VOCAL SYNCHRONY AS A COREGULATION INDICATOR OF ATTACHMENT BONDS

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ABSTRACT

VOCAL SYNCHRONY AS A COREGULATION INDICATOR OF ATTACHMENT BONDS

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This dissertation aims to explore the concept of coregulation in adulthood based on the analyses of vocal cues in conversations. Moderators which potentially affect vocal coordination between romantic partners were also examined. Twenty-four heterosexual dating couples (M_{age} = 21.25; *SD* = 1.03) from Cornell University were recruited for the Study-1. Participants communicated with their romantic and stranger partner in a balanced order. Their conversations were recorded and vocal features were extracted. Granger-causality analyses yielded that close partner conversations were bidirectional, signifying that female participants' previous F0 responses caused male participants' subsequent F0 responses and vice versa. In the stranger partner conversations, however, only female participants' previous F0 responses caused male participants' subsequent F0 responses, implying that there was unidirectional association between stranger partners. Two-level dyadic HLM analysis demonstrated that there was higher level of synchrony in the conversations

of close partners than stranger partners. Furthermore, HLM analysis indicated that the observed synchrony was moderated by attachment-related anxiety and relationship satisfaction. Study-2 examined whether or not the affectionate components of conversations with a close partner could be accurately estimated from intonations only. Participants (N = 156, M_{age}= 34.75yrs, SD=13.06) were asked to guess whether the pairs of speakers were romantic partners or strangers. They rated 1-minute recordings without verbal content after low-pass filtering applied. The analysis using signal detection theory revealed that close partner vocalizations were recognized above the chance. In sum, findings suggest that coregulation process can be observed at the vocal level using synchronous speech pattern and this process is moderated by attachment anxiety and relationship satisfaction. Implications for attachment-in-the-making between romantic partners and the literature on behavioral mimicry were discussed.

Keywords: Coregulation, Synchrony, Fundamental Frequency, Granger-causality, Adult attachment theory.

ÖZ

YETİŞKİNLİKTE BAĞLANMA: BİR EŞ-DÜZENLEME GÖSTERGESİ OLARAK SES UYUMU

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Bu tezin amacı çiftler arası diyalogdaki ses ipuçlarını kullanılarak yetişkinlikteki eşdüzenleme kavramını incelenmektir. Bununla birlikte, çiftler arası vokal koordinasyonu etkileyebilecek olası bireysel farklılıklar ve ilişki temelli farklılıklar da incelenmiştir. Birinci çalışmaya Cornell Üniversitesi'nde lisans eğitimlerine devam etmekte olan 24 heteroseksüel çift katılmıştır ($M_{yaş}$ = 21.25; *SS* = 1.03). Katılımcılar çalışma oturumlarında Rorschach mürekkep lekesi testindeki kartlar hakkında hem romantik partnerleri ile hem de yabancı bir partner ile dengelenmiş sırada konuşmuşlardır. Konuşmalar kaydedilmiş, vokal özellikler kaydedilmiştir. Temel frekans değerleri ile yapılan Granger-nedensellik analizleri romantik partner diyaloglarında vokal özelliklerin birbirini karşılıklı etkilediği, yabancı partner konuşmalarında ise sadece kadınların erkekleri etkilediğini göstermiştir. İki düzeyli Hiyerarşik Doğrusal Modelleme analizleri ise bağlanma

temelli kaygı ve ilişki doyumunun vocal senkroniyi etkilediğini göstermiştir. Bağlanma kaygısı konuşmadaki senkroni ile olumsuz yönde, ilişki doyumu ile ise olumlu yönde ilişkili bulunmuştur. İkinci çalışmada romantik partner diyaloglarındaki tonlamanın ayırt edilebilirliğini sınamıştır. Çalışmaya katılan 156 katılımcıya ($M_{yaş}$= 34.75yıl, *SS*=13.06) bir dakikalık sözel içeriği arındırılmış, sadece tonlamanın olduğu ses dosyaları dinletilmiş ve dinledikleri kesitin romantik çiftlere mi yoksa yabancı çiftlere mi ait olduğu sorulmuştur. Sinyal tanıma kuramı analizlerine göre, romantik partner tonlamasının şans olasığı (% 50) üzerinde bir değerle diğer diyalog tonlamalarından ayrılabildiği bulunmuştur. Bulgular, eşdüzenlemenin vokal düzeyde de gözlenebileceğine işaret etmektedir. Bununla birlikte eşdüzenleme sürecinin bağlanma kaygısı ve ilişki doyumundan etkilendiği gözlenmiştir. Bulguların yetişkinlikte bağlanmanın oluşumuna ve davranışsal taklit yazınına ilişkin doğurguları tartışılmıştır.

Anahtar Kelimeler: Eşdüzenleme, Senkroni, Temel Frekans, Granger-nedensellik, Yetişkin bağlanma kuramı.

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Dedicated to my beloved parents and my wife

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CHAPTER 1

INTRODUCTION

Over time, the emotions of relationship partners become coordinated leading to a mutual involvement in each other's emotional states (Butler, 2011). Involvement (or enlargement) of emotions between partners are associated with flexible emotional balance, which is critical for physical and psychological well-being (Thayer & Lane, 2007; Thayer & Sternberg, 2006). Although emotional coordination in the relationship of mother-infant dyads has been well-documented (see Feldman, 2007a for a review), emotional coordination between adult pairs has not been investigated empirically. Probably because measuring bidirectional associations of emotional changes and its psychological correlates in adult dyads is complicated as well as methodologically and statistically difficult. In this dissertation, it was specifically aimed to focus on (1) the possibility of emotion coregulation between romantic partners, whereby one partner's emotion is used to predict his/her partner's subsequent emotion, and (2) the potential moderators of concurrent variation and adaptation in emotions by which partners experience similar (or different) emotions at the same time. To do this, a number of theoretical and methodological perspectives including normative attachment theory considering coregulation between romantic couples (Sbarra & Hazan, 2008), temporal interpersonal emotion regulation (Butler, 2011; Diamond, 2011), interactional synchrony in natural conversation, and inter-speaker accommodation in spoken language (Giles & Ogay, 2007) were synthesized.

Furthermore, a new method was proposed to empirically capture emotion coregulation using vocal cues, which could be a potential candidate for directly assessing temporal physiological changes (Juslin & Scherer, 2005). For this purpose, real-time conversations were analyzed to estimate partner's emotional coregulation

between partners. It was anticipated that individuals' speech characteristics such as intonation and vocalization would be associated with their partners' voice features and this associations would be observed in a relatively short period in conversations. Resulting coordinated voice characteristics would also be moderated by individual and couple level variables, such as attachment orientations and relationship satisfaction.

CHAPTER 2

CONCEPTUAL AND OPERATIONAL DEFINITION OF COREGULATION

Emotional coregulation has been generally seen as a dyadic process of psycho-physiological balance within a relationship. Hence, this process can also be considered as a unique component of attachment relationships (Hazan, Gur-Yaish, & Campa, 2004). Previous work suggests that the ability to regulate emotional responses in a way that supports one's goals and maintains physiological equilibrium is critical for psychological, physical, and social well-being through the lifespan (Eisenberg, Fabes, Guthrie, & Reiser, 2000; Gross, 2002; John & Gross, 2004). The quality of child-caregiver relationships is central for the successful emotion regulation during infancy and it has implications for later life (see Jaffe, Beebe, Feldstein, Crown, & Jasnow, 2001). In early childhood literature, "coregulation" refers to the process of forming a dyadic emotional system between child and caregiver and co-constructing optimal affective states during social interactions (Feldman, 2003; Tronick, 1989). Although it has been widely studied in early childhood, the role of coregulation has received less attention in adulthood for a long time. In recent years, however, growing body of research highlights the importance of coregulation in the context of adult romantic relationships (Butner, Diamond, & Hicks, 2007; Saxbe & Repetti, 2010; Sbarra & Hazan, 2008; Schoebi, 2008). The initial findings in this arena suggest that a range of dyadic emotional processes play a role in shaping not only the daily (and even momentary) emotional experiences, but also physiological responses (e.g., heart rate, respiration, etc.) of adult romantic partners (Sbarra & Hazan, 2008).

Since there is no consensus on its operationalization in the literature yet, an operational definition of coregulation in adulthood is needed to be able to empirically study its dynamics. The term of coregulation has been used to refer to the various

potentially distinct processes. One of them considers coregulation as romantic partners' emotional experiences *covarying* day to day or showing coupling in their rates of emotional changes (Butner et al., 2007). Another process emphasizes the transmission of one partner's emotions experienced during separation period to the other person in reunion phase (Schoebi, 2008). In another perspective, coregulation has been defined as partners' dynamic and reciprocal physiological responses (Saxbe & Repetti, 2010). These intriguing processes in coregulation should be elaborated by investigating coregulation of emotion at different levels, such as physiological or behavioral, especially given that the recent attachment approach considers coregulation as a marker of adult attachment at multiple levels including vocal, facial, and physiological markers (Hazan et al., 2004).

Although the processes mentioned above focus on different aspects of coregulation (reciprocal physiological processes or emotional transmissions), they all share the assumption that interpersonal coregulation could only be observed in negative or positive emotional states such as conflict or excitement. In other words, majority of these studies have focused on the coregulation processes in positive or negative situations. However, coregulation can also be observed in neutral contexts (Butner, Diamond, & Hicks, 2007). Specifically, emotional coregulation of close partners in daily life should also be captured in neutral conditions through different indicators of this process such as facial expressions or vocal changes.

One of the indicators of coregulation at vocal level is oscillations in the speech episodes within couple conversations (e.g., ups and downs in individuals' speech features such as intonation, frequency, etc). Considering synchronous vocal activity as an indicator of coordination among communication partners is not a completely new idea. Prior work on communication and psycholinguistics has indeed investigated coregulation (or synchrony) by assessing vocal rhythms of partners (McGarva, 2003), frequency of word usage (Nenkova, 2008), non-verbal communication (Richardson, Marsh, & Schmit, 2005), and similarity in text-based and conversational language style (Ireland et al., 2010). Although previous studies provided initial evidence regarding conversation partners' speech patterns among strangers, friends and acquaintance, speech pattern between romantic relationship

partners have not been investigated. The speech patterns of romantic couples in real-time conversations can be an objective and direct way of studying coregulation in romantic partners. Speech-related characteristics such as intonation or vocalizations are directly associated with physiological and emotional changes and these characteristics can be accurately measured using the recent advanced technologies (Scherer, 2005). Moreover, no study so far has examined whether the most typical characteristics of speech (e.g., fundamental frequency, intonation) are related to the functioning and dynamics of romantic relationship, such as relationship duration, satisfaction, attachment anxiety, and attachment avoidance. Previous work on prosody focusing on the question of how various features of spoken language reflects emotional state of the speaker has proposed the robust algorithms for detecting variation in emotional states (Talkin, 1995). In this study, the same method was borrowed to investigate the mechanism of coregulation of emotion between romantic couples.

To sum, this dissertation seeks to answer the question of whether speech characteristics of romantic partners could be used as an indicator of their coregulation process. To this aim, it was explored how relationship partners contribute to each other's emotional states by using measures derived from speech signal in a relatively short time lag (i.e., 5 min conversations). Considering the function of romantic relationships in emotion regulation, it was expected higher levels of synchronicity in the speech pattern of close partners, compared to stranger dyads. More specifically, it was anticipated that the correlations between close romantic partners' speech features would be stronger than those of stranger dyads. Furthermore, the potential individual moderators that can have an impact on coregulation of emotion process were examined. Given that individual differences in attachment orientations (Mikulincer& Shaver, 2005) and relationship satisfaction (Selcuk, Zayas, & Hazan, 2010) are associated with emotional functioning in close relationships, whether attachment dimensions and relationship satisfaction have an effect on the regulation process was also investigated. Specifically, the objective of the study was to innovatively connect the methodological advancement in linguistics and communication science with the adult attachment perspective to further our understanding of the functioning in romantic relationships.

In this dissertation, coregulation was indexed by vocal synchrony indicating covariation in the fundamental frequency (F0) of speech sounds. Previous work on vocal expression of affect has suggested that F0 and F0 variability successfully reflect emotional ups and downs (Juslin & Scherer, 2005). Moreover, fundamental frequency of vocal fold vibration has been accurately assessed using straightforward algorithms such as autocorrelation of time series for speech responses (see Talkin, 1995 for a review). Thus, such analyses of speech would enable us to investigate covariation of emotional states among conversation partners (see Richardson, Marsh, & Schmit, 2005).

