony discovered in those studies. One experimental, within-subject, repeat-measures design study examined the effects of administering oxytocin to fathers on cortisol levels and dyadic behaviors of infants and fathers during face-to-face-still-face experiment (Weisman, Zagoory-Sharon, & Feldman, 2013). Oxytocin is a neuropeptide associated with reduction of stress, affiliative motivation, bonding, and social salience (Weisman & Feldman, 2012). The addition of oxytocin to the dyadic system through the father resulted in a change in the cortisol response and social behaviors (measured through degree of gaze synchrony and gaze engagement attempts) of fathers and infants. Manipulation of a biological factor (oxytocin) in the fathers affected the behavioral and biological processes of both the father and the infant (Weisman & Feldman, 2012). While the direction of the effects was moderated by the degree of gaze synchrony, which is a behavior, the difference in responses for both high and low gaze synchrony dyads between the oxytocin and the placebo conditions indicated
that physiological processes also impact behaviors (Weisman, Zagoory-Sharon, & Feldman, 2013).

A study conducted in the context of a firewalking ritual provides an example of physiological synchrony in the absence of behavioral synchrony. Participants and their spectating family members and friends experienced heart rate pattern entrainment, while other crowd members did not synchronize heart rhythms with the participant (Konvalinka, Xygalatas, Bulbulia, Schjodt, Jegindo, Wallot, Ordem, & Roepstorff, 2011). It is important to note that there were no social interaction behaviors occurring between the firewalkers and their family members in the crowd during the heart rhythm synchronization (Konvalinka et al., 2011). The results of this study by Konvalinka, Xygalatas, Bulbulia, Schjodt, Jegindo, Wallot, Ordem, and Roepstorff imply that mechanisms other than behavioral interaction can generate change in the dyadic system at a physiological level. Thus, the conceptualization of synchrony this study supports does not limit the directionality of influence from behaviors to physiology, and instead allows for a systemic approach that supports multidirectional influence.

Alternate Models

Some other potential mechanisms of multilevel synchrony are being explored in research. While it is beyond the scope of this study to determine if any of these avenues for synchrony are valid, it is beneficial to introduce them to represent the wide array of possibilities for processes through which synchrony could be established and maintained. Future directions for research in the field of parent-child synchrony may address the
mechanisms through which interactional and physiological synchrony are achieved, and some of these theoretical models may be tested empirically.

**Mirror Neurons**

While philosophers and scientists alike have often presumed that behavior entirely mediates the interactions between individuals, research on mirror neurons indicates that there may be more to the way we experience others (Braten, 2007). Mirror neurons were discovered when researchers were studying the motor cortex of chimpanzees; when a researcher ate his lunch in front of the chimpanzee in the study during a break, the chimp’s brain showed activity as if it had reached to grasp the food itself, although it had not moved (Di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992; Gallese, Fadiga, Fogassi, & Rizzolatti, 1996). In essence, a mirror neuron is a motor neuron in the brain that becomes activated when the person observes or hears the action of another person as if the observer had done the action herself (Hari, 2007; Kohler, Keysers, Umilta, Fogassi, Gallese, & Rizzolatti, 2002). Thus, as one person completes an action, the observer and the actor both experience neural activation representing that particular action. Although mirror neurons are yet to be fully understood, particularly in the human brain, the discovery has led to alternate pathways for how we think about consciousness, social processing, and interactional synchrony.

Although it may seem that mirror neurons confirm the idea that behavior mediates the shared interaction, the mirror neuron system lends itself to a “felt immediacy,” which is quite different than the behavior-mediated model that Feldman proposed (Braten, 2007). Feldman’s model follows the Leibnizian school of thought that posits a self-
contained consciousness in which contact with others is entirely mediated by the use of symbols (such as gestures, actions, and language). In the Leibnizian world, an individual would initiate contact with another person through a symbolic action (Leibniz, 1720/1898). The recipient would, through a conscious perception process, evaluate the initiator’s action and compose a response in the form of a symbolic action. The initiator would consciously process the recipient’s response, and compose the next action. In contrast, mirror neuron activation is a non-conscious process, in that observers do not realize that they are experiencing similar activation as they would if they had done the behavior themselves. Mirror neurons are considered to be responsible for shared experiences related to touch, pain, and disgust for examples, even when only one person is only observing (Wicker, Keysers, Plailly, Royt, Gallese, & Rizzolatti, 2003; Keysers, Wicker, Gazzola, Anton, Fogassi, & Gallese, 2004; Saarela, Hlushchuk, Williams, Schurmann, Kalso, & Hari, 2007). Thus, the mirror neuron system allows for co-experiencing, which contradicts Liebniz’s concept of individual, self-contained consciousness. Co-experiencing, or co-consciousness, through the mirror neuron system is potentially a far different mechanism for accomplishing multilevel synchrony than the behavior mediated model.

Also worth noting is that a majority of the literature examining social cognition relies on a “bottom-up” framework, which emphasizes the contribution of information gathered by the senses in order to cognitively process and make decisions. An alternative is the “top-down” framework, which emphasizes the individual’s ability to anticipate and predict impending events, based on prior experiences (Hari, 2007). While both “bottom-
up” and “top-down” processing surely occur, it is worthwhile to examine “top-down” processing as it relates to social cognition. Examples that may support the “top-down” framework are rapid facial expression recognition and anticipatory altercentric participation behavior (Hari, 2007; Braten, 2007a). Altercentric participation is evident when an observing person “joins” the action of another, such as the opening of one’s own mouth while feeding an infant, or unwittingly making small movements as if in support of a professional athlete. Altercentric participation is predictive by nature because it manifests our understanding of both the intent of the person we are observing and what we think should happen next to accomplish that goal (Braten, 2007a). This is most evident when the altercentric participation occurs during speech, such as when one person finishes the sentence of another person (Braten, 2007a). Mirror neurons may play a role in confirming or correcting our predictive hypotheses during social interactions. In a “top-down” framework, synchrony would be mediated not only by behavior, but also by how accurately the dyad members were predicting the behavior and intent of the other.

**Internal Working Model**

Attachment theory contributes the concept of “internal working models” to describe the representation a person maintains internally of self and others (Zeanah & Anders, 1987; Main, Kaplan, & Cassidy, 1985). This representation is dynamic, however, it is much more flexible in the first years of life and tends to become more stable over time. The internal working model includes internalized expectations or “rules” that guide how the person interprets and makes attributions regarding the actions of others (Zeanah & Anders, 1987; Main, Kaplan, & Cassidy, 1985). Logically, the
internal working model also guides how the individual responds to others in relationship. An internal working model may not be entirely accurate, and when the internal working model is mismatched with reality, it is termed an “incoherent” or “inadequate” working model (Zeanah & Anders, 1987, p239). In healthier dyads, the internal working models are coherent, and the expectations, attributions, and responses of the child and caregiver are more consistent with reality and with each other. From an attachment perspective, synchrony may result when the internal working models of the child and the parent are sufficiently accurate and positive to enable periods of interaction where the ongoing exchange of expectations and responses are consistent with each other. If both members of the dyad are accurately anticipating the forthcoming positive action of the other, and thus they are both poised to respond to the other in a likewise positive manner, these conditions could also facilitate interactional synchrony.

**Brain Charge Mechanism**

Another model explains how dyads that synchronize interpersonally also consistently experience physiological entrainment as well (Haas, 2012). This model theorizes that neurological action and reception states correspond with a positive or negative electrical charge due to the electrochemical changes that occur during neurobiological processes (Haas, 2012). In dyadic interactions, the dyad may synchronize through alternate active and receptive behaviors with corresponding positive and negative net neural charges (Haas, 2012). For example, in a conversational exchange, the speaker would be positively activating the brain areas associated with his or her action. In a synchronous exchange, the listener often demonstrates activation in
the same region of the brain as the speaker, perhaps due to memory acquisition or to mirror neurons. In receptive/expressive areas, the dyadic exchange “overlaps” in the opposite charge areas of their respective brains (Haas, 2012). Then, as the dyad switches roles and the listener becomes the speaker, the negative receptive charge becomes a positive charge, and the process repeats with this member as the speaker. After the exchange ends, both members process the interaction and re-establish a balanced (rather than complementary) charged neural state (Haas, 2012).

**Theoretical Foundation**

The theoretical lens for this study originated in a background of therapeutic orientation to relational dynamics. Bowen Family Systems Theory (BFST) served as the overarching theoretical lens (Bowen, 1978). BFST contends that family members function systemically as an emotional unit, and that the health of the system can be determined by how anxiety, or emotional energy, is transferred among family members (Kerr & Bowen, 1988). If the system is flexible and able to regulate emotion in a way that fosters both connection and selfhood of the individual members, then it supports optimal health for each individual (Bowen, 1978). Thus, on the most basic level, one of the criteria for the selection of video segments was the quality of the flow of emotional energy in dyadic interactions.

Integrated with BFST for this study is attachment theory, which provides theoretical conceptualization specific to the parent-child relationship. Bowlby emphasized the parent’s optimal role in dyadic interaction as one that adapts behavior to match the attention, stimulation, and down-regulation needs of his or her infant (1988).
According to Bowlby (1988), sensitive parent-child interactions help the “infant’s rhythms shift gradually” (Bowlby, 1988, p. 8). Schaffer, Collins, and Parsons described the tendency of pre-verbal infants and their mothers to engage in turn-taking during vocalizations, which is also a characteristic of responsive and sensitive parenting (as cited in Bowlby, 1988, p. 8). Secure attachment, the optimal state of relationship health in attachment theory, is associated with parent-child shared positive affect during play (Ainsworth, Blehar, Waters, & Wall, 1978).Insensitive parenting is characterized by the parent’s failure to respond to the infant’s signals accurately, timely, or at all (Bowlby, 1988). Informed by an attachment perspective, video segments were selected as synchronous when the parent’s and child’s interactions displayed signs of positive affect, modulation of arousal and turn-taking rhythms to the child, and the child’s responsiveness to this modulation. Asynchronous segments were selected when the dyadic interactions showed evidence that the parent had misinterpreted, ignored, delayed appropriate response to, or overlooked the child’s signals. In asynchronous segments, the parent and child did not “meet” each other in terms of rhythms of interaction, arousal levels, activity agenda, or attention goals.

Lastly, the conceptual framework was influenced by Kochanska’s work on Mutually Responsive Orientation (MRO). MRO develops as the parent intervenes and responds to his or her child in a way that is sensitive to the needs and desires of the child. This mode of responding results in the child’s receptive stance of willingness to cooperate or comply with the parent (Kochanska, 1997). Willingness to accommodate the other person’s agenda, wishes, and goals is a characteristic of MRO parent-child
interactions. Less forceful measures are required from the parent to exact compliance from the child when MRO is established, because the child is primed to respond to parental prompts and instruction with cooperation (Kochanska, 1997). While MRO research tends to focus on long-term outcomes on the development of children’s moral conscience and internalization of parental socialization guidance, the facilitative stance of the parent and the cooperative stance of the child were useful in the descriptions of moment-to-moment dyadic interactions for the concept of synchrony. In terms of segment selection, dyadic interactions that displayed partners adapting to or incorporating the agenda of the other person were selected as synchronous segments. Interactions that demonstrated the parent and child rigidly adhering to their own agenda, without accommodation of the other’s desires or needs, met criteria for asynchronous segments. Also, interactions that demonstrated greater parental force distinguished asynchronous exchanges.

**Multilevel Synchrony Research**

Although the mechanisms for synchrony are still unknown, there is a body of literature examining the presence of synchrony in dyadic interactions. Most of the synchrony research to this point has been dedicated to establishing synchrony on single levels in the parent-child dyad, but there have also been a few publications on multilevel synchrony. The further examination of synchrony on multiple dyadic levels (behavioral and physiological) is critical to the extension of a systemic understanding of synchrony. The field has yet to explain how and through what modes entrainment of multiple levels of functioning occur during dyadic interactions. With the current body of research, these
questions appear to be most suited to a systemic conceptualization of synchrony that incorporates the multiple physiological, behavioral, and neural processes of dyad members, which may interact with each other in as of yet unknown ways.

In a recent experimental study with a within-subjects, repeated measures, double-blind design, researchers explored the relationship between the neuropeptide oxytocin, gaze synchrony between infants and their father, and stress response as measured by cortisol (Weisman, Zagoory-Sharon, & Feldman, 2013). This study was introduced earlier in the paper as an example of potential multidirectional influence between behavioral and physiological synchrony. Each dyad participated in the study on two separate occasions, once in each of two conditions. Oxytocin was administered intranasally to fathers in the oxytocin condition, and the placebo condition consisted of intranasal administration to the fathers of an inactive solution that was otherwise identical to the oxytocin compound (Weisman et al., 2013). In each condition, the fathers’ interactions with their infants were recorded to measure behavioral synchrony. The study included the fathers engaging in face-to-face-still-face (FTFSF) to provide a social stressor (Weisman et al, 2013). Fathers and infants were recorded interacting with each other and the incidence and degree of gaze synchrony was coded to distinguish two groups (high gaze synchrony and low gaze synchrony) for parent-infant behavioral synchrony (Weisman et al., 2013).

Both fathers’ and infants’ salivary cortisol levels were recorded at several time intervals during and after the interaction sessions (Weisman et al, 2013). The results demonstrated that when the levels of oxytocin in the father were manipulated, there were
differences in the behavioral and physiological responses of both fathers and infants as compared to the control condition (Weisman et al, 2013). The administration of oxytocin resulted in different directions of effects based on high or low classification of dyadic behavioral synchrony. Typically, parents do not have an HPA-axis stress response to the still face interruption in parent-infant interaction, but when fathers who had high gaze synchrony with their infants had been administered oxytocin, they experienced heightened cortisol levels in response to providing a still face to their infants (Weisman et al, 2013). The differential response seen in the infants in the oxytocin condition was the level of distress (as measured both by attempts to resume social gaze and by cortisol levels) in response to the still face of their fathers. For infants with high gaze synchrony with their fathers, their distress was higher than when they were in the placebo condition. It is important to note that in the oxytocin condition, the high synchrony infants and fathers experienced more HPA-axis stress response to the still face exercise than the low synchrony dyads did in either the oxytocin condition or the placebo condition (Weisman et al, 2013). For infants in low gaze synchrony dyads in the oxytocin condition, distress was lower when exposed to the still face than it was when they were in the placebo condition (Weisman et al, 2013).

The researchers hypothesized that oxytocin increased the salience of social cues, and thus when high synchrony dyads experienced an interruption, the oxytocin in the father led to greater physiological distress in father and infant. For infants who were not accustomed to gaze synchrony, the additional oxytocin in their fathers resulted in a reduction of distress when their interaction was disrupted (Weisman et al, 2013). This
indicates that synchrony exists on multiple levels, and that a physiological change in one member of the dyad has effects on the manifestation of synchrony across multiple systemic levels in both dyad members.

As introduced earlier, Feldman and colleagues researched HRV patterns in mothers and their infants during social interaction (Feldman et al, 2011). Both the mother-infant interactions and the mother-infant heart rhythms were analyzed for synchrony, and the results indicated that the greater the behavioral synchrony between mother and infant, the greater the degree of HRV synchronization (Feldman et al, 2011). While much of parent-child research suggests that this type of synchrony (behavior to behavior and physiology to physiology) exists, few demonstrate it so clearly by measuring both behavior and physiology of parent and child in real time. The body of research on parent-child synchrony would benefit from more studies conducted in this manner, and the current research is designed to address this gap on the behavioral level.

**Single-Level Synchrony Research**

Empirical investigation of human dyadic synchrony is not widespread in the extant literature, however, there is evidence indicating that interpersonal synchrony exists on single systemic levels (behavior, physiology). Some research teams hypothesized that they would find synchronous results, while others found synchrony without expecting it. Together these studies provide a foundation to expand upon the existing synchrony research; the field is only a few steps away from exciting and novel insights into the functions and development of the systemic, biopsychosocial parent-child relationship.
Cardiac Vagal Tone Synchrony

One of the measures that has garnered the most research attention in parent-child synchrony is the examination of cardiac vagal tone, or vagal modulation. According to Porges’ Polyvagal Theory, the vagus nerve serves to perform functions of the parasympathetic branch of the autonomic nervous system in regulating cardiac activity (1992). High degrees of activation of the vagus nerve (often measured non-invasively through vagal modulation) is interpreted to represent suppression of an individual’s sympathetic nervous system response to a stressor, and this balancing of sympathetic and parasympathetic activation is a function of self-regulation (Stein, 2005). Because the field of child development has frequently theorized that relationship with a caregiver fosters self-regulation abilities, vagal tone has emerged as an ideal candidate for understanding one of the processes through which the parent-child relationship can support the development of the autonomic nervous system (Stein, 2005). Measuring and interpreting the activation of the vagus nerve is not always straightforward, and more discussion regarding research on vagal tone can be found in Stein’s article (2005). However, the body of literature on vagal tone and the associations with child development and relationships with parents is invaluable to future research. Specifically, there is a gap in the literature for using micro-analytic research methods to investigate the relationship between vagal tone and online parent-child interactions.

Some studies serendipitously discovered evidence of physiological synchrony. One such study measured baseline vagal tone and baseline-to-task change in vagal tone in mothers and their children at child ages of two months and again at five years (Bornstein
& Suess, 2000). The researchers expected to find greater child-parent concordance in the baseline vagal tone than in baseline-to-task change in vagal tone, hypothesized to be due to the baseline vagal tone representing inherited genetic traits of vagal organization (Bornstein & Suess, 2000). However, they found that baseline-to-task change in vagal tone was moderately synchronized between mothers and infants at two months of age, and highly synchronized at five years (Bornstein & Suess, 2000). This was an unexpected result because the baseline-to-task change in vagal tone is thought to be indicative of the activity of several systems, incorporating influence from emotion, physiology, cognition, attention, and environmental demands (Bornstein & Suess, 2000). This supports the position that synchrony between parents and children occurs on various levels simultaneously, a phenomena that is hypothesized to manifest through multiple mechanisms and systemic processes.

**Gaze Synchrony**

Mutual gaze has also been studied as a behavioral manifestation of synchrony. Gaze synchrony was defined as a type of behavioral synchrony in which the dyad members are gazing at each other, otherwise described as “making eye contact” (Harel et al., 2011). In a study examining the similarities and differences between visual abilities and gaze synchrony of preterm and full-term infants at age three months, researchers found that the duration of gaze synchrony with mothers was longer for infants who were born full-term (Harel, Gordon, Geva & Feldman, 2011). Infants who were born preterm sustained gaze synchrony for a maximum of two seconds before the infants or mothers averted their gaze. Full-term infants had much greater amounts of total time spent in
gaze synchrony than pre-term infants did (Harel et al., 2011). It is possible that sustaining gaze synchrony is an ability that develops with physiological maturity (Harel et al., 2011). They also found that preterm infants and their mothers had a greater frequency of gaze synchrony than full term infants, perhaps suggesting that mothers and infants reinitiate gaze synchrony more frequently to compensate for the brief periods of synchrony before disengagement (Harel et al., 2011). However, even this compensation did not result in as much total time in gaze synchrony when compared to full-term infants and their mothers (Harel et al., 2011). Thus, preterm infants and their mothers demonstrated shorter and more frequent gaze synchrony episodes at three months of age, which may be due to disadvantaged developmental processes and compensatory behaviors. Full-term infants at three months engaged in longer episodes of gaze synchrony, perhaps due to typical development of physiologic capabilities. Thus, physiological development may have an impact on the ability of the dyad to engage in certain synchrony behaviors, but further research is needed to establish that relationship.

**Positive Affect Synchrony**

Positive affect is considered one of the markers of dyadic synchrony (Lunkenheimer et al., 2011). In one of Feldman’s earlier studies, one hundred families consisting of father, mother, and firstborn child were studied to evaluate patterns of synchrony and positive affect arousal in parent-infant dyadic interactions (2003). Synchrony was defined as “the degree to which the partners change their affective behavior in reference to one another” (Feldman, 2003, p. 10). While the patterns of affective arousal differed between mother-infant and father-infant interactions, both
parents demonstrated capacity for synchrony (Feldman, 2003). Male infants and fathers both demonstrated a tendency toward intense, rapid, high positive affect peaks during parent-infant play. Mothers tended to engage in cyclical, gradual, low-to-medium affective arousal. Perhaps because of this difference, there were fewer incidences of mother-son synchrony than in any other pairing, possibly due to affective arousal mismatch (Feldman, 2003). Fathers and sons demonstrated the highest degree of synchrony (Feldman, 2003). Daughters had greater synchrony with mothers than sons did with their mothers; however, the affect synchrony was not as strong as that between fathers and sons (Feldman, 2003). In terms of the patterns of synchrony that are described by Feldman, it should be noted that she utilized regression models to predict changes in the behavior of the dyad members, which is not as sensitive in representing behavioral change as other analytic methods (Bakeman & Gottman, 1997). However, it is important to note that positive affect arousal is a critical component in the context of parent-infant synchrony.