Previous work suggests that romantic partners provide stronger and faster conditioning of physiological reward systems, compared to friendships or non-attachment relationships (Sbarra & Hazan, 2008). Thus, correspondence in intonation or vocalization is anticipated to be higher in attachment relationships, compared to non-attachment relationships. If emotional coregulation refers to coupling physiology between romantic partners and intonation is the product of physiological states, it is plausible to expect a correspondence in vocalizations such as bidirectional associations in F0 between romantic partners. Moreover, it was anticipated that observed "*covariation*" in conversation episodes would be associated with both relationship (e.g., attachment orientations, relationship satisfaction) and individual level variables (e.g., social closeness, mood state).

In the following sections, previous studies on early childhood attachment and mother-infant synchrony will be summarized in an integrative framework. First, the formation and function of attachment relationships in early interactions with caregiver will be presented. In this respect, past studies focusing on animal models of mother-infant interactions leading to the physiological balance for the new born will be briefly reviewed. Second, the similarities between the animal models and human mother-infant studies will be elaborated. Third, studies on coregulation in adulthood, specifically from the perspective of temporal interpersonal emotion system and normative attachment theory will be presented. The potential individual and relationship related differences that may potentially moderate the coregulation process will also be discussed. Fourth, a new alternative method for studying dyadic

interactions in close relationships; namely, utilizing speech characteristics such as vocalizations in couple conversations will be elaborated. Finally, the section will end with the specific hypotheses of the study.

2.1. Attachment and coregulation: From infancy to adulthood

Attachment theory of John Bowlby is one of the influential milestones in the evolution of modern psychology. Drawing from a combination of diverse perspectives such as psychoanalysis, evolutionary theory, ethology, and cognitive science, Bowlby (1969) proposed that human beings are equipped with a set of behavioral systems; each having its own functions and set-goals. He devoted the most attention to the attachment behavioral system and its goals. These goals are evolutionally set to protect a newborn from the external dangers by ensuring proximity to the protective and/or caring others (called attachment figures). Bowlby (1969) described four distinct behaviors signifying attachment bond: proximity-seeking behaviors, secure base behaviors, safe haven activities, and separation protests as the building blocks of attachment behaviors. In his formulation, any sign of internal and/or external threat on the part of the infant results in the activation of the attachment system which leads to proximity-seeking behaviors. When the "set-goal" for proximity is achieved, attachment system is deactivated. According to Bowlby (1969), the maintenance of proximity results in feelings of security and love, whereas failing to maintain the desired level of proximity leads to anxiety, sadness, or anger. In addition to the proximity maintenance, the caregiver assumes two more responsibilities for effective functioning of the attachment bond. The attachment figure becomes (1) a "safe haven" to shelter from perceived dangers and (2) a "secure base" from which to explore. In other words, attachment figure provides emotional security which plays critical role in the daily affect regulation of infant. Infants consciously or unconsciously modulate variability in positive or negative affect states via successful affect regulation processes (Cassidy, 2008; Feldman, Weller, Sirota, & Eidelman, 2002).

Ainsworth (1982) described four phases in the development of attachment in early childhood based on her observations of babies in Uganda and in Baltimore. Firstly,

infants respond indiscriminately with cries, gazes, and smiles to promote contact and affection from anyone nearby (i.e., indiscriminate sociability). Secondly, infants' behaviors were linked to the presence of specific caregiver (i.e., attachment in the making). Even if several caregivers are regularly available, an infant reliably seeks and maintains proximity to one, especially when distressed (Ainsworth, 1967, 1982). Later, at 6-18 months, infants seek comfort from one specific caregiver and develop separation protest when the specific caregiver leaves and exhibit stress on the presence of unfamiliar people (i.e., clear-cut attachment). Finally, by 18-24 months of age, infants develop "goal-corrected partnership" as their cognitive abilities mature and they come to appreciate mutual influence between themselves and caregivers. Infants start to recognize the goals and plans of the attachment figure. Up to this point, the child is focused on having needs met, and the attachment bond is a rather one-sided relationship. At this stage, partnership behaviors are developed and the increased opportunities for reciprocal interactions benefit both the child and the adult. Thus, development of goal-corrected partnership seems to be an important component of coregulation process in the early childhood.

Attachment researchers have theorized that experiences with a stable and sensitive caregiver may facilitate infant's regulation of attention, emotion, and physiological arousal. In other words, normative attachment relationships provide a "homeostatic set point" for those infants whose self-regulatory abilities are still developing (Sbarra & Hazan, 2008). Stable physiological arousal zone has critical implications for both caregiver and infant. For instance, in both human and animal infants, physical contact with early caregivers helps to organize sleep and eating behavior and the development of autonomic systems like the vagal system, as it has been observed in rats (Hofer, 1984) and in human babies who receive "kangaroo care" (skin-to-skin maternal contact; Feldman & Eidelman, 2004). Thus, "set-point" of the attachment system, characterized by felt security, includes common properties and functions for both animals and human mother-infant pairs.

2.1.1. Animal models and human mother-infant interactions

The formation and regulatory functions of attachment bond can be best inferred from animal and human infant studies. In this section, initially, animal models of

behavioral and physiological regulation were presented. Specifically, how attachment bond is manifested in early behavioral and physiological interactions was given. Then, the formation and function of coregulation among mother and human infants were briefly described with empirical findings. Finally, the recent theoretical framework about the coregulation in intimate adult relationships was provided.

In his seminal work, Myron Hofer (1984) devised laboratory animal models to understand the basic developmental processes of the mother-infant relationship. Through experimental analyses of the behavioral and physiological interactions between the infant rat and its mother, Hofer and his colleagues (1994) discovered “hidden regulatory” processes; a process that became the basis for a new understanding of the early origins of the attachment bond, the dynamics of the maternal separation response and the shaping of postnatal development through the first relationship. Hofer (1994) used the term "hidden regulators" because they were not apparent when simply observing the mother with her infant. He proposed that those regulators allow the mother to control the level, intensity, and pattern of the infant rat's response systems gradually. By this way, the provision of warmth, the tactile and olfactory stimulation of the mother's physical interactions were found to provide specific and independent sources of regulation for the infants' emerging behaviors and regulatory systems. According to Hofer (1994), these hidden regulators modulate the various systems such as behaviors, autonomic system, secretion of endocrine, and sleep-wake states of the infant rat. The discovery of these hidden regulators has provided a new level of understanding of the processes underlying attachment, separation, and loss. Besides, this conceptualization has enabled researchers to form a conceptual bridge between the simple sensory motor processes of very early development and the formation of the mental representations. These representations, called as the internal working models, organize the inner experience of emotional relationships with the significant others in the lives of older children and adults, guide expectations and behaviors in close relationships.

The discovery of these novel behavioral and physiological processes has implications for the understanding of both psychological and physiological regulatory functions of social relationships, and for understanding the formation of mental representations

(Hofer, 1984, Shear & Shair, 2005). Apparently, early attachment relationships have unique functions such as regulation of physiological systems via the mother–infant interaction. Considering its survival function, the loss of the regulatory interaction has detrimental effects on infant rats (Hofer, 2006). For example, previous work has consistently indicated that maternal separation resulted in slowed behavior and lowered heart rate (i.e., fall by 40% in 24-hour after maternal separation) among new born rats (Hofer, 1994).

Social interactions between human mothers and infants share similar aspects with their mammalian heritage, yet they also have many unique aspects. Other than feeding, care, or protection, human mothers and infants use early social play to match socio-affective facial and vocal signals. For instance, during the third month of life, infants begin to join social interactions that are marked by synchrony of non-verbal cues, including mutual gazing, co-vocalizations, and the matching of affective expression (Stern, 1985; Tronick, 1989). This interaction synchrony plays an important function in the maturation of brain circuits that support social engagement. Experience of synchrony within the sensitive period of 3–6 months also contributes to cognitive, social, and emotional growth (Jaffe, Beebe, Feldstein, Crown, & Jasnow, 2001). Moreover, interaction synchrony at 3 months provides the foundation for purely human achievements and predicts the development of complex symbolic expression and the capacity for empathy throughout childhood and adolescence (Feldman, 2007a). In short, previous work has primarily focused on the nature, formation, and the function of social interactions characterized by coregulation among human mothers and infants.

2.1.2. The nature of coregulation in infancy

Research on the nature of coregulation process in infancy has benefitted from the animal studies and indirectly supports the predictions of the attachment formation phases. Studies on human mother-infant are consistent with Hofer's hidden regulators hypothesis in which physiological infrastructure of mother and infant become coordinated to increase infant's survival after attachment relationship begins to establish in the first three months. Specifically, previous work with human infants showed that mother and infants' physiological systems adapt to each other and this

adaptation process helps organize infant growth (Shanberg, Ingledue, Lee, Hannun, & Bartolome, 2003), shapes the brain structure that regulate the stress response (Champagne, 2008), and coordinates heart rhythms within the interaction episodes (Feldman, Magori-Cohen, Galili, Singer, & Louzoun, 2011). For instance, in their study, Feldman et al. (2011) observed face-to-face interactions of mothers and their 3-month old infants and cardiac measurements were also taken from each pair simultaneously. They found that mother and infant coordinated their heart rhythms during affective episodes (i.e., positive or negative affect) and they showed vocal synchrony (i.e., proportion of time mother and infant produce positive affect). These researchers assessed successful coordination of heart rhythms and vocal synchrony during affect episodes as an indicator of regulating or modulating emotions in a given situation.

2.1.3. Formation of coregulation in infancy

Extant studies on mother-infant social interaction have provided extensive evidence regarding the formation of synchronicity. The developmental sequence of coordination between mother and infant proposed by Feldman (2007a) seems to be parallel with the attachment formation stages proposed by Ainsworth (1982). As illustrated in Figure 1, the last trimester of pregnancy is thought to be the first period of interaction synchrony between mother and infant. Biological rhythms, emerging at this stage, provide the neurobiological substrate for coordinated interactions (Feldman, 2006). At birth, there is an innate tendency to contingency detection (Tarabulsy, Tessier, & Kappas, 1996) and there are innate maternal behaviors by which they easily detect infant's emotional cues (Fleming, O'Day, & Kraemer, 1999). These two characteristics of infant's and mother's behaviors are the basic indicators of the temporally-matched interaction. The first period of interaction synchrony overlaps with the first stage of the attachment relationship in which infant responds indiscriminately with cries, gazes, and smiles to promote contact (proximity) and affection from anyone nearby at birth (i.e., indiscriminate sociability).

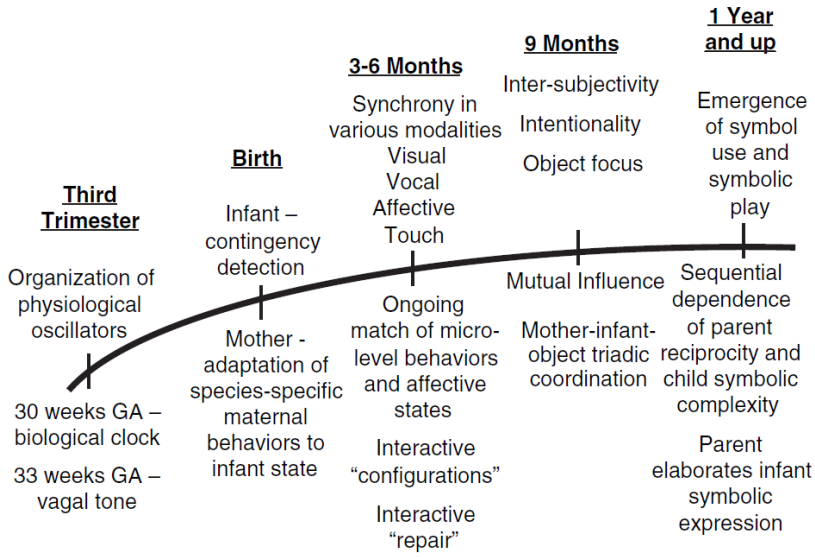


Figure 1

*Figure 1.The developmental timeline of synchrony. (*adapted from Feldman, 2007a)

From the third month to the sixth month, synchrony in its more conventional form is seen as the coordination of emotions and behaviors in various modalities (e.g., visual, vocal, and tactile) develops. Synchrony in various modalities can also be seen as the indicative of attachment in the making phase. It was proposed that infant's behaviors are contingent to the presence of specific caregiver and infant seeks proximity to that caregiver especially when distressed (Ainsworth, 1967, 1982). Supporting this, Feldman, et al., (2011) showed that 3-month old infants and their mothers get synchronous at vocal and affective level when infants feel distress.

At the intersubjectivity level at around 9 months of age, social interactions mature in various ways and develop into a solid give-and-take mutuality (Stern, 1985). It should be noted that intersubjectivity stage shares some common properties with the clear-cut attachment phase. In this phase, infant successfully separates caregiver from others, seeks proximity to caregiver for relief, and exhibits protests when separated due to the well-developed intentionality. Toward the end of the first year, as infants begin to use gesture and symbolic communication (Bates, O'Connell, & Shore, 1987), the synchrony experience undergoes further transformation that opens the previously established non-verbal reciprocity to the entire range of interactions. Similarly, by the age of 18-24 months, infant and mother develop a partnership of

mutual appreciation and influence which is described as goal-corrected partnership in the formation of attachment stages.

Past studies on both attachment formation and parent-infant synchrony have supported the idea that regulating inner states begins early in life extends into adulthood. Repeated social interactions with caregiver promote synchrony between mother-infant dyads at physiological and psychological level. In other words, synchrony can be seen as a salient marker of established attachment relationships and the term synchrony is sometimes used interchangeably with coregulation. Thus, it is plausible to argue that development of interpersonal synchrony (or coregulation) between mother-infant dyads has critical functions for infants' optimal development and their later intimate relationships in adulthood.

2.1.4. Functions of Coregulation in infancy

Three main channels of interpersonal synchrony are apparent during social interaction. These channels are gaze synchrony, affect synchrony, and vocal synchrony. Gaze synchrony refers to the matching of social gaze between mother and child. It sets the framework for social relatedness and contributes to cognitive growth (Kaye & Fogel, 1980). Affect synchrony, which indicates the matching of affective expression, plays an important role in the development of self-regulatory capacities (Cohn &Tronick, 1988).Vocal synchrony, engaging in "proto-conversations", serves as the building blocks of spoken language and promotes attachment security (Jaffe et al., 2001). Each of these forms of synchrony has shown to predict long-term outcomes and it is thought to provide essential environmental inputs for the physiological and social growth. One potential mechanism by which gaze, affect, and vocal synchrony shape development is that these moments facilitate, separately or in combination, biological synchrony between the mother and infant's heart rhythms (Feldman, 2007b). Such biological and behavioral synchrony appears to support the infant's autonomic maturation by means of social contact.

Basically, engaging in synchronous relationship with caregiver helps children to set "stable arousal zone" in which children regulate his/her emotion more easily due to the lack of unexplained emotional states and this promotes later functioning. In their

longitudinal study, for example, Jaffe et al. (2001) examined mother-infant rhythmic coupling, bidirectional coordination, and its impact on later socio-emotional development among 4-month old infants. Rhythmic coupling which is characterized by vocal rhythm coordination, at age 4 months predicted attachment and better cognition functions at age 12 months. Similarly, Feldman and Eidelman (2004) found that low levels of synchrony of 3-month old infant and parents were associated with more internalizing problems (e.g., anxiety, withdrawal) two years later. Another study on the function of coregulation also showed that mother-infant synchrony was inversely related to infant negative emotionality (Feldman, 2003) and positively associated with positive affective behaviors during interaction episodes (Tronic & Gianino, 1986). Overall, past research has consistently suggested that mothers provide important scaffolding for the development of infant emotion regulation by modulation of negative (or even positive) emotion. In the light of these findings, an intriguing question can be asked. How does coregulation occur in adult attachment relationships?If romantic relationships can be conceptualized as the "adult versions" of infant and caregiver attachment bonds as postulated by Hazan and Shaver (1987), similar coregulation patterns would also be observed in adulthood both physiological and behavioral levels. In this vein, recent research has investigated the possibility and the function of coregulation in adulthood.

CHAPTER 3

EMOTION COREGULATION IN CLOSE RELATIONSHIPS AND NORMATIVE ADULT ATTACHMENT

Although the majority of the aforementioned studies focused on the coregulation between mother and infants, only very few studies have attempted to investigate coregulation in the context of adult romantic relationships (e.g., Butner, Diamond, & Hicks, 2007; Saxbe & Repetti, 2010; Schoebi, 2008). Past findings point out that synchronous interactions have a critical role in developing a stable arousal zone; a zone that has implications for successful emotion regulation for adult interaction partners. Similar to the mother-infant dyad, partners in close relationships show a vast range of emotional and physiological covariations which is one of the core tenets of adult attachment (Hazan, et al., 2004). Such covariations seem to help partners to maintain their physiological homeostasis in their relationships (Sbarra & Hazan, 2008).

Emotion regulation in social relationships will be briefly presented in light of the growing body of research on interpersonal emotion system based on Butler's (2011) conceptualization in the next section to better understand their functions for adult couples. The concept of coregulation and related constructs in adult close relationships (i.e., stress buffering, interpersonal affect regulation and social support) will also be discussed. Finally, the potential moderating role of individual and relationship-related differences in the coregulation process will be presented.

3.1. Temporal Interpersonal Emotion System: The ways of influencing partners

Although it was not directly investigated, there are studies implying that adults may also coregulate with the close others (Diamond, 2011; Pietromonaco, Barrett, & Powers, 2006; Sbarra & Hazan, 2008), such that cohabiting partners may influence each other's mood and physiology. Initially, in its well-known study, McClintock

(1971) found that roommates' menstrual cycles synchronized over time. Similarly, other researchers have found evidence of emotional contagion and convergence within adult dyads (e.g., Anderson, Keltner, & John, 2003; Butner, Diamond, & Hicks, 2007). Sbarra and Hazan (2008) have suggested that coregulation is defined as the up- or down-regulation of one partner's psychophysiological arousal by the other partner. As an external regulator, romantic partner provides "safe haven" to individual for overcoming problems related with emotion regulation. In the related literature, interconnected patterns of physiology (e.g., synchronous heart rhythms or respiration) and affect within close relationships have also been conceptualized as synchrony, social entrainment, or attunement. Although these concepts share common properties with coregulation, they sometimes refer to different processes (e.g., similarity or convergence of affect systems). Similarity, for example, they may refer to similar baseline levels of physiological responses (e.g., heart rhythms or similar intonation in speech). Convergence refers to being similar or getting close in terms of the aforementioned responses. Convergence includes being similar (not synchronous) in time such as reaching similar respiration rate after 3 months living together. However, similarity or convergence may not guarantee synchrony all the time. Synchrony is a state in which the same behavioral and affective state at the same time with respect to the occurrence and intensity is observed. The concept of coregulation, used in this dissertation refers to the phenomenon of reciprocal dynamic coupling of partners' multiple biological systems and it represents process of synchronous interactions.

It is also important to distinguish between coregulation and stress buffering which refers to the ability of close relationship partners to dampen the impact of each other's stressful experiences. Whereas stress buffering implies a unipolar direction of the effect targeting to reduce one partner's arousal and negative affect, coregulation corresponds to a bidirectional or cyclical effect which reflects mutual influence of relationship partners on each other. In this sense, coregulation is distinct from empathy or perspective taking. Furthermore, coregulation may occur without conscious effort or even awareness. In the following sections, how coregulation concept could be manifested in close relationship context will be presented from the

perspective of interpersonal emotional system. Then, distinctive features of coregulation will be detailed.

3.1.1. Coregulation as a dynamic system

Butler (2011) proposed a perspective, labeled as temporal interpersonal emotional systems (TIES) to better understand how partners influence each other, under which circumstances, and how it can be empirically investigated. According to TIES, emotion is framed as an intrapersonal system comprised of subcomponents, such as experience, behavior, and physiology, which interact over time to lead an emotional state. Whenever emotions occur in the context of social interactions or ongoing relationships, a temporal interpersonal emotion system (TIES) comes into existence. In social interactions, the subcomponents of emotion interact not only within the individual but also across the partners. For example, observing one partner's behaviors related to his/her happiness may trigger other partner's increased hearth rate, memories of pleasant experiences, and facial expression of happiness). Emotional interdependence is established following the functioning of these emotion systems between partners. Butler and Randall (2013) have proposed that coregulation is one of the potential states of an interpersonal emotion system defined by synchronized oscillations between partners' emotions that converge on a stable level.

There are two different patterns in emotion regulation in the relationship process. According to Butler (2011), individuals within the relationship can covary with each other in either *morphostatic* (stable) or *morphogenic* (changing) ways (see Figure 2 for graphical demonstration of morphostatic (Panel A) and morphogenic patters (Panel B). Various biological and behavioral subsystems are correlated such that they can mutually influence each other's patterns of *stability* and *change*. This interrelated process can be best manifested in emotion coregulation of couples in the stressful situations. In other words, characteristics of interrelatedness in the biological and behavioral subsystems can be observed in negative affect situations (e.g., conflict) successfully. Another alternative for examining interrelated systems could be drawing into stable stimuli, which are multidimensional states that repeated over time. Specifically, to investigate coregulation in detail, one can focus on physiological and psychological responses in neutral setting (e.g., speaking about

daily life). Thus, covariations in neutral settings are basically more similar to morphostatic covariations. Morphostatic covariation refers to stable arousal zone for romantic partners due to their established attachment relationship and it represents coregulation process, whereas morphogenic covariation includes between partner emotional covariation around a changing trajectory and refers to stress buffering or emotional contagion (Butler, 2011, Butler & Randall, 2013). This conceptualization provides a pathway to define coregulation by using structural description and offers specific methodology to observe coregulation or contagion.

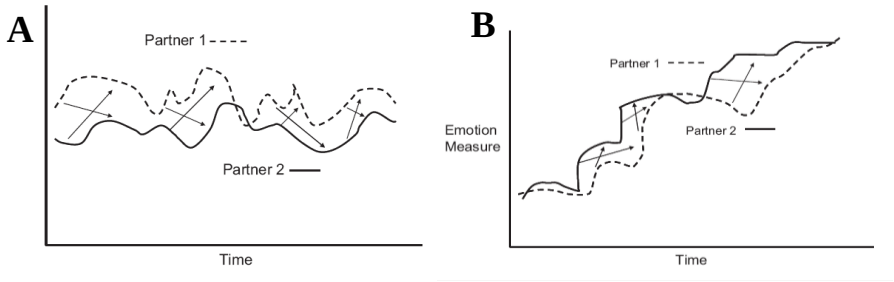


*Figure 2. Feedback processes within the relationships (*adapted from Butler, 2011*)*

Note: Panel A refers to morphostatic (stable) pattern; Panel B indicates morphogenic (changing) patterns of emotional covariation.

Within this framework, contemporary models of emotional and physical well-being suggest that stability, adaptability, and health are maintained through dynamic patterns of organized variability (Thayer & Sternberg, 2006). Morphostatic balance refers to the stability through change, and by this way, morpostatic balance optimizes one's performance and minimizes costs from external word (Sterling, 2003). For example, individuals' optimal energy expenditure is constantly changing due to internal and external demands. To support this, partners' heart rate fluctuates continuously around a mean level that is itself fluctuating in response to energy demands (Thayer & Lane, 2000, 2009). Healthy morphostatic balance is characterized by the rapid psychological and physical responses to threats, challenges, and opportunities followed by a quick return to an energy-efficient resting state (Thayer & Lane, 2000, 2009; Thayer & Sternberg, 2006). Morphostatic balance can be achieved through co-vocalization. Higher correlations and/or lower variability in vocal cues may indicate coordinated variation in speech episodes.

The dynamic interplay between coregulation and morphostatic balance is evident in the past research on parent–infant relationships as mentioned above. Research with humans, monkeys, and rats suggests that infants' behavior and physiology are initially regulated by the sensory characteristics of the caregiver, such as voice, smell, and touch. The caregiver's behavior and physiology are in turn reciprocally responsive to stimulation by the infant, again through senses such as touch and smell, but also behaviors such as crying (Field, 1985; Hofer, 1984, 1994; Kraemer, 1992). In this sense, both infant's and parent's emotional and biological dynamic stability are partially dependent upon the other. Similar process can be applied to adulthood in the context of secure attachment relationships. Repeated social contact with a rewarding partner leads to a conditioned response, whereby that partner is associated with psychological security and physiological calmness (Sbarra & Hazan, 2008). Attachment behaviors, such as cuddling, touching, and sexual contact activate oxytocin and opioid systems, which together induce pleasure and alleviate distress, and hence, they provide a physiological basis for felt security and contribute to both partners' physiological and emotional balance (Diamond, 2011; Sbarra & Hazan, 2008).

The findings from the past studies on separation have shown that the disruption of coregulation may impair morphostatic balance of couples via creating dysregulation (see Sbarra & Hazan, 2008 for a review on dysregulation process). Similarly, Vormbrock (1993) reviewed work on extended separations between married partners and found that such separations were generally associated with increased negative emotions, sleep disturbances, and a variety of other behavioral and psychological dysregulations. Diamond et al. (2008) investigated cortisol levels and emotional experiences of romantic couples after a brief separation due to one partner's traveling. They found that experiencing separation was associated with disturbances in sleep, subjective stress, and physiological stress responses. Thus, previous findings support the coregulatory functions of close relationships and indicate intimate relationships protect felt security and physiological and emotional balance.