**Heart Rhythm Synchrony**

There is evidence that heart rate patterns can synchronize between family members and friends in the absence of behavioral interaction. While conducting a study in effort to capture the physiological activity of collective emotion, a research team discovered synchrony in heart rate patterns of family members. The context for this study was measuring physiological arousal of participants and spectators during a Spanish firewalking ritual, which served as the emotional event for the study (Konvalinka et al., 2011). In the firewalking ritual, a select number of community members take turns
walking across live coals while the rest of the community, including family members and non-related spectators, watch the event. Without rhythmic movement, breathing, or communication, the firewalker and his or her family members experienced a synchronized pattern of heart rhythm during the firewalking ritual (Konvalinka et al., 2011). This is a similar result to the vagal tone study in which mothers and children had synchrony in their vagal tone change as a response to a task, even though they were not interacting at the time of task completion (Bornstein & Suess, 2000). Results indicating levels of physiological synchrony without behavioral interaction may be key to exploring synchronization through a systemic lens.

**Related Constructs**

Other researchers have utilized similar constructs that are conceptually related to synchrony, and contribute to establishing a framework into which the construct of parent-child synchrony can be developed further.

**Co-regulation**

The concept of co-regulation focuses on the manner in which a child’s ability to self-regulate emotion is potentially fostered by particular parental behaviors and parent-child relationship characteristics. Often, a premise of co-regulation is that the child synchronizes his or her behaviors and physiology to match that of the parent, and through the parent’s guidance and influence, the child is able to develop self-regulation capabilities. In one such study, the researchers defined their construct of co-regulation as “coordinate(d) states of positive affective arousal in close temporal proximity” (Lunkenheimer, Olson, Hollenstein, Sameroff, & Winter, 2011, p. 576). Coordinated
responses, shared positive affect, and matched arousal states in close temporal location are all components of synchrony.

**Mutually Responsive Orientation**

Another concept closely related to parent-child synchrony is termed “Mutually Responsive Orientation,” or MRO (Kochanska, 2002). This construct is based on Attachment Theory and refers to a particular quality of some parent-child relationships in which both the parent and the child have demonstrated sensitivity to the other over time, and as a result, they demonstrate a “ready willingness” to comply with the wants and/or needs of the other. This willingness is visible in mutual accommodation of the goals of the other person (Kochanska, 1997). As would be expected, when parents and children have established a mutually responsive orientation towards each other in their relationship, less force is required by the parent to accomplish compliance in the child (Kochanska, 1997). Kochanska and colleagues have demonstrated that MRO in early parent-child relationships predicts outcomes in children such as development of conscience, moral cognition, and expressions of empathy (2002).

**Joint Attention/Shared Intentionality**

A portion of the synchrony research has focused on the capacity of the mind to focus simultaneously on the same activity or object as another person. Feldman has used similar constructs in her coding schemes for behavioral synchrony (Feldman et al., 2011; Harel et al., 2011). Sometimes this construct is measured by concurrent eye gaze by two people with a shared focus (Kawai, 2011), and other times it is defined by the instructions to the participants in the experiment (Naeem, Prasad, Watson, & Kelso, 2012). Some
Researchers use a more stringent definition, which requires both individuals to indicate an understanding of the intentions of the other person (Tomasello, 1995). This concept is found in the literature under the terms “joint attention” and “shared intentionality” (Kawai, 2011; Naeem et al, 2012). Studies on joint attention and shared intentionality relate the outcomes to concepts such as the development of theory of mind and early literacy (Calder, Lawrence, Keane, Scott, Owen, Christoffels, & Young, 2002; Farrant & Zubrick, 2011). Theory of mind is the ability to hypothesize, understand, and predict the mental processes and states of another person (Astington, Harris, & Olson, 1988). Synchrony has also been studied as a precursor to theory of mind capabilities, so there are multiple ways that the constructs of joint attention and synchrony are interrelated (Feldman and Greenbaum, 1997).

All these studies point to a foundation of literature surrounding the research gaps for synchrony. While synchrony is a multilevel construct, involving multiple systems in dyadic interaction, this study addresses the research gap associated with the need for a more precise and reliable operationalization of behavioral synchrony. The hypothesis for this study is that using behavioral codes developed from concepts related to synchrony in the literature, episodes of synchrony can be distinguished from asynchrony. The existing literature on behavioral synchrony uses different methods for operationalizing synchrony, thus making it difficult to compare results. Even Ruth Feldman, the premier researcher in the field of synchrony, uses different behaviors and methods to operationalize synchrony in her many studies on the topic. There is a dearth of published literature that utilizes an approach that makes it possible to investigate the dynamic interaction processes involved
in parent-child synchrony. The aim of this study is to operationalize behavioral synchrony using a time-series, micro-analytic approach to investigate dynamic dyadic interaction patterns associated with synchrony, thus addressing the research gap.
Chapter 3: Methods

Data Set

The data set used for this study is a portion of a pre-existing data set collected in 2008 by a research team in the Department of Child, Youth, and Family Studies at the University of Nebraska-Lincoln consisting of Julia Torquati. The aim of the original study was to explore the mechanisms of social influence on self-regulation in the parent-child dyad. The original data set includes a sample of thirty-nine parent-child dyads with children between the ages of three and six, of which four dyads participated in an EEG protocol. This study utilizes data from the four EEG dyads. The EEG data subset was selected because I hope to continue research with this data beyond the scope of the present study, and to include the EEG data in analysis at a later time. Although primary analysis of the original data set has yet to be completed, the current study has followed the format of a secondary analysis due to the application of new research questions to the existing data set. The original study was designed with the intention of investigating the development of self-regulation. This study applies the research question of, “Can behavioral synchrony between parents and children be operationalized?” This research question can be applied to this data set because there is sufficient data of parents and children interacting in semi-structured and free play activities to afford opportunities for synchronous and asynchronous interactions.
Participants.

Participants were from a university town in the Midwest. Participants were four parent-child dyads, and all of the dyads identified as Caucasian with a primary language of English. All of the dyads came from intact families. The child participants were between the ages of 46 months (3.8 years) and 64 months (5.3 years) at the time of data collection. Of the children, three were male and one was female.

Parent participants were between the ages of 28 and 38 years at the time of data collection. The parent members of the dyads were all female. The mothers’ highest levels of education were as follows: one with some college, one with a bachelor’s degree, one with a master’s or other professional degree, and one with a doctoral degree. In the families represented by mother-child dyads, the fathers’ highest levels of education were as follows: two with a bachelor’s degree, one with a master’s or other professional degree, and one with a doctoral degree. Table 3.1 below displays the characteristics of each of the four dyads in the sample. The dyads are labeled as they were in the data set, and these dyad names are consistent throughout the chapters.
Table 3.1

Demographic Description of Sample Dyads

<table>
<thead>
<tr>
<th></th>
<th>Dyad 01</th>
<th>Dyad 03</th>
<th>Dyad 05</th>
<th>Dyad 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child Age (months)</td>
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<td>57</td>
<td>63</td>
<td>64</td>
</tr>
<tr>
<td>Mother Age (years)</td>
<td>38</td>
<td>28</td>
<td>Missing</td>
<td>31</td>
</tr>
<tr>
<td>Mother Education</td>
<td>Ph.D.</td>
<td>B.A.</td>
<td>Some College</td>
<td>Master’s or other Professional Degree</td>
</tr>
<tr>
<td>Father Education</td>
<td>Ph.D.</td>
<td>B.A.</td>
<td>B.A.</td>
<td>Master’s or other Professional Degree</td>
</tr>
<tr>
<td>Child Sex</td>
<td>Female</td>
<td>Male</td>
<td>Male</td>
<td>Male</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>Caucasian/White</td>
<td>Caucasian/White</td>
<td>Caucasian/White</td>
<td>Caucasian/White</td>
</tr>
<tr>
<td>Family Income (annual)</td>
<td>$150,000+</td>
<td>$25,000-$49,999</td>
<td>$50,000-$74,999</td>
<td>$25,000-$49,999</td>
</tr>
</tbody>
</table>

Sample selection

Notices of information regarding the opportunity to participate in the larger initial study were advertised in community child care facilities, as well as in the university child development laboratory. All of the dyads were offered the opportunity to participate in the EEG protocol, and selection was determined by the order in which the dyads volunteered. The four dyads in this study represent the first four dyads who volunteered and met inclusion criteria. Exclusion criteria were: (a) a medical history that included
epilepsy or a disorder of the central nervous system that could be detected on an EEG trace; (b) an allergy to medical gels and liquids that would be applied to the scalp; and (c) use of prescription neuroleptics that could distort or confound the EEG trace. The parents in these four dyads received one hundred dollars cash for each laboratory Quantitative EEG (QEEG) session.

Procedures

Four dyads consisting of one parent and one child visited the child development laboratory to participate in QEEG and behavioral observations. There were three lab visits during which parents and children engaged in a set of activities described below. Lab tasks and collection of QEEG data took place in a room equipped with remotely controlled video cameras. An EEG technician remained in the room to monitor the quality of the QEEG signals throughout the data collection. The technician, EEG equipment, and monitors were located on the opposite side of the room from the participants, who were seated on a small couch. Another researcher controlled the video cameras from the next room to maximize ability to effectively observe the dyadic interactions. For each visit, the parent and child entered the testing room, which had a couch, a small table, the EEG equipment, and two small cameras that were mounted to the walls. As they entered the testing room, the researcher (associated with the original data set, not the researcher for this study) explained the next step. As each step was completed, the researcher explained the next step and gave any needed instructions. Each session was video recorded in entirety and included five parts:
1. Informed consent was completed during the first visit; all visits included: explanation of procedures, opportunity for questions, and QEEG preparation.