3.1.2. Attachment relationship as regulation: From regulation to coregulation

As explained above, normative attachments are characterized by the presence of four distinct forms of behavior; proximity seeking, safe haven behavior, separation distress, and secure base behavior (Ainsworth, Blehar, Waters, & Wall, 1978; Bowlby, 1982). According to Weiss (1982), these four features of infant–caregiver bonds can also be seen in romantic relationships. That is, romantic partners derive comfort and security from his/her partner, want to be with the partner (especially in times of stress), and protest when the partner threatens to become unavailable. Attachment theory also suggests the quality of early attachment relationships subsequently results in the quality of adult attachment relationships. Expectations about the availability and responsiveness of attachment figures are incorporated into "internal working models," which guide perceptions and behavior in later relationships.

Hazan and Shaver's (1987) seminal study is the first attempt in studying the dynamic of adult romantic relationships from the attachment perspective. Although there are differences between adult attachment and parent-child relationship, especially considering the reciprocity of the attachment behavior systems in adult relations, these authors conceptualized romantic love as an attachment process. Other obvious difference is that attachment relationships between adults often serve a wide variety of other functions, including sexual bonds, companionship, sense of competence, and shared purpose or experience (Ainsworth, 1982; Weiss, 1982). Adult attachment is also different from nonromantic attachments such as friendships. Sexual and physical intimacy provides the strongest and fastest conditioning of physiological reward systems for romantic partners. However, in friendships, the same processes are likely operating (e.g., distress-alleviation), but in a much slower fashion and with less potent physiological correlates (Hazan, Gur-Yaish, & Campa, 2004).

In parallel with Ainsworth's four phases in the development of infant–caregiver attachments, Zeifman and Hazan (1997) have proposed a corresponding four-phase process model to integrate and explain the phenomenology of pair-bond development. Although it is still unclear whether adult attachment follows similar developmental pathway as in infancy period, they proposed that Ainsworth's four-

phase model can serve as a provisional research guide. For example, they proposed that what Eibl-Eibesfeldt (1989) called the "proceptive program" is similar to the adult counterpart of the infant pre-attachment phase. Accordingly, males and females in reproductive age are inherently interested in social interaction with potential mates and display flirtatious signals somewhat indiscriminately. It is likely that these playful, sexually charged exchanges continue in the initial stages of romantic relationships.

Romantic infatuation in adulthood is also similar to infant–caregiver interactions (Shaver et al., 1988). It includes prolonged mutual gazing, cuddling, nuzzling, and "baby talk." These emotional exchanges can be seen as the indicators of the "attachment in the making", the second phase of attachment formation. Supporting this argument, Bowlby (1979) states that *"...In terms of subjective experience, the formation of a bond is described as falling in love"* (p. 69). The third phase, "clear-cut attachment," is indicated by the emergence of new attachment behaviors. Specifically, single caregiver becomes a reliably preferred target of proximity maintenance and safe-haven behaviors, and secure-base and separation distress behaviors can be observed in this phase. Zeifman and Hazan (1997) have suggested that the selective orientation of these four attachment behaviors toward a partner signal clear-cut attachment in adulthood as well.

The childhood indicators of the fourth phase, "goal-corrected partnership," primarily reflect cognitive-developmental changes over the first 3 years of life. In this vein, it was proposed that there may be a comparable final phase in adult attachment formation, characterized by a decline in overt displays of attachment behavior and a redirection of attention to other aspects of life (e.g., work, hobbies, and friendships). In a goal-corrected partnership, a romantic partner has achieved the status of an attachment figure and serves as a secure base, encourages his/her partner to explore his or her environment with a greater sense of security. Besides, this felt security enables the partners to regulate their own feelings and distress and theoretical frameworks on attachment have been assessed behavioral synchrony as an evidence of reciprocal, goal-corrected partnership between romantic partners (Bowlby, 1969).

In previous research, the security-provision and distress-alleviation functions of attachment relationships have been conceptualized in terms of affect regulation (Brennan & Shaver, 1995; Feeney, 1995; Field, 1991; Field & Reite, 1984). These processes involve the modulation of emotional and physiological reactivity to external and internal stimuli so that individuals can respond appropriately to the demands of everyday life and accomplish their goals (Thompson, 1994). Although both positive and negative feeling states are subject to regulation, attachment researchers have paid more attention to negative feeling states than the positive ones considering that distress-alleviation is a coregulation function of the attachment system (Bowlby, 1982).

Prior work mainly focused on affect and arousal regulation along a positive-negative dimension. Daily life experiences consist of not only emotions at high intensity level but also emotions at mild forms. Moreover, they include neutral contexts in which close partners communicate their internal states in a dyadic way. How coregulation functions at those moments is also important to show morphostatic balance or coregulation within the relationships. Specifically, investigating daily life experiences (i.e., neutral interactions) has been suggested as one of the mechanisms through which close partners co-regulate their emotions in optimal arousal level (Fredrickson, 1998; Fredrickson & Levenson, 1998). Besides, investigating coregulation patterns in the neutral context would also enable researchers to observe normative patterns, independent from cultural manifestations of positive and/or negative states. Hence, different from previous work on regulating negative emotion, the current study aims to investigate coregulation reflected in voice characteristics and its psycho-social correlates within the framework of neutral contexts.

3.2. Potential moderators in coregulation

3.2.1. Individual differences in Attachment

In addition to analyzing normative processes in coregulation in adulthood, how individual differences such as attachment-related anxiety and avoidance, and relationship satisfaction, moderate coregulation processes should be examined. Recently, researchers have viewed attachment styles as interpersonal strategies for

affect regulation that develop in the context of early attachment experiences and influence relationship interactions (Mikulincer & Florian, 1998; Rholes, Simpson, & Orina, 1999). According to recent conceptualization, the two attachment dimensions underlie the dynamics of affect regulation. The dimension of attachment anxiety is associated with the hyperactivating patterns of affect regulation involving heightened sensitivity to threats and stressors, excessive reliance on others for distress alleviation, hypervigilance to cues of the attachment figure's (un)availability, and responsiveness, and heightened efforts to maintain physical and psychological proximity (see Mikulincer, et al., 2003). Thus, people scoring high on attachment anxiety are often unable to suppress their own negative thoughts and feelings, tend to disclose them indiscriminately to their partners, and may be unable to provide sensitive and responsive care to their partner at times of need (e.g., Mikulincer et al., 2004; Mikulincer & Nachshon, 1991; Reizer, Ein-Dor, & Possick, 2012). This may increase their partners' distress and dissatisfaction with the relationship.

In contrast, the dimension of attachment avoidance is associated with the deactivating patterns of affect regulation that involve minimizing experiences and expressions of negative affect, directing attention away from threats and stressors, and excessive self-reliance (Fraley & Shaver, 1997; Mikulincer, et al., 2003). People with high attachment avoidance may remain distant from their close partner even when he or she needs emotional closeness and support (e.g., Kunce & Shaver, 1994), and they are also less likely to seek support, to express their distress, and to share their negative experiences with their partner (Shaver & Mikulincer, 2007). It is plausible to suggest that attachment orientations will have an effect on both each partner's reaction to the emotion regulation efforts and his or her partner's reaction to these affective changes. Specifically, individuals with high attachment anxiety are likely to show increased responses to emotion regulation efforts, whereas individuals high on avoidance will exhibit an attenuated response to these efforts. Moreover, the attachment insecurities of one partner, in the form of either anxiety or avoidance may cause the other partner to feel dissatisfied in the relationship (e.g., Mikulincer & Shaver, 2005; Rokach & Brook, 1998).

Limited research has examined the attachment dimensions (i.e., anxiety and avoidance) as the moderators of coregulation. Moreover, previous research mainly focused on how romantic partners regulate their negative emotions when they feel distressed. For example, Butler, et al. (2007) examined attachment as a moderator of emotional synchrony and coupling between partners relying on a diary methodology in which both partners in romantic couples reported daily on their positive and negative emotional experience. Results indicated that partners' level of positive and negative affect co-varied, above and beyond the influence of the emotional tone of their shared daily interactions. Attachment anxiety affected the pattern of covariation for negative emotion, such that highly anxious couples showed the lowest covariation in negative affect. In contrast, the coupling of positive emotion was found to be negatively associated with attachment avoidance – partners with high levels of attachment avoidance were less influenced by their partner's positive affect. Because of the complexity of the findings, it is difficult to conclude what effect attachment dimensions (i.e., anxiety and avoidance) may have on the coregulation of emotions. In this study, the concept of coregulation, indexed by morphostatic pattern of emotional covariation will be investigated within a relatively neutral context. Investigating coregulation as morphostatic pattern would provide important information regarding romantic couples' emotional covariation around a stable trajectory and the impacts of attachment differences on coregulation process. However, to our knowledge, no study has examined the communication of emotion in neutral context. The present study will further our knowledge of how emotions between partners get linked around a stable trajectory and what role (if any) individual factors play at the dyadic level.

3.2.2. Relationship Satisfaction

In addition to the individual differences in attachment orientation, the quality of relationship can be another critical factor for coregulation process (Saxbe & Repetti, 2010). Observational research has revealed the crucial role of coregulation in relationship interactions. Levenson and Gottman's (1983) study on marital interaction showed that couples' physiological linkage (an association between husbands' and wives' physiological arousal) was associated with their relationship

satisfaction, suggesting that negative emotions of partners are reciprocally affected by each other and this may trigger a cycle of negativity and dissatisfaction. Supporting thing, past studies showed that dissatisfied couples were more likely to experience negative affect reciprocity in which negative affect expressed by one spouse during the interaction is responded to with negative affect expressed by the other spouse (Carstensen, Gottman, & Levenson, 1995; Gottman, 1994; Gottman, Coan, Carrere, & Swanson, 1998). In contrast, married couples with high relationship satisfaction expressed a significantly higher ratio of positive rather than negative affect during interactions (Gottman, 1994), suggesting that they successfully employ affective regulation strategies. Besides, Levenson and Gottman (1983) found that married couples with lower marital satisfaction tend to show the greater physiological synchrony, while discussing problem areas in their marriage. Consistent with this, Saxbe and Repetti (2010) showed that lower marital satisfaction was linked to greater coregulation in cortisol levels between couples. This line of research finding suggests that intimate partners who have lower relationship satisfaction have also greater synchrony in discussing problematic issues in their relationships. However, the majority of previous studies were based on the observational data without using the objective measures of emotion and they generally answered the question of how couples regulate their negative and positive emotions in specific situations (i.e., emotion regulation strategies in manipulated emotion conditions). To our knowledge, no study has examined the link between coregulation and relationship satisfaction by using explicit measures such as vocalization, intonation or other speech characteristics. Moreover, previous work has not focused on the covariation of emotions during the relatively neutral emotional states in relationships or covariation of stability, rather they basically focused on regulating either positive (e.g., discussing the most exciting moment) or negative emotions (e.g., discussing problematic issues) manipulated in laboratory settings. Coregulation in neutral context would indicate morphostatic pattern of emotion covariation. In the current dissertation, relationship satisfaction was considered as a potential moderating factor that can influence the coregulation process between couples.

Following the previous studies with animals and human participants, the current research will investigate the formation and the function of coregulation at multiple levels including, behavioral, physiological, and affective processes. Majority of the past studies have focused on either day-to-day changes in emotional states (Randall, et al., 2011) or momentary physiological covariation in positive or negative affect states (Ben-Naim, Hirschberger, Ein-Dor, & Mikulincer, 2013; Liu, Rovine, Klein, & Almeida, 2013). Further studies should also examine coupling around the stable trajectory whereby one partner's emotion is used to predict their partner's subsequent emotion in a neutral context and by using a novel technique. To do this, a robust algorithm was borrowed from the psycholinguistic literature to analyze vocal covariation within romantic relationships. Individuals' speech characteristics seem to be useful indicator of emotional states even in neutral conditions because even minor changes in emotional state could be easily detected via voice cues. New methodological advances that enable researchers to detect speech covariation during dyadic interactions also helped examine this question.

CHAPTER 4

STUDYING DYADIC INTERACTIONS VIA SPEECH ACTIVITY

In the present dissertation, speech features of individuals as a novel perspective was examined to understand how the properties of voice covary between partners during conversation episodes. As Darwin (1872) boldly pointed more than a century ago, human voice is one of the principal converters of social and affective communication. Beginning from the early years, infants actively response to affect-laden vocal expressions coming from their mothers (Fernald & Morikawa, 1993; Jaffe, et al., 2001). Vocal affect seems to be a primary channel of emotion expression especially during early development (Shackman & Pollak, 2005) and continue throughout the lifespan. Although emotional vocal expressions are as important as facial expressions in everyday life and are recognized across cultures at rates comparable to facial expressions (Scherer & Wallbott, 1994), vocal expressions of emotion have received far less attention from psychologists and cognitive scientists than facial expressions. Besides, previous work focusing on interpersonal associations has investigated negative or positive vocal expressions by manipulating those emotions. Past studies have mainly focused on either expression and/or recognizing emotion in an isolated manner or interactions between strangers. However, assessing affective communication of close partners via speech characteristics has a potential to provide valuable explicit information on affect communication.

Human voice may reflect various unique features of the speaker or the utterance including the emotional state of the speaker, the form of the utterance (statement, question, or command), the presence of irony or sarcasm, emphasis, contrast, and focus, or other elements of language that may not be encoded by grammar or choice of vocabulary.

Prosody can indeed represents the basic features of speech and fundamental frequency (F0) carries prosodic information. F0 is a physical property of the speech sound wave that is perceived as the pitch of the human voice. It can be assessed mechanically, and thus, it is independent of subjective interpretation. During the first phase of speech production, air is released from the lungs and passes over the vocal folds in the larynx as it exits the throat. The tension of the vocal folds creates vibrations in the passing air, and F0 refers to the lowest harmonic frequency of these vibrations. F0 is measured in hertz (Hz), and higher frequency vibrations correspond to higher F0. Higher F0 is perceived as higher pitch of the voice (Banse & Scherer, 1996). Although it is possible to describe F0 as a quantity that can be calculated instantaneously (e.g., 10 milliseconds episodes from the conversation could be extracted), the F0 of adult speech changes rapidly. Hence, it should not be considered as a static measure. Numerous summary indexes can be used to specify F0 during a sequence of speech. Previous research on F0 and emotion using a number of experimental paradigms including portrayals of emotion has shown that higher levels of mean F0 was linked to higher levels of emotional arousal (Banse & Scherer, 1996), recordings of naturally occurring disasters (e.g., the crash of the Hindenburg/ zeppelin crash; Williams & Stevens, 1972), and experimental induction of emotion (Streeter, Krauss, Geller, Olson, & Apple, 1977; see also Juslin & Scherer, 2005 for a review). Developmental psychologists have also investigated the descriptive aspects of F0 variability in arousal (Protopapas & Eimas, 1997). Accordingly, F0 variability was found to be a rich source of information indicating that higher variability in F0 is rated as the state of urgency sickness, angry/sad, distressing, and asynchrony (Scherer, Johnstone, & Klasmeyer, 2003; LaGasse, Neal, & Lesser, 2005). In that vein, higher variability in F0 in adult communication may be associated with decreased synchrony in the conversation episodes.

F0 is also related with biological sex. The two primary anatomical determinants of F0 are the tension and the length of the vocal folds in the larynx (Titze, 1989). Tension is determined by activation of the muscle connected to the vocal folds and length is largely determined by the overall size of the larynx. Since men typically have larger bodies and longer throats than women, they typically have longer larynxes and correspondingly longer vocal folds. This biologically determined sex

difference in anatomical size corresponds to well-established sex differences in F0. After puberty, men consistently have a lower F0 (e.g., ranged from 75 to 150 Hz) than women (e.g., 125-250 Hz) (Titze, 1989). Sex differences in voice characteristics are critical for developing methodological standards for assessing F0 during couple conversations.

Evolutionary models for vocal expression (Juslin & Laukka, 2003) and empirical research on the neural substrates of speech production suggest that F0 is influenced by basic biological processes. Some of the basic vocalizations (such as signaling intimacy by using baby talk) do not have to be learned and they are innate. For example, the F0 of infant vocalizations conveys information about pain and discomfort (Young, Parsons, Stein, & Kringelbach, 2012). These vocalizations are controlled by the periaqueductal gray, a structure in the brain stem that is also responsible for control of the cardiovascular system and is known to control and coordinate cardiovascular and motor responses to stress (Benarroch, 2012). In contrast, vocalizations that are the product of social learning are controlled by laryngeal motor neurons (Bass, Giland, & Baker, 2008). Involvement of these different neural substrates in vocalizations suggests that F0 is probably related to the indices of physiological arousal as well as to the communication behaviors during couple interactions in everyday life. Involvement of the periaqueductal gray in controlling both vocal expression and cardiovascular responses to stress suggests that F0 is also associated with cardiovascular variables, such as heart rate and increased or decreased blood pressure (Benarroch, 2012). In sum, previous findings suggest that F0 is sensitive to emotional oscillations in daily life conversations. In other words, studies in psycholinguistics proposed that prosodic features such as F0 and F0 variability related to emotional state of speaker in natural speech (Lindström, Lepisto, Makkonen, & Kujala, 2012; Kujala, Lepistö, Wendt, Naatanen, & Naatanen, 2005). From the perspective of coregulation in adulthood, F0 and F0 variability can be utilized as critical parameter of vocal covariation in conversation. If F0 is closely linked to the emotional states, it should be proposed that synchronous F0 and decreased F0 variability in conversation can be expected to be linked to emotional coregulation of romantic partners.

4.1. Estimation of prosodic synchrony in close partner conversation

The prosodic features, the rhythmic and intonation characteristics of one's speech are the first linguistic features that a child acquires before any other linguistic levels (phonemes, lexicon, syntax etc.). Recent studies have shown that newborns are able to distinguish their mother voice from any other language relying on rhythmic cues only (Decasper & Prescott, 2004). Besides, individuals could easily distinguish synchronous prosody success from scattered speech patterns fully (O'Dell, Nieminen, & Mustanoja, 2010).

In natural conversation, a turn end is usually accompanied by a number of acoustically marked prosodic boundary cues such as intonation, utterances, and pauses (Gerken & McGregor, 1998). In general, prosodic boundary cues help to segment linguistic units (Gerken & McGregor, 1998), making them an important feature in the acquisition of language (Gerken, 1996). At the end of conversational turns, the F0 rises or falls, the last vowel is lengthened, and pauses are longer compared with the end of clauses or phrases. It has been shown that adults were, in principle, able to use these cues to identify a speaker's turn. When utterances are made unintelligible, with only prosodic cues (notably intonation) still intact, participants could identify the end and beginning of turns at above chance level (de Ruiter et al., 2006). Past experimental studies suggest that adults can use prosody to better anticipate the end of a sentence, but mainly do so once neither semantic nor syntactic information is available (Grosjean & Hirt, 1996). However, no study so far, to our knowledge, has examined whether individuals accurately judge utterances of conversations rather than turns. The ability to correctly discriminate the conversations of close partners and stranger dyads without verbal content would indirectly support the idea that close partner prosody (or speech patterns consisted of F0) carry unique features compared to stranger speech episodes. Therefore, in this study, first, it was aimed to examine individuals' ability to detect the features of close partner conversations based on the F0.

CHAPTER 5

THE CURRENT STUDY

Research on the development of emotion regulation has emphasized the transition from infant's dependency to his/her caregiver for regulatory assistance to internalization of regulatory strategies in adulthood. Infants achieve this transition via increased mastery of self-regulatory strategies, such as attention shifting, active coping, or selective approach/avoidance behaviors (Kobak, Cole, Ferenz-Gillies, Fleming, & Gamble, 1993). Even after the internalization of regulation strategies, significant other has still important functions in individuals' life. Significant other continues to serve as an external "regulator" over the life course, through diverse mechanisms such as comfort and support provision, helping with cognitive reframing of stressful events, and the communication of emotion. A growing body of research suggests that the process between internalized regulatory strategies (e.g., attention shifting or distracting) and external regulators (e.g., pleasure induction or distress alleviation) are bidirectional. In other words, significant others who serve a function as an external regulator, helps individuals use their internalized regulation strategies by keeping them in a stable arousal zone.

The main aim of this study is to explore the possibility of coregulation in adulthood using the novel methodology based on the assessment of F0 and F0 variability. It was anticipated that two F0 series of close partners' conversations, but not strangers, would be significantly correlated with each other. Moreover, it was hypothesized that close partner's previous speech features (F0) would predict another partner's subsequent F0 values independent from individual's previous own F0 responses. Higher correlations between the time series of F0 with close partner conversation are assumed to indicate synchrony between close partners. Besides, speaking with close partner is expected to predict lower rate of variability in F0.

Previous work suggests that differences in attachment styles and relationship satisfaction could moderate relationship interactions (Butner, Diamond, & Hicks, 2007; Mikulincer et al., 2004). It was anticipated that attachment anxiety and avoidance have potential to deteriorate coregulation process. Specifically, it is expected that attachment anxiety and avoidance would predict increased F0 variability in close partner conversations. In addition to the individual differences in attachment orientations, levels of relationship satisfaction is expected to have an impact on coregulation process. Thus, higher relationship satisfaction is expected to promote successful coregulation between couples. In other words, relationship satisfaction would predict decreased F0 variability in conversations with close partner. In sum, the second objective of this dissertation is to investigate the moderating role of attachment related anxiety and avoidance and relationship satisfaction in coregulation process.

Speech features were selected as a marker of affective responses originated from physiological oscillations, in particular fundamental frequency (F0; perceived as pitch) was chosen as a speech feature parameters. Previous research on psycholinguistics has shown that F0 and affective states are linked to each other and it could be used as a representative parameter indicating momentarily changes in physiological systems. Considering that prosody (which includes the characteristics of speech style such as mean F0 and F0 variability) is innate, and thus, perceived automatically, it is proposed that individuals can distinguish close partner prosody accurately from the conversations of strangers. Thus, in a separate study, whether a third person (not interlocutor in the conversation) could distinguish intonation differences in the conversations of close partner and stranger dyads above the chance was examined. Accordingly, it was anticipated that participants would accurately recognize close partner intonations without the verbal content above the chance level.

CHAPTER 6

STUDY 1

6. Initial data processing and data analytic strategies

The hypotheses regarding the dyadic changes of couple's physiological systems marked by speech features of speakers can be tested via specific statistical models that can capture cross-partner changes. Modeling of this association must be able to show the temporal changes of individuals' speech signals and quantify the association between both individuals in the conversations. Initially, signal-derived features (i.e., fundamental frequency) are extracted to model the within person and between couples changes in speech episodes. The feature extraction (i.e., F0 calculation) consists of converting the speech waveform signal into a parametric representation. Following previous works (e.g., Buder & Eriksson, 1997), F0 values were extracted for each speaker and used for the session level and turn level analyses in this study. Whereas session level indicates obtaining F0 series from each session without dividing F0 series into sub-turns, turn level reflects the extraction of F0 series based on the turn-taking of participants. In this section, first, the definition and preprocessing of F0 will be described. Then, analyses units, namely session vs turn level analysis, used in this dissertation will be explained. Finally, strategies for statistical analyses of synchrony at vocal level will be presented.

6.1. Definition and extraction of fundamental frequency (F0)

The time domain representation of a human speech consists of voiced (i.e., all vowels) and unvoiced sounds (i.e., some consonants: /p/ /t/ /k/ /s/ /h/). Human speech shows a periodic pattern. While each of the identifiable repeating patterns is called a cycle, the duration of each cycle is called the pitch period length. The periodicity of the complex wave form as a whole (the number of cycles per second or millisecond) is determined by the sinusoidal component with the lowest frequency—the

fundamental frequency (F0). This frequency roughly corresponds to what a listener perceives as the pitch of the sound (see Figure 3).

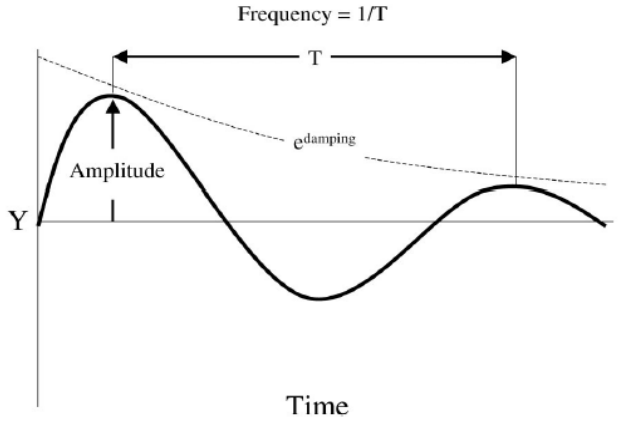


Figure 3. Illustration of frequency on a given time sample. Frequency = the number of cycles per time period,; T= the period or time to complete one cycle.

The pitch period length is generally represented by the Greek letter tau, τ. When the pitch period length is measured in milliseconds, it is represented by τms. The fundamental frequency (F0) of a periodic signal is the inverse (reciprocal) of the pitch period length. Thus, the relationship between the fundamental frequency and the duration of the glottal pulse could be shown as follows:

$$F0 = 1000/\tau ms$$

6.2. Data extraction and algorithm for automated turn-taking detection

Two specific strategies were applied for the data extraction process in this study. First, individual voice activity detection was applied to each participant's audio recording to eliminate the nonspeech regions (e.g., silences). To do this, an algorithm was written to detect on and off activity in speech episodes (see Appendix 1 for MATLAB code detecting on off voice activity). Following previous work (Boersma, 1993; Juslin & Scherer, 2005), the speech signal derived from each participant was divided into a number of time windows each consisting of 10 ms for speech regions and F0 value was extracted for each of these analyses windows using autocorrelation function of PRAAT (Boersma & Weenink, 2013). Second, dyadic voice activity and

turn-taking behavior in a given conversation were identified from the conversation recordings. In this step, an algorithm was developed to identify automated turn-taking cues in spontaneous speech. Specifically, the algorithm detected on and off points in each turns (female or male turns) automatically and recorded F0 values at those points in the conversation recordings (see Figure 4).