2. Calibration of QEEG equipment; synchronization of QEEG equipment, computer, and video recorder; and baseline QEEG reading

3. Parent and child read a book together

4. Task that varied with each session (see below)

5. Removal of QEEG electrodes and residual gel

The parts of the procedures that pertain to this study are described in further detail. The parts that pertained to the collection of EEG data are not elaborated upon because the EEG data is not included in the present study. It should be emphasized that the consent procedure was completed during Part 1 of the first visit, which covered the procedures associated with collection of both the EEG and behavioral data.

**Part 3.** The dyad was given a children’s picture book and instructed to read it together in the same way they would if they were at home. They were allowed to take as much time as they needed to read the story, and in all instances it took 10 minutes or less. A different book was presented at each of the three visits. These books for Part 3 all contained a written story as well as illustrations for the parents and children to read together.

**Part 4.** Note: all of these activities were open-ended, which provided a qualitatively different affordance for interaction than the more scripted interaction in Part 3.
Part 4 – visit 1. The dyad was given a different children’s storybook than the one given in Part 3. This story in this book was told entirely in pictures (without words), “A Boy, a Dog, and A Frog” by Mercer Mayer (1967). They were invited to tell/explore the story together. The dyad was given a maximum of 10 minutes to complete the story, and instructed to signal the investigator if they were done with the story in less than 10 minutes. If the dyad was still engaged in the activity after 8 minutes, the researcher asked them to take a few minutes to finish and informed them that they would begin the next activity soon. If they were not done in 10 minutes, the researcher transitioned them to the next activity. The child was given the book to take home.

Part 4 – visit 2. The dyad was given blocks and asked to build a structure together. The dyad was given a maximum of 10 minutes to complete the structure, and instructed to signal the investigator if they were done prior to the 10 minutes. After 10 minutes, the researcher informed them that they were done with the experiment, and informed the child that he/she could continue playing with blocks after completing an eyes open and eyes closed calibration of the EEG equipment.

Part 4 – visit 3. The dyad was given a blank book with six pages (three 8.5 X 11 sheets of paper stapled in the middle) and crayons. They were invited to tell the story of something they have done together recently. The dyad was given as much time as they needed to complete the story, and instructed to signal the investigator when they were done.
Measures

The measures for the present study included means of assessing the construct of behavioral synchrony and asynchrony through dyadic interactions. The procedures for developing observational codes to assess behavioral synchrony are described here. Both behavioral synchrony and asynchrony were examined, using the video recordings of the three visits (three sessions) for each dyad. The video sessions ranged from 30 to 45 minutes, yielding a total of 90 minutes or more of data for each dyad. First video segments were selected for subsequent coding was based on global concepts of synchrony and asynchrony. Second, the criteria for behavioral codes were developed from constructs of synchrony in prior research.

First, the researcher viewed all the video data for the four EEG dyads. Then, the researcher developed criteria for selecting the video segments. After selecting the segments of video data, the researcher developed the behavioral coding scheme. Then, the researcher coded the video segments with the behavioral codes. The researcher trained an independent coder on the coding scheme, and she also coded all of the video segments. The researcher and the secondary coder compared the coding results. Next, they viewed the video segments together to reach consensus on all of the coding discrepancies. The theoretical development of the video selection criteria, the conceptual development of the behavioral codes, and further discussion of the coding process are explained in the next sections.
**Video segment selection.**

I selected segments of video data in increments of twenty seconds, based on the determination that they were exemplars of either behavioral synchrony or asynchrony for that dyad. There were two synchronous segments selected for all dyads, and two asynchronous segments selected for dyads 05 and 12. However, due to lacking asynchronous interactions, dyads 01 and 03 had one segment each of asynchrony selected. These segments were selected based on global criteria related to dyadic interactions, not specific behaviors by either member of the dyad. The criteria for segment selection were developed from an integrated conceptual lens. This conceptual integration is comprised of Bowen Family Systems Theory (BFST), Attachment Theory, and Mutually Responsive Orientation (MRO). The goal was to have two synchronous and two asynchronous segments selected for each dyad, however, for dyads 01 and 03, there was only one segment each that met criteria for asynchrony. It was determined for the purpose of this study that it was more important in the effort of operationalizing synchrony to have exemplars that met criteria than to include additional asynchronous segments that did not meet the criteria described below. Thus, there are different amounts of analyzed data for different dyads. Dyads 01 and 03 have two synchronous and one asynchronous segment, and dyads 05 and 12 have two synchronous and two asynchronous segments.

Overall, interactions that were flexible, sensitive, positive, cooperative, responsive, and matching in rhythm and arousal met criteria for synchronous selection. Thus, in synchronous interactions, the parent and child were both engaged in the
cooperative co-construction of their shared experience. Conversely, the criteria for asynchrony were met in dyadic interactions that were irregular, uncooperative, mismatched, forceful, non-responsive, and disengaged. In asynchronous interactions, the parent and child maintained separate agendas. They either tried to force the other to adopt his or her agenda, or ignored the other in pursuit of the personal agenda. The quality of interaction was the criteria, and the type of task (book reading, blocks, etc) was not included as a consideration in segment selection. If the EEG equipment was not yet set up, or was being adjusted due to a loose electrode, however, those sections were also not included in segment selection because the eventual goal is to compare behavioral patterns to the EEG data.

There was also an inductive element to segment selection, insofar as the degree of synchrony or asynchrony of the selections depended on the dyad. What was an exemplar of synchrony for a dyad was determined by comparisons of the interaction sequences of that dyad, not comparisons to other dyads. A highly synchronous interaction for one dyad might not have been an unusually synchronous interaction for a different dyad. While the two interactions may have been equal on an absolute theoretical level, the relatively highly synchronous interaction for the first dyad would have been selected, while the usually synchronous interaction for the second dyad would not have been selected.

**Behavioral codes.**

To operationalize behavioral synchrony, a series of social behaviors were identified and defined to use in coding the selected video segments. The behavioral
categories associated with synchrony and asynchrony were developed from theoretical and empirical positions using face validity and prior research. Synchronous behavior codes were developed from existing literature, and asynchronous behaviors were identified as behaviors that could undermine or preclude the synchronous behaviors. Each behavioral code is accompanied by description of the code, identification of the theoretical origin of the code, and examples of behaviors fitting the code. The goal for the identified behaviors is to use the codes to distinguish between episodes of synchrony and asynchrony. Thus, dyadic behaviors that would not serve to distinguish between asynchrony and synchrony were rejected. This description applies to bids for attention, which are conceptually neutral, and present in both highly asynchronous and highly synchronous dyadic interactions.

While Feldman and colleagues’ prior synchrony research served as a guide, this study did not utilize their behavioral coding scheme because the configuration of the present data set differs from theirs in ways that prevent replication. Feldman’s coding scheme also differs from study to study. Feldman’s indices for behavioral synchrony that were closest to this study included facets of parent and infant gaze, affect, and vocalizations (Feldman et al., 2011). For gaze, the team identified whether the parent or infant was looking at the face of their dyad partner, to an object or environment, or away from their dyad partner but not specifically to an object (termed gaze aversion) (Feldman et al., 2011). Affect was coded for parent and infant as positive, neutral, or negative (Feldman et al., 2011). Parent vocalizations were coded in four categories. The first category was “motherese,” a particular type of infant-directed speech that is high-pitched
and has a sing-song inflection and rhythm (Feldman et al., 2011, p. 571). The second type of parent vocalization was typical infant-directed speech, and the third category was for speech that was typical of adult-to-adult communication (Feldman et al., 2011). The last category was for no speech. Infant vocalizations were categorized into either positive or negative vocalizations (Feldman et al., 2011). Feldman and colleagues distinguished between three types of synchrony: gaze synchrony, affect synchrony, and vocal synchrony. Gaze synchrony consisted of social gaze when parent and child were looking at each other (Feldman et al., 2011). The criteria for affect synchrony was shared positive affect. Vocal synchrony was identified when parent and infant made simultaneous positive vocalizations (Feldman et al., 2011).

While I did not utilize the same codes as Feldman and her colleagues, the conceptualization of behavioral synchrony was similar. Participants in this study were not required to face each other, as they were in the study conducted by Feldman’s research team. Furthermore, the dyads were engaged in tasks together, so sustained eye contact was not likely. Also, in the present research the dyads were comprised of young children and their mothers, a demographic that resulted in more complex social interactions than would be found with infants and mothers. Following are each of the behavioral codes for this study, with their definitions and conceptual origins.

**Synchrony codes.**

Some of the synchrony codes identify the behaviors of individual dyad members, while other codes reflect dyadic behaviors that require participation from both the parent
and the child. The codes for the behaviors of an individual have parallel codes for parent and child. All of the synchrony codes could co-occur with each other.

*Parent facilitative response to bid.*

The parent responds to a bid to engage from the child in such a way that facilitates the goal of the child. The bid can be verbal or non-verbal, and the facilitative response may be verbal or non-verbal. For this code, the distinguishing characteristic is that the behavior of the parent reflects acknowledgement of the child’s goals and acceptance of the child’s influence. This code is informed by attachment theory’s emphasis on responsive parenting and on MRO’s description of the parent’s incorporation or accommodation of the child’s goals (Bowlby, 1988; Kochanska, 1997). An example would be if a parent pauses in reading a book to her child to respond to the child’s question, “What’s that?” This code is mutually exclusive with “parent suppress response to bid” and “parent ignore bid.”

*Child facilitative response to bid.*

The child responds to a bid from the parent in such a way that facilitates the goal of the parent. This may look like “compliance” but is not limited to behavior management bids. The bid can be verbal or non-verbal, and the facilitative response may be verbal or non-verbal. As a parallel code to “parent facilitative response to bid,” the behavior of the child indicates acceptance and accommodation of the parent’s agenda. This code is related to attachment theory’s position that a child with a secure attachment style trusts her parent to meet her needs (Bowlby, 1988). MRO posits that children in optimal parent-child relationships are oriented toward willingness to accept and comply
with the agenda of their parents (Kochanska, 1997). If a child is getting ready to turn the page of a book, but stops when the parent says, “Look at the boy in the book,” then criteria is met for “child facilitative response to bid.” This code is mutually exclusive with “child suppress response to bid” and “child ignore bid.”

Collaboration.

The parent and child both contribute to the current task by building on the other’s contribution. Parallel play and actions that undermine the contribution of the other do not meet criteria for the “collaboration” code. As a dyadic code, criteria are met only when both members of the dyad are contributing and incorporating the contributions of the other dyad member. In collaboration, the parent and child co-construct a shared agenda, which is evidenced by the accommodation of the agenda to include the contribution of the other person at each turn. This code was developed from Feldman’s conceptualizations of turn-taking and co-construction of shared “relational moments” (2007b; 2007a, p. 330). For example, “collaboration” criteria would be met if parent and child participate together in playing with building blocks on the same composition. The parent may say, “How tall can we make the tower?” The child may respond, “Here’s a tall block,” and place the block on top of another. After which may follow, “It’s getting wobbly,” and the parent might reach out to stabilize the blocks. This code is mutually exclusive with “separate attention.”

Joint attention.

The parent and child are paying attention to the same thing, which can be an object or an activity. For this study, joint attention criteria are simply the behaviors of
both parent and child visually attending to the same object or activity. This has been defined as “joint visual attention,” by Butterworth (1991, p. 223). Other definitions of joint attention have been more restrictive by requiring signs that the dyad members are accurately interpreting the intentions of the other person (Tomasello, 1995). Because the development of theory of mind was not the focus of this study, a simpler definition of joint attention was used than is endorsed by Tomasello (1995). However, the position also exists that visual gaze is indicative of shifting attention to a shared target, regardless of other cues (Kawai, 2011). Examples of joint attention include scenarios where the parent is reading and the child is visually attending to the book, in addition to situations where both parent and child are assembling a puzzle together. This code is mutually exclusive with “separate attention.”

*Shared affect.*

The parent and child display signs of the same affective state. The affect is categorized as either positive or negative valence emotion. While this study did not exclude the possibility for negative valence shared affect, no instances of shared negative affect were coded. Shared affect was indicated by smiles, laughter, voice inflection, and body language. Because it is a dyadic interaction code, both dyad partners had to be demonstrating signs of the same affective state simultaneously to meet criteria for this behavioral code. Positive affect has been utilized in multiple studies, including two led by Feldman (Feldman et al., 2011; Feldman & Greenbaum, 1997). When a child finds the story being read to them humorous and then the parent joins in the laughter, the
moment when the parent starts laughing would mark the beginning of an episode of shared affect. This code is not mutually exclusive with any other behavioral code.

**Asynchrony Codes.**

While Feldman does include codes in her study on HRV synchrony and behavioral synchrony such as “gaze aversion” and “negative affect,” they are not conceptualized as asynchrony (Feldman et al., 2011, p. 571). Feldman et al. did not include these constructs in their results or discussion, so it is unknown what findings related to these behavioral codes may have resulted from that study. The codes related to asynchrony for the current study were developed from conceptualizations of behaviors that would prevent or compromise synchrony. These codes were developed as mutually exclusive behaviors from their synchronous counterparts.

**Parent suppress response to bid.**

The parent makes an attempt to make the child cease the bidding behavior, either through verbal or physical control tactics. It does not matter if the attempts are successful in ceasing the child’s bidding behavior, as long as the behavior is an overt tactic to discourage further bidding. This code is an active behavioral sign that the parent is not accepting or incorporating the child’s agenda. A response that attempts to suppress a child’s bid is conceptually incompatible with a facilitative response to a bid, thus this code differentiates between asynchrony and more synchronous interactions. A classic example of a parent making a suppressive response to the child’s bid is, “Stop that!” This code is mutually exclusive with “parent ignore bid” and “parent facilitative response to bid.”
Child suppress response to bid.

The child makes an attempt to make the parent cease the bidding behavior, either through verbal or physical control tactics. This is a parallel code with “parent suppress response to bid.” As with the “parent suppress response to bid,” the criteria for this code are not dependent on the success of the attempt in ceasing the parent’s bidding behavior. The active behavioral signal that the child is not incorporating the parent’s agenda is conceptually incompatible with “child facilitative response to bid.” If when a parent reaches out to guide the child, the child pushes the parent’s arm away, this would be a “child suppress response to bid.” This code is mutually exclusive with “child ignore bid” and “child facilitative response to bid.”

Parent ignore bid.

The parent does not acknowledge the child’s bid. This behavioral code is a passive response to a child’s bidding behavior. Even though there is no active attempt to stop the bidding behavior, it still signals that the parent is not responsive to the child’s wishes or needs. This can manifest in any situation where the parent continues with his or her agenda despite the child’s bid. For example, during a shared book-reading activity, the child might say, “I want to play.” If the parent continues reading the book without acknowledging the bid, criteria would be met for “parent ignore bid.” This code is mutually exclusive with “parent suppress response to bid” and “parent facilitative response to bid.”
Child ignore bid.

The child does not acknowledge the parent’s bid. As a parallel code to “parent ignore bid,” this code represents a passive behavioral response to the parent’s bid. It is a sign that the child is not accepting or accommodating the parent’s agenda. This behavioral code is conceptually incompatible with “child facilitative response to bid.” When a parent makes a request for the child to respond to a prompt, such as “How many birds are on this page?” and the child does not acknowledge the question, criteria are met for “child ignore bid.” This code is mutually exclusive with “child suppress response to bid” and “child facilitative response to bid.”

Separate attention.

The child and parent are visually attending to different things, which can be objects or activities. This is the asynchronous code that corresponds with joint attention in the synchrony classification. As with joint attention, the code does not attempt to reflect intent. It represents common visual attention and gaze direction between parent and child. As a dyadic code, if either dyad member looks to the object the other person is attending to, then “separate attention” is no longer present. As an example, if a child is playing with blocks, and the parent is checking his or her phone, criteria are met for “separate attention.” However, as soon as the parent looks back to the blocks, “separate attention” criteria are no longer met. This code is mutually exclusive with “joint attention” and “collaboration.”
Coding Process.

Two independent coders, using a micro-analytic behavioral approach (Bakeman & Gottman, 1997), coded the video data. The video data were coded second-by-second, with the onset of behaviors represented in the second in which they begin (rather than rounded to the next second). Both of the coders were female, Caucasian graduate students enrolled in a Marriage and Family Therapy master’s degree program. Both of the coders utilized a BFST theoretical orientation.

After coding the video segments independently, the two coders compared codes and together examined segments in which there was disagreement in order to determine consensus codes. The process for establishing consensus codes began with a comparison of the two coders’ coding for the segment, identifying areas of disagreement. Then the two coders viewed the video segment, looking specifically for the behavior codes on which there was disagreement. At times, one of the coders conceded at this point that the other coder’s code was more consistent with the code criteria. If there was not instant agreement at this point, each coder explained what she had seen and interpreted that led to her code that was in question. Considering the rationale of the other coder, the video segment was viewed several more times, often pausing and re-watching the seconds in question in slow motion. Discussion between the two coders was ongoing until consensus was reached. All of the consensus codes were endorsed by both coders. Kappa coefficients for coding prior to consensus were computed for each segment.
Chapter 4: Analysis

In dealing with observed behavioral data that was coded on a second to second interval, there are challenges to finding an analytic model that reflects the pattern and the complexity of human interactions. One of the most interesting aspects of assessing the visual inspection graphs is the pattern of onsets of new behaviors. Analyzing the sequences of behavior onsets can be done through time series analysis (Bakeman & Gottman, 1997). Time series analysis is used to answer questions about the transitions from one behavior to the next (Bakeman & Gottman, 1997). For example, it can be used to determine a statistic for how often behavior B follows behavior A. This would be a transitional frequency (O’Connor, 1999). Transitional probability is a statistic used to describe how likely it is for behavior B to follow behavior A as a conditional probability (O’Connor, 1999). Transitional probability is the core concept of lag sequential analysis. Because base rates of the behavior codes affect the transitional probabilities, researchers often utilize adjusted residuals (or z scores) for the transitional probabilities so that significance can be compared across groups (in the case of this project, dyads) (O’Connor, 1999). With lag sequential analysis, it is also possible to examine sequences of observed behaviors in chains consisting of three or more behavioral events (Bakeman & Gottman, 1997). For example, transitional probabilities for a three-event sequence would be the likelihood of behavior C, given behavior B, and the likelihood of behavior B, given behavior A (Bakeman & Gottman, 1997).

Analysis of the behavioral data consisted of a time series analysis utilizing transitional probabilities. This allows researchers to analyze moment-to-moment changes
in behavioral event sequences, as well as determine the space of the intervals between them, or lags. Transitional probabilities generate a statistic that represents the likelihood of a particular behavioral event to follow the specified initiating event after the specified lag interval (Bakeman & Gottman, 1997). In other words, the statistic allows the researcher to identify to what degree the presence of the criterion event predicts the subsequent presence of the next specified event. Sometimes the specified subsequent event is termed the “target” behavior (Bakeman & Gottman, 1997). The series of identified behavioral events in the specified order are called chains. As the number of unique behavioral events in a chain increases, the likelihood of that particular chain being present in the data decreases. For transitional probabilities to be useful, there must be some variability in the data, and in long behavior chains, there is little variability because many data selections will not have the specified behaviors in the order of the chain. Because of this, it is not recommended that behavior chains exceed six unique behaviors (Bakeman & Gottman, 1997). Thus, in the literature these chains of behavioral events frequently range from two to about six.