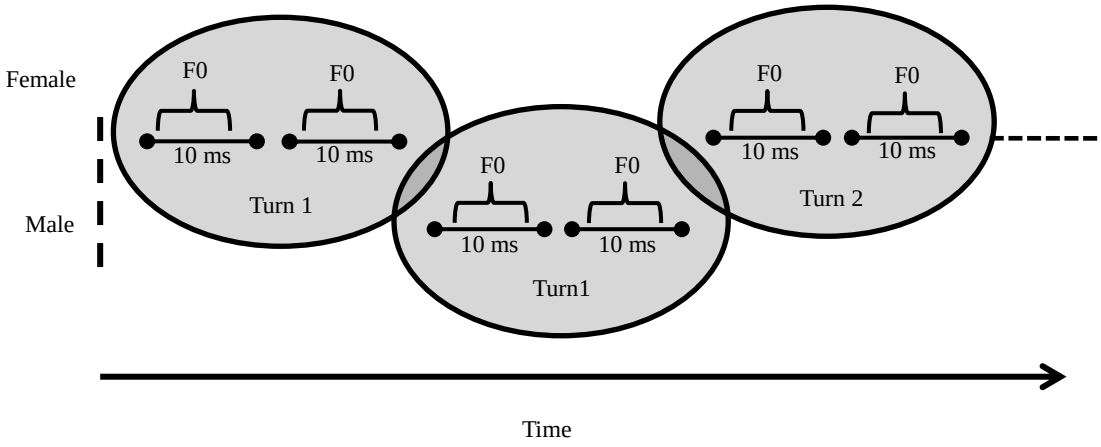


Figure 4. Example of F0 extraction at turn-based conversation

Automated turn detection algorithm was assessed by using the mean F0 and standard deviation of each individual in the conversations. Specifically, an individual turn was detected when the range of the F0 was between +/- 2 standard deviation of each speaker. If detected F0 was in the out of this range, it means that the turn was switched to other partner and s/he started to her/his turn in the conversation. For example, participant A spoke 5 seconds at the beginning of conversation and her F0 responses were calculated at each 10ms (i.e., 500 F0 responses). The algorithm automatically computes the mean and ±2 standard deviation of F0 series. If F0 response is detected higher (or lower) than 2 standard deviation of F0, the algorithm will code that the speaker switch her turn. Overlapping episodes (e.g., speaking at the same time) were extracted manually from the conversations. This classification was also controlled manually and turn taking behaviors were classified successfully (see Appendix 2).

6.3. Data Analytic Strategies

A number of statistics were utilized to analyze the data on the vocal cues and individual differences in the coregulation process. First, bivariate analyses were conducted to examine the effect of sex differences and relationship types (close vs stranger partner) in the speech features at session level. As mentioned in the previous sections on data processing and data analytic strategies, session level analyses included whole F0 series without considering turn-taking responses. Second, Granger causality analyses were conducted to examine the turn by turn synchrony. Finally, dyadic HLM was conducted to examine the role of potential moderators in turn by turn synchrony and to predict F0 variation in each turn.

6.3.1. Bivariate analysis: testing session level synchrony

Bivariate analyses were conducted to test group differences in speech features and the effects of the attachment dimensions and relationship satisfaction. Each participant had roughly 100.000 data points obtained from the speech with his/her conversation partner. Previous studies using similar methods have shown that such a large amount of data (even if they have relatively small sample size) would allow researchers to reach reliable results (Feldman, 2003; Gottman, 1981). We compared these individual time series data by using bivariate analyses.

The relationship between the F0 series was tested by employing cross-correlation function (CCF). However, at the first step, cross-correlations between series at the session level which refers to F0 levels of each speaker without separating into turns at different conditions (i.e., conversations with romantic vs. other stranger partner) were estimated. Univariate time-series of F0 values were also plotted separately to visualize co-occurrence of partners' vocal activity (See Appendix 3 for MATLAB code).

Secondly, a mixed design ANOVA with a within-subjects factor of relationship nature (close partner vs. stranger partner) and a between-subject factor of sex was conducted in order to test group differences in F0 values. Both correlation analyses

and ANOVA results were anticipated to show whether or not close partner speech patterns are different from the conversations of stranger partners.

6.3.2. Causality in speech episodes and turn-by-turn synchrony

Once the data were separated into the turns by the automated turn-taking detection algorithm, it is possible to examine cross-partner associations in the time domain. The concept of *turn* refers to pause-free units of speech from a single speaker separated from one another by at least 50ms

The correlation analyses provide information about the question of how two conversation partners' vocal cues were correlated at session level. However, the correlation between two time series on the session level may not imply synchrony. It does only indicate convergence or similarity in time rather than synchronous interaction, in which partner's previous responses predict actor's later responses reciprocally. To do this, one should estimate causality and reciprocity. There are sophisticated regression-based techniques that can be used to test for causality and/or bidirectionality under these specific conditions. Granger causality test is one of those alternative techniques.

Granger causality (or "G-causality") was developed in 1960s and has been widely used in economics. However, recently it has become one of popular techniques among the neuroscientists. It answers simple question of, 'Do changes in y1 cause changes in y2?'. The argument follows that if y causes x, lags of y should be significant in the equation for x. If this is the case and not vice versa, it would be said that y 'Granger- causes' x or there is unidirectional causality from y to x. If x causes y, lags of x should be significant in the equation for y. If both sets of lags were significant, it would be said that there was 'bidirectional causality' or 'bidirectional feedback'. If y is found to Granger-cause x, but not vice versa, it would be said that variable y is strongly exogenous (in the equation for x). If neither set of lags are statistically significant in the equation for the other variable, it would be said that y and x are independent. Finally, the word 'causality' is somewhat of a false conceptualization, for Granger-causality really means only a correlation between the

current value of one variable and the past values of others. The simplest test of Granger causality requires estimating the following two regression equations:

$$y_t = \beta_{1,0} + {}_{1,i}y_{t-i} + {}_{1,p+j}\chi_{t-j} + {}_{1t} \quad (1)$$

$$x_t = \beta_{2,0} + {}_{2,i}y_{t-i} + {}_{2,p+j}\chi_{t-j} + {}_{1t} \quad (2)$$

Let's consider the equations 1 and 2 as a regression model of female and male speech, respectively. In those equations, *p* refers to the number of lags (in our case turn number of the conversant). The error terms may, however, be correlated across equations in our case. If the *p* parameters $\beta_{1,\,p+j}$ are jointly significant, then the null hypothesis that '*x* does not Granger cause *y'* can be rejected. Similarly, if the *p* parameters $\beta_{2,\,p+j}$ are jointly significant then the null hypothesis that '*y* does not Granger cause *x'* can be rejected. The theory and application of Granger-causality (and its extensions) to neural system identification has also been elaborated in a number of studies (Kaminski, Blinovska, & Szelenberger, 1997; Eichler, 2007; Blinowska & Kaminski, 2006; Schlogl & Supp, 2006; Bressler & Seth, 2011). Following similar research direction, this methodology was adopted for this study. In sum, using individuals' time series data consisted of their F0 values per 10 ms, Granger-causality was used to examine direction of associations between partners. The advantage of this analysis is that it takes into consideration one partners' previous vocal activity in the conversation as well as the other partner's history in estimating directionality of speech activity.

A series of Granger-causality tests were computed and plotted for each dyad by using EViews 5.1 (McKenzie & Takaoka, 2007). Consequently, the results of this analysis will show how partners influence each other reciprocally at turn-by-turn. If each participant influences the other (i.e., bi-directionality), it means that there is a co-variance in their speech characteristics (i.e., synchrony at turn level analyses). Otherwise, if only one partner influences another, it refers unidirectional responses reflecting convergence in F0 values.

6.3.3. Turn-by-turn synchrony testing using Time Series Analysis and Dyadic HLM

There are recent strategies for analyzing data in estimating the synchrony between couples. These analytic approaches try to predict partner's behaviors (or emotional states) from other partner's previous responses. One of the approaches for assessing time-lagged synchrony (e.g., turn-taking conversations) involves using time-series methods (Feldman, 2003; Gottman, 1981). The strength of this approach is that covariation is simultaneously assessed across a wide range of time lags (e.g., Person A is predicted from Person B 1 second earlier, 2 second earlier, 3 second earlier F0 values, etc.). The approach requires a fairly large number of repeated observations.

6.3.3.1. Autoregressive Integrated Moving Average Models (ARIMA)

Univariate time series models are the analytic strategies where researcher attempts to model and to predict future behaviors using past responses and current and past responses of an error term. An important class of time series models is the family of Autoregressive Integrated Moving Average (ARIMA) models (Box & Jenkins, 1976). Time series models may be useful when researchers need to estimate subsequent responses. The model is generally referred to as an ARIMA(*p*,*d*,*q*) model where parameters *p*, *d*, and *q* are non-negative integers that refer to the order of the autoregressive (p), integrated (d), and moving average (q) parts of the model, respectively. *Autoregressive component* (p) refers to the number of autoregressive orders in the model. Autoregressive orders specify which previous values from the series are used to predict current values. For example, an autoregressive order of 2 specifies that the value of the series 2 time periods in the past is used to predict the current value. More specifically, the values of the series 2 turns before F0 responses will be used as the predictors to estimate the current F0 responses of the participant. *Integrated component* (d) refers to the order of differencing applied to the series before estimating models. Differencing is necessary when trends are present (series with trends are typically *nonstationary* and ARIMA modeling assumes stationary) and is used to remove their effect. The order of differencing corresponds to the degree of series trend. First-order differencing accounts for linear trends, second-order differencing accounts for quadratic trends, and so on. From this perspective,

each component for each time series is calculated. Finally, *Moving Average component* (q) indicates the number of moving average orders in the model. Moving average orders specify how deviations from the series mean for previous values are used to predict current values. For example, moving-average orders of 1 and 2 specify that deviations from the mean value of the series from each of the last two time periods is considered when predicting current values of the series.

Psychological research using ARIMA models are rare and past research has generally selected ARIMA (1,0,1) models as default (see Butler, 2011 for a review). However, the model specification of each individual time series should be conducted separately because component of ARIMA models (i.e., p, d, and q) could be divergent for different time series (Brooks, 2008). To obtain the best model produced by ARIMA models, Akaike Information Criteria (AIC) was used in this study. AIC is a widely used measure of a statistical model and it quantifies the goodness of fit and the parsimony of the model into a single statistic. F0 series (raw data) and series derived from ARIMA models were compared by using AIC. The model with the lower AIC indicated that series of data was better than another data series. As mentioned in the results section in the dissertation, all of models derived from ARIMA models are better than the raw data series (Brooks, 2008).

Various pieces of information from the ARIMA models were noted, and then used as *"synchrony indicators"* in subsequent analyses of variance (ANOVAs) or regression analyses (see Gottman, 1981, for a complete discussion of time-series analysis and the complexities of model fit in psychology research). F0 variability at each turn of specific speakers was utilized by using ARIMA models with MATLAB (the codes presented in Appendix 4). In sum, time-series data derived from ARIMA models was used in different analyses: (1) Granger causality analyses and (2) dyadic HLM (time-series were used as dependent variables). In computing outcome variables process, following stages were completed:

1. Individuals' ARIMA models were applied to the speech data separately (F0 series in a specific conversation);

a. New series obtained from ARIMA modeling was saved and used in further analyses and then, Granger causality analyses were run using ARIMA derived series

2. 3. The ARIMA derived series were divided into turns based on the algorithm mentioned above. F0 variability was computed for each turn individually. For example, if the participant spoke 54 turns with his/her romantic (or stranger) partner, s/he had 54 subsequent F0 variability series (the same series were computed for his/her partner).

6.3.3.2. Dyadic HLM: Testing Potential Moderators in Coregulation

HLM is an analytic technique for analyzing nested or hierarchically structured data in which individual observations are nested within groups. A common example is the data that involve students nested within classrooms and classrooms nested within schools. That is, students who share the same teacher, facilities and curriculum tend to have related or dependent scores. These data structures lead to the violation of the independence assumptions of traditional regression analysis whenever the measure of nonindependence, the intra-class correlation coefficient (ICC), is greater than zero.