Some of the software for analyzing data using time-series analysis approaches are highly specialized or expensive, however, Statistical Analysis System (SAS) software also contains programs with sequential analysis capabilities (O’Connor, 1999; SAS Institute, 2004). It is important that the method of analysis for this project be both precise and accessible because the goal is to operationalize synchrony in a way that can be utilized by future studies. Because of this, SAS software was selected as the program to utilize for the time series analyses.
The ability of this statistical model to be used to highlight the strength of behavioral chains is useful for the aims of this study. Because the aim involving the behavioral data includes identifying behaviors and behavioral patterns that differentiate synchronous interactions from asynchronous interactions, transitional probabilities were calculated in a time series analysis. To highlight synchronous interactions, the behaviors selected were “Parent Facilitative” and “Collaboration,” with “Parent Facilitative” as the initiating event. To highlight asynchronous interactions, the behaviors selected were “Parent Suppress” and “Separate Attention,” with “Parent Suppress” as the initiating event. These behaviors were selected for analysis because they represent a parent behavior and a dyadic behavior for what would be expected in synchronous and asynchronous interactions, respectively. Parent Facilitation and Parent Suppress were selected because they are active responses the parent makes to a child’s bid, either in a synchronous or an asynchronous manner. Collaboration and Separate Attention were selected because it was hypothesized that they would differentiate between synchronous and asynchronous interactions. The selection of behaviors was also consistent with the theoretical position that parent behavior provides the framework in parent-child dyadic interaction for initiating and maintaining synchrony (Bowen, 1978; Bowlby, 1988; Feldman, 2003). BFST maintains that the child is impacted by the emotional processing of the parent through intergenerational transmission (Kerr & Bowen, 1988). Attachment theory indicates that the parent is responsible for creating a secure bond with the child through sensitive and responsive parenting (Bowlby, 1988).
Chapter 5: Results

Frequencies

At the most basic level, analysis of the behavioral data began with frequencies of observed behaviors. This analysis was used to address the hypothesis that the behavioral codes could be used to distinguish synchrony from asynchrony. The primary researcher and an independent coder coded all of the segments, and Kappas for inter-rater reliability ranged from 0.47 to 1.0, with an outlier of 0.29. The range for the kappa scores is 0.71, the median is 0.74, and the mean is 0.73. The mean and the median kappa scores are within the substantial range for agreement, and only the outlier score was below the moderate range (Landis & Koch, 1977). Consensus codes for all segments were utilized for all analyses. The frequency analysis represents the number of one-second intervals in which a particular behavior was observed, and does not represent duration of the behavioral events. It should be noted that the total number of seconds for synchronous and asynchronous segments is not equal due to segment selection criteria. There are 160 seconds of synchronous data and 120 seconds of asynchronous data. However, Table 5.1 has values for the proportion of a particular behavior present in asynchronous versus synchronous segments. This table is a summary of the data from all the selected segments, both synchronous and asynchronous from all four dyads.
Table 5.1

Behavior Frequency and Segment Type Proportions

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Synchrony</th>
<th></th>
<th>Asynchrony</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Count</td>
<td>Percentage of Behavior Counts</td>
<td>Count</td>
<td>Percentage of Behavior Counts</td>
</tr>
<tr>
<td>Parent Facilitative</td>
<td>48</td>
<td>92.3%</td>
<td>Parent Facilitative</td>
<td>4</td>
</tr>
<tr>
<td>Child Facilitative</td>
<td>21</td>
<td>95.5%</td>
<td>Child Facilitative</td>
<td>1</td>
</tr>
<tr>
<td>Joint Attention</td>
<td>158</td>
<td>69%</td>
<td>Joint Attention</td>
<td>71</td>
</tr>
<tr>
<td>Collaboration</td>
<td>75</td>
<td>100%</td>
<td>Collaboration</td>
<td>0</td>
</tr>
<tr>
<td>Shared Affect</td>
<td>20</td>
<td>100%</td>
<td>Shared Affect</td>
<td>0</td>
</tr>
<tr>
<td>Parent</td>
<td>0</td>
<td>0</td>
<td>Parent</td>
<td>27</td>
</tr>
<tr>
<td>Suppress Child</td>
<td>0</td>
<td>0</td>
<td>Child Suppress</td>
<td>2</td>
</tr>
<tr>
<td>Parent Ignore</td>
<td>2</td>
<td>6.7%</td>
<td>Parent Ignore</td>
<td>28</td>
</tr>
<tr>
<td>Child Ignore</td>
<td>7</td>
<td>15.2%</td>
<td>Child Ignore</td>
<td>39</td>
</tr>
<tr>
<td>Separate Attention</td>
<td>2</td>
<td>4.3%</td>
<td>Separate Attention</td>
<td>45</td>
</tr>
</tbody>
</table>

It is clear that many of the identified behaviors are much more frequently present in one type of segment compared to the other. For example, Parent Suppress and Child Suppress were never present in any synchronous segments. However, nearly a third of all the Joint Attention codes were assigned to asynchronous segments. Some of the behaviors distinguish asynchrony from synchrony more reliably than others. For example, Parent Ignore is a much better predictor of an asynchronous segment than Child Ignore is because over 15% of Child Ignore codes are present in synchronous segments. While the frequency results begin to indicate differentiation between synchronous and
asynchronous segments, a visual inspection of graphed codes is a useful next step to
demonstrate behaviors that co-exist and their patterns of onset and offset.

**Visual Inspection Graphs**

Following are three notable visual inspection graphs reflecting three segments of
the coded data, which serve two purposes. First, the visual inspection graphs provide useful information regarding the dynamic interaction between parent and child. These graphs allowed the researcher to assess the segments for different behavior pattern characteristics in synchronous versus asynchronous segments. Second, the visual inspection graphs provide orientation for the subsequent time series analysis and give visual display of the characteristics that are quantified. The visual inspection graphs are not necessarily an exhaustive representation of all behavioral codes for the segment. Graph 1 and Graph 2 depict synchronous segments, and Graph 3 displays an asynchronous segment. These demonstrate the characteristically different interaction patterns found in asynchronous versus synchronous segments.
Behavior Code Graph for Synchrony 12 B

**Segment 12 B**

<table>
<thead>
<tr>
<th>Collaboration, Joint Attention, &amp; Shared Affect</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Collaboration</strong></td>
</tr>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

**Segment 12 B**

<table>
<thead>
<tr>
<th>Parent Facilitative, Joint Affect, &amp; Child Facilitative</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Parent Fac.</strong></td>
</tr>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

Graph 5.1
Behavior Code Graph for Synchrony 03 A

### Segment 03 A
**Collaboration, Joint Attention, & Shared Affect**

<table>
<thead>
<tr>
<th>Collaboration</th>
<th>J. Attention</th>
<th>S. Affect</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>12</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>15</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>18</td>
<td>19</td>
<td>20</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>9:44:29</th>
<th>9:44:30</th>
<th>9:44:31</th>
</tr>
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<tbody>
<tr>
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<td>9:44:39</td>
<td>9:44:40</td>
</tr>
<tr>
<td>9:44:44</td>
<td>9:44:45</td>
<td>9:44:46</td>
</tr>
<tr>
<td>9:44:47</td>
<td>9:44:48</td>
<td></td>
</tr>
</tbody>
</table>

### Segment 03 A
**Parent Facilitative, Joint Affect, & Child Facilitative**

<table>
<thead>
<tr>
<th>Parent Fac.</th>
<th>S. Affect</th>
<th>Child Fac.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>12</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>15</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>18</td>
<td>19</td>
<td>20</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>9:44:29</th>
<th>9:44:30</th>
<th>9:44:31</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:44:35</td>
<td>9:44:36</td>
<td>9:44:37</td>
</tr>
<tr>
<td>9:44:38</td>
<td>9:44:39</td>
<td>9:44:40</td>
</tr>
<tr>
<td>9:44:44</td>
<td>9:44:45</td>
<td>9:44:46</td>
</tr>
<tr>
<td>9:44:47</td>
<td>9:44:48</td>
<td></td>
</tr>
</tbody>
</table>

Graph 5.2
Behavior Code Graph for Asynchrony 05 B

<table>
<thead>
<tr>
<th>Segment 05 B</th>
<th>Parent Suppress, Separate Attention, &amp; Child Ignore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parent Sup.</td>
<td></td>
</tr>
<tr>
<td>Sep. Atten.</td>
<td></td>
</tr>
<tr>
<td>Child Ignore</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<th>7</th>
<th>8</th>
<th>9</th>
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<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
</tr>
</thead>
</table>

Graph 5.3
One incidental result that was found through the visual inspection graphs was that in these segments with these dyads, “shared affect” was only found in synchronous interactions where there were multiple other synchronous behaviors present, such as “parent facilitative,” “child facilitative,” “collaboration,” and “joint attention.” This indicates that there may be specific behavioral patterns for synchrony that need to be further analyzed.

**Time Series Analysis**

Time series analysis permits the researcher to investigate dynamic interaction patterns because it analyzes the behavioral coded data as it relates to each other through time. This is essential for the aim of the study, which is to operationalize behavioral synchrony using a time-series, micro-analytic approach to investigate dynamic dyadic interaction patterns associated with synchrony. The results for the time series analyses are organized in the following Tables 5.2 and 5.3. The first table organizes the results for analysis I used with the initiating behavior of Parent Facilitation and the target behavior of Collaboration. The far left column is the name for the segment within the dyad. The next column is the dyad name; the dyads are named 01, 03, 05, and 12 from the original data set. Next to the right are the columns with transitional probabilities. These values are separated into columns demonstrating the four different event possibilities given the initiating event and the target event. “N/N” represents the probability in the segment that there was neither the initiating event or the target event. “N/Y” represents the probability that the initiating event was not present, but the target event was present. “Y/N” represents the probability that the initiating event was present, but the target was not, and
“Y/Y” represents the probability that the target event followed the initiating event after a lag of two seconds. When these columns contain “-,” it means that there was no variability in the data for the segment, and in these segments neither of the identified behaviors in the chain were present at all. The next column is the Segment type, which simply indicates with an “S” if the segment includes synchronous interaction and an “A” if the segment contains asynchronous interaction. Adjusted residuals are the z-scores for the transitional probabilities, which are necessary because transitional probabilities can be affected by frequency (Bakeman & Gottman, 1997). The adjusted residuals in the tables also have significance ratings based on a Pearson two-tailed significance test.

Yule’s Q is a statistic used to analyze categorical data associations, and is widely accepted as a method of analyzing two event binomial sequences (Yules & Kendall, 1957; Lloyd, Kennedy, & Yoder, 2013). Values for Yule’s Q range from -1.0 to 1.0, and associations with a zero value indicate there is no greater association between the events than would be expected by chance (Lloyd, Kennedy, & Yoder, 2013). Thus, Yule’s Q also serves as a measure of effect-size (Bakeman & Gottman, 1997). The accepted thresholds for strength of effect for Yule’s Q values are as follows: .20 small, .43 moderate, and .60 large (Rosenthal, 1996).
<table>
<thead>
<tr>
<th>Segment</th>
<th>Dyad</th>
<th>Transitional Probabilities</th>
<th>Segment type</th>
<th>Yule’s Q</th>
<th>Adjusted Residuals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N/N</td>
<td>N/Y</td>
<td>Y/N</td>
<td>Y/Y</td>
</tr>
<tr>
<td>A</td>
<td>01</td>
<td>.93</td>
<td>.07</td>
<td>.11</td>
<td>.89</td>
</tr>
<tr>
<td>B</td>
<td>01</td>
<td>.86</td>
<td>.14</td>
<td>.08</td>
<td>.92</td>
</tr>
<tr>
<td>C</td>
<td>01</td>
<td>1.00</td>
<td>0.00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>A</td>
<td>03</td>
<td>.78</td>
<td>.22</td>
<td>.25</td>
<td>.75</td>
</tr>
<tr>
<td>B</td>
<td>03</td>
<td>.94</td>
<td>.06</td>
<td>.09</td>
<td>.91</td>
</tr>
<tr>
<td>C</td>
<td>03</td>
<td>1.00</td>
<td>0.00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>A</td>
<td>05</td>
<td>1.00</td>
<td>0.00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>B</td>
<td>05</td>
<td>1.00</td>
<td>0.00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>D</td>
<td>05</td>
<td>.97</td>
<td>.03</td>
<td>.50</td>
<td>.50</td>
</tr>
<tr>
<td>E</td>
<td>05</td>
<td>.84</td>
<td>.16</td>
<td>.23</td>
<td>.77</td>
</tr>
<tr>
<td>B</td>
<td>12</td>
<td>.42</td>
<td>.58</td>
<td>.27</td>
<td>.73</td>
</tr>
<tr>
<td>C</td>
<td>12</td>
<td>1.00</td>
<td>0.00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>D</td>
<td>12</td>
<td>.97</td>
<td>.03</td>
<td>.00</td>
<td>1.00</td>
</tr>
<tr>
<td>E</td>
<td>12</td>
<td>.97</td>
<td>.03</td>
<td>1.00</td>
<td>0.00</td>
</tr>
<tr>
<td>total</td>
<td>pooled</td>
<td>.94</td>
<td>.06</td>
<td>.18</td>
<td>.82</td>
</tr>
</tbody>
</table>

1 S=Synchronous, A=Asynchronous

* p < .05, ** p < .01, *** p < .001

There are several interesting results in this table. First of all, the instances of zero variability (when neither of the identified behaviors were present during the segment) are from asynchronous segments. Second, there were only two instances when there was variability present in the data and the adjusted residuals, and thus the transitional probabilities, were not significant (B 12 and E 12). Third, Yule’s Q values of 1.0 or -1.0 result when there are zeros in the contingency table, which can be confirmed with the
transitional probability results as well for segments D 12 and E 12 (Lloyd, Kennedy, & Yoder, 2013).

Overall, the results support a very strong and significant association and transitional probability for Parent Facilitative followed by Collaboration with a lag of two seconds. The Yule’s Q values for segments with variability ranged from 0.32 to 0.99, indicating strong associations and large effect sizes for all but the segment with 0.32, which is in the small effect size range. Of the nine synchronous segments, the segments with variability, only two segments did not have significant results for the transitional probabilities as indicated by the adjusted residuals. All but two of the significant transitional probability results were significant at the $p < .001$ level, and the other two segments had transitional probabilities that were significant at the $p < .01$ level. This is further confirmed by the pooled data in the last row, for which the adjusted residuals are significant and the Yule’s Q effect size is large. For the pooled data, the Yule’s Q value is .97 and the transitional probabilities are significant at the $p < .001$ level. These results are of interest because they support the aim, which is to use time series analysis of behavioral patterns to differentiate between synchronous and asynchronous interactions. The behavior pattern of Collaboration following Parent Facilitative is significant in all but two of the synchronous segments, and is not found in the asynchronous segments.

The next table follows the same format as 5.2, which means it organizes the time series analysis results for each selected segment. This table, however, depicts the results for the transitional probabilities of Separate Attention following Parent Supress after a lag of two seconds. In these results, it would be expected to find the behavior pattern present in the asynchronous segments, and little or no variability in the synchronous segments.
Table 5.3

Transitional Probabilities of Separate Attention following Parent Suppress after Two Seconds

<table>
<thead>
<tr>
<th>Segment</th>
<th>Dyad</th>
<th>Transitional Probabilities</th>
<th>Segment type</th>
<th>Yule’s Q</th>
<th>Adjusted Residuals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N/N</td>
<td>N/Y</td>
<td>Y/N</td>
<td>Y/Y</td>
</tr>
<tr>
<td>A 01</td>
<td></td>
<td>1.00</td>
<td>.00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>B 01</td>
<td></td>
<td>1.00</td>
<td>.00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
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1 S=Synchronous, A=Asynchronous
* p < .05, ** p < .01, *** p < .001

Again, the instances of zero variability are found in segments classified as synchronous, which is to be expected because the “parent suppress” and “separate attention” behaviors were associated with asynchronous interactions. All of the transitional probabilities and adjusted residuals for the segments with variance had significant results. The transitional probability with Parent Suppress as the criterion event and Separate Attention as the target event ranged from .67 to 1.00, which means that when Parent Suppress was present, Separate Attention followed a minimum of 67 percent of the time in this data set. All of the segments with variability had results that were significant at the p < .001 level. The Yule’s Q values for the asynchronous segments all indicated a very large effect size, with values from .94 to .99. The pooled data also
reflects significant transitional probabilities, with Separate Attention following Parent Suppress with a two second lag of .90, and a large effect size of .996. Thus, for “separate attention” following “parent suppress” after a lag of two seconds, there is a significant transitional probability and a strong association between the two events.
Chapter 6: Discussion

Research Implications

The aim of this study was to operationalize dyadic synchrony using a micro-analytic approach. The hypothesis that behavioral codes developed from concepts related to synchrony in the literature could be used to differentiate episodes from asynchrony was tested. By comparing the results from the two time-series analysis tables, it is clear that synchronous interactions can be distinguished from asynchronous interactions, and quite consistently within this data set. Dyadic behavioral codes (“Collaboration” and “Separate Attention”) are strongly associated with and can be predicted by the presence of corresponding parent behaviors (“Parent Facilitative” and “Parent Suppress”). This supports the position of the theoretical framework incorporating BFST, Attachment Theory, and Mutually Responsive Orientation that states that parent behavior guides dyadic behavior between parent and child (Bowen, 1978; Bowlby, 1988; Kochanska, 1997).

The behavioral data results allowed the researcher to differentiate between synchronous and asynchronous segments based on the transitional probabilities of corresponding two-event chains with a two-second lag. High transitional probabilities for “Parent Facilitative” predicting “Collaboration” were found only in segments that were identified as synchronous prior to coding. The micro-level analysis of behavioral codes was independent of the global classification of the segments as synchronous or asynchronous based on the segment selection process. These results corroborate both the selection of the synchronous segments as well as the operationalization of synchrony in
terms of select behavior patterns. High transitional probabilities for “Parent Suppress” predicting “Separate Attention” were found only in segments that were considered asynchronous on a global level. Similar to the results for the synchronous interactions, these results support the selection of asynchronous segments as well as the behaviors selected to operationalize asynchrony.

While other researchers have studied behavioral synchrony, there have not been published studies on the behavioral pattern markers of synchrony. That is, while foundational work on synchrony has attempted to describe synchrony and its correlates and outcomes, there have not been results that demonstrate an ability to distinguish between synchronous and asynchronous interactions (Feldman, 2003; Feldman, 2006; Feldman, 2007a; Feldman, 2007b; Feldman, 2011; Feldman 2012). The ability to distinguish between synchronous interactions and those that are not in terms of operationalized behavior pattern markers will likely be useful for future studies. The ability to differentiate synchronous interactions by using behavior pattern markers could facilitate the identification of physiological processes that are associated with parent-child dyadic synchrony.

The results of this study are useful in the context of the larger body of literature. Few studies examining synchrony have used a time series analysis (Feldman, 2011). This study contributes to bridging this research gap. It is critical to understand synchrony as an unfolding interaction, and most of the analyses in studies on synchrony do not allow for interpretation of the dynamic interactions. This limits the contributions to the field. For instance, shared affect is considered a basic and fundamental ability demonstrated frequently by parents and infants in dyadic interaction (Stern, 1985; Tronick & Cohn,
The results of this study demonstrate that multiple behaviors may be involved in possibly meeting a threshold before shared affect can be achieved. A micro-level approach to examining behavioral dynamics of parent-child behavior as they unfold through time is necessary to answer these further questions about shared affect.

Part of the research gap is that there is no accepted or standard means of operationalizing synchrony. Each researcher operationalizes the construct in a different way, and may vary the operationalization from study to study in their own work (Harel, Gordon, Geva, & Feldman, 2011; Feldman, 2003; Feldman, 2006; Feldman, 2011; Weisman, Zagoory-Sharon, Feldman, 2013). Thus, it is difficult to determine whether results from one study are similar or divergent from the other published results. That is why this study focused on operationalizing behavioral synchrony.

There are likely two reasons why synchrony research has not utilized a single operationalization of synchrony. First, each research project has focused on a different facet of synchrony, and thus researchers have frequently operationalized synchrony by focusing on one behavior, such as gaze or positive affect arousal (Weisman, Zagoory-Sharon, & Feldman, 2013; Feldman, 2003). This may also be due to the developmental stage of the children in the sample. Synchrony is not only dynamic in terms of interaction between parent and child, but it is also dynamic through a child’s development (Feldman, 2007b). Finding a means of operationalizing synchrony as an interaction pattern is key to connecting the body of literature because then researchers could utilize the same behavior pattern to operationalize synchrony instead of selecting one or two behaviors they are interested in. Second, a micro-level approach to behavior
observation, coding, and analysis can be time intensive. Time series analyses are more complicated and less familiar than correlation or analysis of variance approaches. Software for time-series analyses can be expensive and specialized. This is to say, without an accepted standard for operationalizing synchrony, researchers have likely chosen methods that are designed to investigate synchrony with the resources available. This project was designed to be a first step to addressing this gap in the field by operationalizing synchrony in terms of an interaction pattern and using a widely available software package for analysis. Replication of this study could result in a model for approaching investigation of parent-child synchrony from a micro-analytic time-series perspective that demonstrates interaction dynamics and could provide a standard operationalization of synchrony.