Dyadic data, such as couples, twins, parent-child interaction, or friendship pairs, can be analyzed by using HLM analysis technique. There is a growing body of publications that use HLM for the analysis of dyadic data (e.g., Barnett, Marshall, Raudenbush, & Brennan, 1993; Kurdek, 1997; Windle & Dumenci, 1997; Kashy & Kenny, 2000). In this data analytic strategy, dyad members are assessed as individuals nested within groups of two.

In this study, both male and female relationship type (romantic vs. stranger), attachment anxiety, avoidance and relationship satisfaction were used to predict the variability in vocal cues (i.e., F0 variance at each turn while speaking with male partner) separately. Generalized least squares (GLS) regression technique was used to achieve an efficient estimation (Kashy & Kenny, 2000).

Another advantage of the analytic approach adopted here is that it takes into account the errors of measurement of the dependent variable, time-series F0 variances at each

turn. These measurement errors would otherwise have two undesirable effects on the results. First, the cross-correlation between male and female F0 variance (derived from time-series modeling) would be attenuated by measurement error and would, therefore, understate the relational character of synchrony within couples. Second, the proportion of variability accounted for by the model would be underestimated. Without partitioning variability into components attributable to true score variance and measurement error variance, one might mistakenly conclude that the model has poor explanatory power, when, in fact, a substantial proportion of variation in F0 activity at each turn might be attributable to errors of measurement that are not explainable. As a result, the analysis yielded estimates of the internal consistency of the outcome separately for males and females.

In particular, we adapted the two-level hierarchical linear model as described by Raudenbush and Bryk (1986). Although this methodology has been commonly used to analyze data collected on individuals nested within groups, such as classrooms and schools, as well as to model individual change over time (Bryk & Raudenbush, 1987), the methodology can also be adapted to incorporate within-subject variability attributable to measurement error (Raudenbush, Rowan, & Kang, 1991). To apply the hierarchical analytic approach, a *Level 1 model* represents F0 variances in each turn of male and female participants with both romantic and stranger partner as a function of a true score plus a measurement error. In other words, Level 1 model includes two variables: participants' sex (i.e., female vs male) and relationship nature (i.e., romantic vs stranger). At *Level 2*, each pair of true scores associated with couple (i.e., attachment anxiety, avoidance, relationship satisfaction) is viewed as varying randomly over the population of couples (see Figure 5 for graphical demonstration of data structure for HLM).

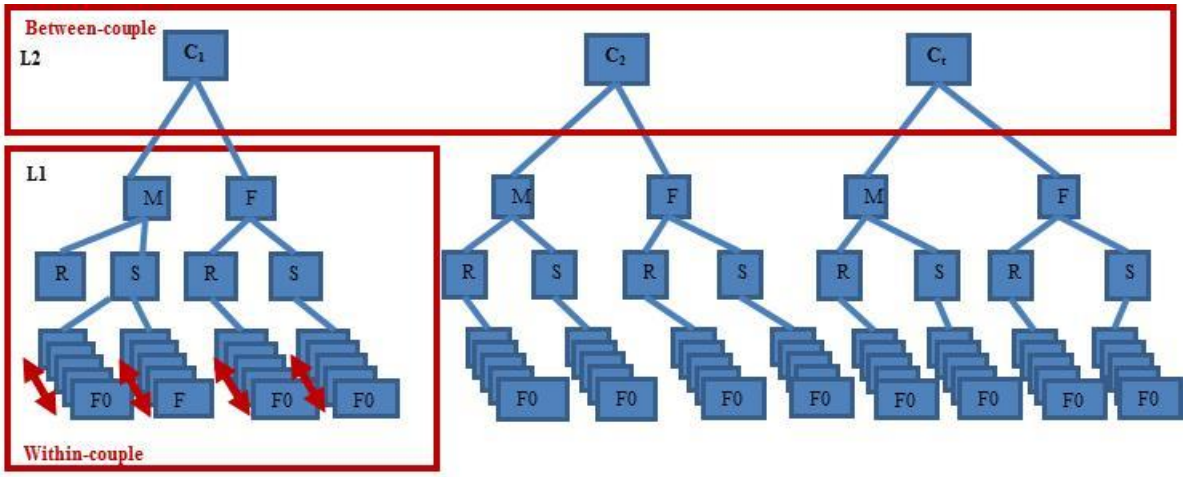


Figure 5. An illustration of dyads as 2-level data structure

Note: F0 = F0 variability in a given turn; S= Stranger partner; R = Romantic partner; M = Male; F = Female; C = Couple; L1 = Level-1; L2 = Level-2.

6.3.3.2.1. Level 1 Model

F0 variability of each interlocutor was obtained by ARIMA models. Those data series were computed for each turn in conversations separately. Moreover, because participants attended conversations with both their romantic and stranger partner, we computed turn-based F0 variability of individuals for two separate conversations (see Procedure section). Thus, for each individual, there were a number of outcome scores (depending on turn number in the conversations), half of them obtained from romantic partner conversations and the other half of them obtained from stranger partner. The measurement model postulates simply that each outcome score (F0 variance in this case) for each member of a couple is the sum of a true score plus a measurement error, where the measurement errors are uncorrelated with constant variance. The model may be written as follows:

Level-1 (within-dyad):

(3)

$$\text{Outcome (F0-variability series)}_{ti} = \beta_{0im}\,(\text{Male}) + \beta_{0if}\,(\text{Female}) + \beta_{1im}\,(\text{Romantic})_{ti} + \beta_{1im}\,(\text{Stranger})_{ti} + \beta_{1if}\,(\text{Romantic})_{ti} + \beta_{1if}\,(\text{Stranger})_{ti} + {}_{ti}$$

The Level 1 model explains within-gender and within-couple variation in F0 as specified in the Equation 3. *Outcome (*F0-variability*)$_{ti}$* refers to t times F0 variance (i.,e., turns) for couple *i*. The predictor *Male* is an indicator for male equal to 1 if *Outcome$_{ti}$* is measured on a male and 0 if *Outcome$_{ti}$* is measured on a female; *Female* is an indicator for females equal to 1 if *Outcome$_{ti}$* is measured on a female and 0 if *Outcome$_{ti}$* is measured on a male. Another predictor was relationship nature in the Level 1 model. Thus, similar to participants' gender, relationship nature (i.e., romantic vs stranger) was dummy coded (1=Romantic). The predictor *Romantic* is an indicator for romantic partner conversation equal to 1 if *Outcome$_{ti}$* is measured on a romantic partners and 0 if *Outcome$_{ti}$* is measured on a stranger dyads; *Stranger* is an indicator for stranger dyad conversation equal to 1 if *Outcome$_{ti}$* is measured on a stranger conversation partners and 0 if *Outcome$_{ti}$* is measured on a romantic partner conversations.

6.3.3.2.2. Level 2 Model

The Level 2 model specifies the individuals' F0 variability true scores as outcomes to be predicted by a set of explanatory variables that are expected to be related to vocal covariation in the conversations. The model may be written as follows:

Level-2 (between-dyad)

(4)

$$\beta_{0jm} = \gamma_{00m} + \gamma_{10}(\text{Anxiety})_m + \gamma_{20}(\text{Avoidance})_m + \gamma_{30}(\text{Relationship Satisfaction})_m + u_{0jm}$$

$$\beta_{0jf} = \gamma_{00f} + \gamma_{10}(\text{Anxiety})_f + \gamma_{20}(\text{Avoidance})_f + \gamma_{30}(\text{Relationship Satisfaction})_f + u_{0jf}$$

and

$$\beta_{1ir} = \gamma_{10r+} \gamma_{11}(\text{Anxiety})_r + \gamma_{21}(\text{Avoidance})_r + \gamma_{31}(\text{Relationship Satisfaction})_r + u_{1ir}$$

$$\beta_{1is} = \gamma_{10s} + \gamma_{11}(\text{Anxiety})_s + \gamma_{21}(\text{Avoidance})_s + \gamma_{31}(\text{Relationship Satisfaction})_s + u_{1is}$$

where γ_{00m}, γ_{10m} and γ_{00f}, γ_{10f} are the intercepts for male and female, respectively, $\gamma_{10}(\text{Anxiety})_m$, $\gamma_{20}(\text{Avoidance})_m$, $\gamma_{30}(\text{Relationship Satisfaction})_m$ are the predictors for male F0 activity in j^{th} turn; $\gamma_{10}(\text{Anxiety})_f$, $\gamma_{20}(\text{Avoidance})_f$, and $\gamma_{30}(\text{Relationship Satisfaction})_f$ are the predictors for female F0 activity in j^{th} turn; $\gamma_{11}(\text{Anxiety})_r$, $\gamma_{21}(\text{Avoidance})_r$, and $\gamma_{31}(\text{Relationship Satisfaction})_r$ are the predictors of romantic couples' F0 activity in i^{th} turn; and $\gamma_{11}(\text{Anxiety})_s$, $\gamma_{21}(\text{Avoidance})_s$, and $\gamma_{31}(\text{Relationship Satisfaction})_s$ are the predictors of stranger dyads' F0 activity in i^{th} turn. The residuals u_{0jm}, u_{0jf}, u_{1ir}, and u_{1is} are assumed to be normally distributed over gender and couples. Figure 5 depicts two-level statistical model, estimating F0 activity (or covariation of F0 between couples).

In sum, the two-level HLM would provide information regarding the question of (1) if there is a significant relationship between two interlocutors' F0 variability during the conversations; (2) if there is a difference between romantic partners and stranger dyads' F0 activities during their conversations; (3) how attachment-related anxiety, avoidance, and relationship satisfaction have an impact on covariation of F0 values during the conversations. Following previous work on prosody, lower variability in F0 in each turn would be associated with higher conversation synchrony. In other words, it was expected that relationship status would negatively predict F0 variability in each turn. Besides, it was also expected that attachment anxiety, avoidance would predict F0 variability positively, relationship satisfaction would predict F0 variability negatively.

6.4. Methods

The first aim of the Study 1 was to develop a new methodology in order to model the changes of couple's physiological systems marked by one of the speech features, namely F0 activity. In other words, the possibility of coregulation in adulthood was

examined and the question of whether partners' speech features would show covariation over the course of neutral conversations was tested. The second aim was to investigate the potential moderators that may have an effect on coregulation process. Specifically, we examined how attachment-related anxiety, avoidance, and relationship satisfaction moderate synchrony process between dyads.

6.4.1. Participants

The sample included 12 heterosexual American couples. The mean age of the total sample was 21.25 (*SD* = 1.03). Female participants' age ranged from 19 to 22 (*M* = 21.17, *SD* = .94) and males' age ranged from 19 to 24 (*M* = 21.33, *SD* = 1.15). Couples had to meet following criteria to be able to participate in this study: (a) they should be native English speaker; (b) they should not have a history of speech related problems that might adversely affect current utterance in conversations; and (c) they should be in a romantic relationship with the current partner for at least three months.

The average duration of relationship was 16.04 months (*SD*=6.17). The participants were recruited through the SUSAN participant pool at the Cornell University Psychology Department and via flyers posted in the campus. Participants received $5 or course credit for their participation as compensation.

6.4.2. Procedure, Apparatus, and Measures

Two male experimenters conducted the study in the laboratory. Each subject was given a brief description of the study before the trails (see Appendix 5 for Consent form). Study sessions included three stages: (1) setting the lab equipment before participants' arrival (preparation); (2) meeting with couples, presentation of informed consent forms, and switch of couples (introduction). Switching couples had 3 steps (for details see below); and (3) administration of self-reported measures, debriefing and closing equipments.

In the preparation stage, experimenters prepared the equipment used in the study. Specifically, the microphones and volume level of earphones at the same level located in the different rooms were set. In the introduction stage, experimenters run the experiment with two couples. Specifically, two couples (4 participants) were

invited to the experiment sessions at the same time. In the speech tasks, participants were asked to engage in a conversation with their romantic partner and with the other opposite sex participant in a balanced order. Conversations were about their subjective evaluations of the inkblots from the Rorschach test. To eliminate other non-verbal cues, couples communicated from the separate rooms (see Appendix 5 for experiment stimuli). Recordings were made using an SHURE dynamic microphone in a quiet room using Audacity 1.3 recording software (Audacity Team, 2008), in stereo, and at a sampling rate of 44.1 kHz with l6-bit amplitude quantization. Two USB adapters (MXL Mic Mate Pro) were connected to the dynamic microphones and they converted voice records into computer. Partners were able to hear each other via headphones as they were talking about inkblots. In the second stage of the session, one of the interlocutors was shifted to a stranger participant. Thus, each participant spoke with his/her close partner and a stranger in counter-balanced order. Conversations took about ten minutes (mean duration of conversations was 7.54 minutes (*SD*=4.78)). Participants were debriefed and compensated following the completion of experiment. After conversation session ended, at the closing stage, participants were asked to complete the self-report measures described below.