Multilevel synchrony is a critical next area for investigation for the field, and yet, without a means of operationalizing synchrony in standard and meaningful ways, results on multilevel synchrony are difficult to compare. This study contributes to the ability to conduct multilevel and systemic synchrony research in two ways. First, this study contributes to the gap in the literature regarding operationalization of synchrony. Second, this study utilized a micro-analytic approach that potentially may aid in a more nuanced, precise, and reliable approach to multilevel synchrony research. The ability to collect physiological data in fractions of seconds is now commonplace, yet in terms of behavioral synchrony, most researchers are still coding behaviors from a global perspective. With this method of analyzing behavioral synchrony, there would be no way to determine what behavior or interaction shift corresponded to a change in heart rate, brain activity, respiration, vagal tone, or other physiological measure. The multilevel
synchrony study conducted by Feldman utilized a time-series analysis to investigate heart rhythm patterns and behavioral synchrony between mothers and infants (Feldman, 2011). Time-series analysis is critical for the expansion of the field into multilevel synchrony.

**Limitations**

Limitations of this study point to future directions for research. One consideration that should be made with regards to the results is the variance between dyads. With only four dyads in this data set, it is difficult to determine if the behaviors identified to characterize synchrony and asynchrony are consistent across the majority of parent-child dyads. Because the results for the asynchronous behavior chain (“Parent Suppress” and “Separate Attention”) were so consistent across all segments and dyads and the associations so large, similar results would be unsurprising in other dyads. However, dyad 12 yielded non-significant results for both of its synchronous segments. It is possible that different behaviors may better characterize synchrony for this dyad, or that the synchronous interactions in the selected segments were not synchronous enough to yield significant results. There are many sources of between-subject variability when it comes to contingency tables for observed behavior, which can influence the statistic for the pooled data from all dyads (Wickens, 1993). It is unknown what proportion of the population at large is represented by parent-child dyad 12 because the sample was so small.

One of the reasons why there may be between-dyad variance is because the segments were selected with partially inductive criteria. The threshold for synchrony for segment selection for one dyad may have been slightly different than for a different dyad. However, if the interaction was not characterized by the qualities of synchrony or
asynchrony, the segment was not selected. This is why two of the dyads had each had only one segment of asynchrony. The reason why this method was used for segment selection is that it was an effort to adjust for differences in temperament and development in the individuals in the sample. It was considered that the baseline for interaction for each dyad could vary, so what was synchronous and especially cooperative for one dyad may have been very usual for another dyad. This method attempted to adjust for the different baselines that the dyads maintained. The limitation of this approach is that there was not an absolute threshold across dyads. The inductive approach may have contributed to the differences in the results for dyad 12, for example.

Also to be considered with respect to the variability between dyads is the range of ages for the children. From age three to age six there are incredible changes in development, and this would likely impact the nature of the interactions a child has with his or her parent through these ages. Because of the small sample that spans a wide range of development, the results of this study should be generalized with caution. At this point, little is known about how the interaction patterns of synchrony change in a dyad as the child develops. It may be that the nature of the interactions remain similar in synchrony across development, while the specific behaviors involved change. For example, a facilitative response is a behavioral quality that may manifest as cooing to an infant, but as answering the question of a five-year-old. On the other hand, the actual processes by which the dyad enters synchrony may change as the child’s cognitive, verbal, and self-regulation abilities increase. Researchers of future studies on parent-child synchrony may want to consider targeting a smaller age range or controlling for cognitive or verbal abilities.
In terms of parent characteristics, all the parents in this sample were mothers, and all had some post-high school education. It is possible that there may be gender or education effects that are not represented in this sample. A study on gender differences between mothers and fathers in synchrony with their child indicated that while both mothers and fathers are equally able to engage in synchrony, the range of affective expression was different between children and their mothers versus children and their fathers (Feldman, 2003). It may also be that a higher education level for the parent leads to more exposure to or awareness of child development and recommended parenting practices. Those who design future research projects on synchrony may wish to include fathers as well as mothers and to gather a sample with representative levels of education.

Another limitation includes the unilateral segment selection of the synchronous and asynchronous segments. The primary researcher viewed the video data for each dyad, and selected what was determined to be the best exemplars of synchrony and asynchrony for each dyad. However, in the future it may be useful to have a second researcher perform a similar process on the same data to determine consensus on the segment selection. The results for this data set confirm that synchronous behaviors occur predominantly during the selected synchronous segments, and that asynchronous behaviors occur predominantly during the selected asynchronous segments, so this limitation does not appear to have substantially interfered with the ability to differentiate between synchrony and asynchrony for this data set. In fact, part of the value of these results is that they indicate that the interactions selected by a systemically trained therapist can be confirmed with quantitative analysis of the behavioral patterns. It may also be, however, that the researcher’s selection of segments biased the coding process,
even though efforts were made to reduce this effect by requiring full endorsement of consensus codes by both coders. If the second coder did not agree with the researcher’s code, discussion continued, and was as likely to result in adoption of the second coder’s original code as it was that the primary researcher’s code would be adopted. Replication studies are needed with two or more researchers selecting segments in order to examine the impact of this limitation more closely.

Because two pairs of behaviors were selected for transitional probability analysis, it is not possible to determine that the criterion events caused the target events, or that the criterion events truly precede the target events sequentially. A Lag Sequential analysis would identify the sequential pattern by comparing transitional probabilities of all the behaviors at each lag, however, without the full Lag Sequential analysis, it is not possible to determine the order of behaviors (Bakeman & Gottman, 1997). It is possible that Separate Attention as often precedes Parent Suppress as it follows. What is known from the results of this study is that the transitional probabilities are, with the exception of two segments when measuring synchronous behaviors transitional frequencies, significant. It is also known that the Yule’s Q measure of the associations between behaviors were large effects, except for one segment that had a small effect size for Parent Facilitation and Collaboration.

**Future Directions**

The data utilized in this study are rich, and there are extensive possibilities for further research within the existing data. With this data set, the next directions would be to further extend the time series analyses to multiple chain events and to a complete Lag Sequential Analysis (Bakeman & Gottman, 1997). This would possibly yield more
complex behavioral patterns that may characterize synchrony and asynchrony. Behavioral data could also be coded and analyzed from the non-EEG sample in the larger data set to provide a reference point for the results of this study, so that the question, “How representative are the interactions of these four dyads?” could be answered.

Another direction for this data set is to analyze the EEG data so that multilevel synchrony can be examined. The field of Interpersonal Neurobiology (IPNB) posits that brain development and functioning are constantly interacting bi-directionally with relational behaviors and experiences (Siegel, 2010). For this, an analytic plan detailing the means of comparing frequency domain data to time series data would be necessary. In one study Feldman compared HRV to synchrony behaviors and used a time-series regression model for her behavioral analysis (Feldman, 2011). The next study would build on Feldman’s foundational work. An analytic plan that successfully represented multilevel, neural and behavioral synchrony would be invaluable to development of the field with regards to parent-child synchrony.

Synchrony is understood to be multi-faceted, encompassing multiple systemic levels such as behavior, physiology, emotions, and cognitions. However, when extant research has examined multiple systemic levels of synchrony and co-regulation, the focus has been primarily how parental behaviors correspond with child physiological states. For example, parental marital discord has been correlated to elevated cortisol levels of children (Pendry & Adam, 2007). Similarly, children’s vagal tone and heart rate have been associated with stressful interactions with their parents (Gottman & Katz, 2002). Feldman and her research teams have introduced a few multilevel synchrony studies

Overall, however, the trend is to approach multiple levels of synchrony in a unidirectional method, and this limits our understanding of multilevel synchrony. Multilevel synchrony is theorized to be the mechanism by which children develop socialization skills such as self-regulation and conscience (Kochanska, 2002). The technology exists to gather neural and cardiac data, and is increasingly accessible for researchers to gather various measures of physiological functioning; it is the next step for the field to develop a means of exploring associations between physiology and relational interactions.

**Clinical Implications**

Eventually, this line of research may yield important findings regarding child development, particularly in the realm of physiological regulation and development of self-regulation. Understanding the behavioral and physiological underpinnings of synchrony could help to inform therapeutic interventions with at-risk families or traumatized children to better target the needs of those vulnerable populations. Currently, it is known that self-regulation abilities are compromised by experiences of trauma (Seeman & McEwen, 1996). Techniques that successfully ameliorate the deleterious effects of trauma through the multilevel effects of dyadic synchrony would make a significant impact on the clinical world.

A solid understanding of parent-child synchrony generates opportunities to expand the concept of synchrony to triads or even larger groups. It would be interesting to operationalize and investigate synchrony in the family unit, or different family constellations. Synchrony could be studied in foster and adoptive families. It is
unknown if engaging in synchrony is a skill that can be applied to other relationships, or if a person has to learn a new “synchrony” with each new person. Interventions based on synchrony could help adoptive parents and children establish synchronous interactions, which could improve permanency rates for children in foster care. It could possibly be applied to military personnel or prison inmates when they return to their families to ameliorate the difficulties of those transitions.

Research on peer groups or on best friends in childhood may be fertile ground for applications of synchrony. Synchrony may exist between children and their teachers, and this relationship may be influenced by a child’s experiences with their parent or the parents’ interactions with the teacher. If synchrony can be found in classroom settings, it may impact learning or provide a buffer for disadvantaged children to help close the achievement gap.

Operational measures of synchrony could also be used in outcome assessment for therapeutic models geared toward improving parent-child interactions. There are many clinical models designed to enhance parent-child relationships, notable among them is Parent Child Interaction Therapy (PCIT), which has been evaluated in terms of treatment efficacy (Lenze, Pautsch, & Luby, 2011). If synchrony could be measured on physiological levels, it could increase researchers’ ability to utilize objective and reliable data in outcome measurement.

Ultimately, this study accomplished the aim set forth to operationalize the construct of parent-child behavioral synchrony. The results predominantly were both significant and had large effect sizes, and the interpretation of the results confirms behavioral patterns that distinguish synchronous interactions from asynchronous
interactions. It is critical for further study of parent-child synchrony for there to be a means of operationalizing the construct of parent-child behavioral synchrony so it can be analyzed from various perspectives. With this study, it was demonstrated that it is possible to identify certain behavioral markers that distinguish synchrony from asynchrony.
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