6.4.2.1. Attachment Dimensions

A short form of the Experiences in Close Relationships measure of *attachment dimensions* (original scale; Brennan, Clark, & Shaver, 1998; short form; Wei, Russell, Mallinckrodt, & Vodel, 2007), a 10-item scale yielding two 7-point scales—attachment anxiety and attachment avoidance (e.g., *I often worry that my partner doesn't really love me*; and *I find it difficult to allow myself to depend on my partner, respectively*). Coefficient alphas were .78 (Anxiety) and .84 (Avoidance) for the 10-item ECR-S and .92 (Anxiety) and .93 (Avoidance) for the 36-item ECR in this sample. Although lower than the values for the original version of the measure, it appeared that the coefficient alphas of the 10-item ECR-S were acceptable for use in college student samples (Wei, et al., 2007). Correlations between the Anxiety and Avoidance subscales were r = .19 (10-item short version) and r = .17 (36-item original version), which indicated that these two measures reflected distinct dimensions of attachment.

6.4.2.2. Relationship Satisfaction

Relationship satisfaction was measured using the 18 item Perceived Relationship Quality Components (PRQC) Inventory (Fletcher, Simpson, & Thomas, 2000). The PRQC measures six components of relationship quality: satisfaction, commitment, trust, intimacy, passion, and love. Each component is measured with 3 questions (e.g., satisfaction is measured with "*How satisfied are you with your relationship?; "How content are you with your relationship?*"). Participants were asked to rate their current partner and relationship on each item using a Likert-type 7-point scale ranging from "Strongly Disagree" to "Strongly Agree". The scale demonstrated good internal reliability in previous study (alphas range from .86 to .96) (Fletcher, Simpson, & Thomas, 2000). Finally, participants completed a demographic form (including questions on age, relationship duration, and gender). At the end of the session, they were given debriefing.

6.5. Results

6.5.1. Descriptive Statistics and Bivariate Analyses

6.5.1.1. Group Comparisons

Table 1 provides descriptive statistics for the major study variables. Initially, gender and relationship type (close vs. stranger partner) differences in vocal features, and speech related properties (i.e., turn number and speech duration in conversations) were examined. A series of mixed design ANOVAs were run to compare the effect of gender and relationship type on mean F0 values, mean number of turn in conversation, and duration of speech.

A mixed-design ANOVA with relationship type as a within-subjects factor (close partner vs stranger partner) and sex of the participant as a between-subject factor (male and female) was conducted on three speech features: Mean F0 values, duration of speech, and the turn number in the conversations. Mauchly's test indicated that the assumption of sphericity was accepted ($\chi 2(2)$ = 42.40, *ns*). Confirming the sex difference, there was a significant main effect of sex on mean F0 values with a large

effect size ($F\ (1, 22)$ = 990.71, $p < .01$, η^2 = .79), indicating that female participants had higher mean F0 values than male participants. There was a main effect of relationship type on the turn number in the conversations ($F\ (1, 22)$ = 17.58, $p < .001$). Overall, participants took more turns in conversations with their romantic partner (M = 33.50, SD = 2.05) than a stranger partner (M = 24.54, SD = 1.31). Finally, both relationship type ($F\ (1, 22)$ = 14.41, $p < .001$) and sex ($F\ (1, 22)$ = 5.92, $p < .05$) had a significant main effect on speech duration in conversations. Participants spoke longer with their romantic partners (M = 291.17 secs., SD = 18.92) than stranger partner (M = 237.67 secs., SD = 12.64) and female participants (M = 299.63 secs., SD = 20.46) spoke longer than male participants (M = 229.21 secs., SD = 20.46). There was no significant interaction effect between within- and between-subject factors in all analyses.

Independent sample t-tests were conducted on attachment anxiety, avoidance, and relationship satisfaction to examine sex differences. Analyses yielded that there was only sex differences in attachment anxiety ($t\ (22)$ = 2.39, $p < .05$), indicating that female participants reported higher attachment anxiety (M = 2.89, SD = 1.79) than male participants (M = 1.71, SD = 0.80).

Table 1. Descriptives for study variables

	Close Relationships							
	Male				Female			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Mean F0 (Hz.)	108.13	9.48	95.51	120.47	199.75	32.99	120.31	241.22
Mean duration of speech (in secs.)	253.42	83.86	168	424	328.92	100.76	204	497
Mean number of turn in conversations	33.75	10.1	22	60	33.25	9.97	22	59
Attachment anxiety	1.71	0.8	1	3.4	2.89	1.79	1	6.2
Attachment avoidance	1.73	1.05	1	4.6	1.64	0.68	1	3.2
Relationship satisfaction	6.03	0.94	3.39	6.94	6.26	0.46	5.44	6.89
Relationship duration (month)	16.04	6.17	6	26	16.04	6.17	6	26
	Stranger Dyads							
	Male				Female			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Mean F0 (Hz.)	110.46	6.84	98.5	119.04	200.46	35.74	115.11	259.03
Mean duration of speech (in secs.)	205	38.41	163	287	270.33	78.73	164	472
Mean number of turn in conversations	25.08	6.37	13	37	24	6.45	12	36
Attachment anxiety	-	-	-	-	-	-	-	-
Attachment avoidance	-	-	-	-	-	-	-	-
Relationship satisfaction	-	-	-	-	-	-	-	-
Relationship duration (month)								

In addition to session level differences, bivariate analyses were conducted to examine the cases in which the speakers' mean values were more similar to each other in the second part of the session. If conversation partners convergence their speech features in time, two halves of F0 distances would be expected to be significantly different. To examine this, paired-sample t test analyses were conducted to compare the two halves of the each conversation. Specifically, each individual's F0 series were divided into two equal parts and mean F0 values were obtained for each half. Paired sample t-test yielded that stranger pairs became convergent in the second part of the conversation ($t\ (11) = 2.90$, $p < 0.01$) but not close partners ($t\ (11)$=0.29, *ns*). Specifically, the distance between stranger pairs' F0 value became significantly closer in the second half of the conversation ($M_{1st\ half} = 105.51$; $M_{2nd\ half} = 99.63$).

However, there was no significant difference between the two halves of close partners' conversation ($M_{1st\ half} = 104.60;\ M_{2nd\ half} = 103.75$, *respectively*).

In sum, ANOVAs yielded only sex differences in session level mean F0 values. As expected, female participants had higher F0 values than male participants. However, mean F0 values of close partner and stranger partner conversations did not significantly differ. Moreover, paired sample t-test analyses showed that close and stranger partner conversations had different patterns. Stranger partners converged their mean F0 values in time, whereas there was no evidence for convergence among close partner conversations, indicating that they had different speech pattern in their conversations. In other words, close partners might have already converged their vocal features and thus two halves of their F0 responses did not vary. Thus, additional bivariate correlation analyses were run to investigate session level data.

6.5.1.2. Correlations between F0 series: The associations between speech features among romantic and stranger partners

Bivariate correlation analyses were conducted to examine association between two time-series of data consisted of F0 values. To do this, cross-correlations between F0 series at the session level, referring F0 levels of each speaker without separating into turns were estimated. Cross-correlation function (CCF) was run for the each conversation pair (N=24) to test the correlation between two voice waves. Table 2 depicts correlations between time-series of F0 values at session level. As explained in the procedure section, two couples (4 participants) were invited into the sessions at the same time. In Table 2, correlations between romantic partners were highlighted in grey. For instance, considering subject IDs 101 and 102 as an example for making the interpretation of the Table easier, 101F-101M and 102F-102M were romantic partners. The correlations between their F0 values were .22 for romantic couple 101F-101M and .18 for romantic couple 102F-102M. Later, for stranger partner condition, the two couples were mixed such that 101M was matched with 102F, and 101F was matched with 102M. Their bivariate correlation was .06 for 101M-102F couple and .02 for 102M-101F couple. Other correlations should be interpreted in this way. The average correlation coefficient was also computed for close partners (r=0.25) and stranger pairs (r=0.07).

Table 2. Spectrogram correlation coefficients for each dyad's conversation

	101 F	**102 F**	**103 F**	**104 F**	**105 F**	**106 F**	**107 F**	**108 F**	**109 F**	**110 F**	**111 F**	**112 F**
101 M	0.22	0.06										
102 M	0.02	0.18										
103 M			0.25	0.10								
104 M			0.07	0.21								
105 M					0.32	0.05						
106 M					0.12	0.23						
107 M							0.36	0.02				
108 M							0.03	0.19				
109 M									0.27	0.04		
110 M									0.12	0.34		
111 M											0.25	0.08
112 M											0.10	0.20
Mean Close Relationships	0.25											
Mean Stranger Pairs	0.07											

M. Male Participant; F. Female Participant
Note: Diagonals represent the correlations between romantic partners.

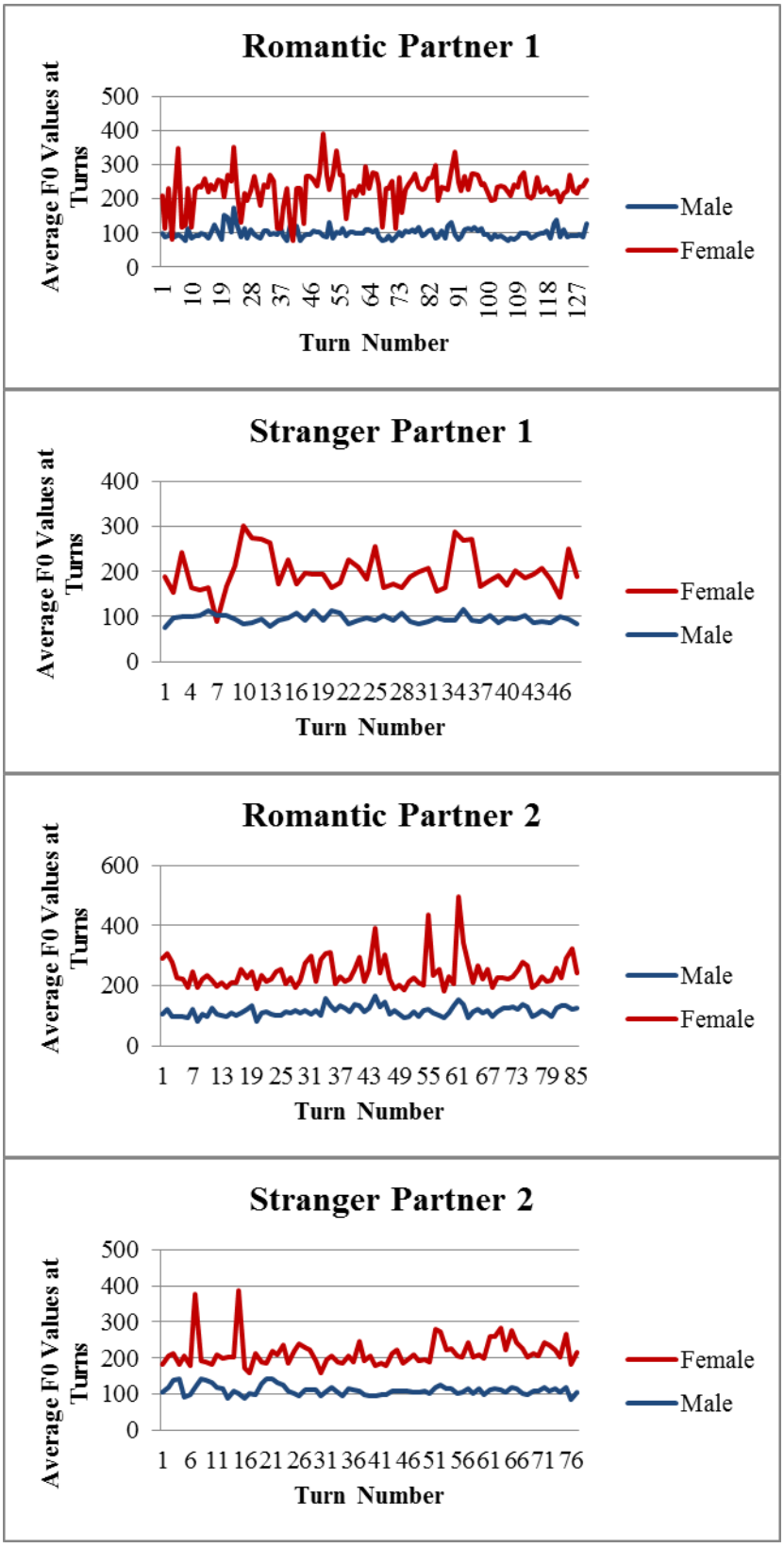
Although the magnitude of the correlation coefficients for close partners were relatively higher than the stranger pairs, Fisher's r-to-z transformation test yielded no significant differences between stranger pairs and close partner correlation coefficients (z=0.40; p=0.34). Since Fisher's r-to-z transformation is sensitive to sample size (Preacher, 2002), this non-significant difference may be due to the small sample size.

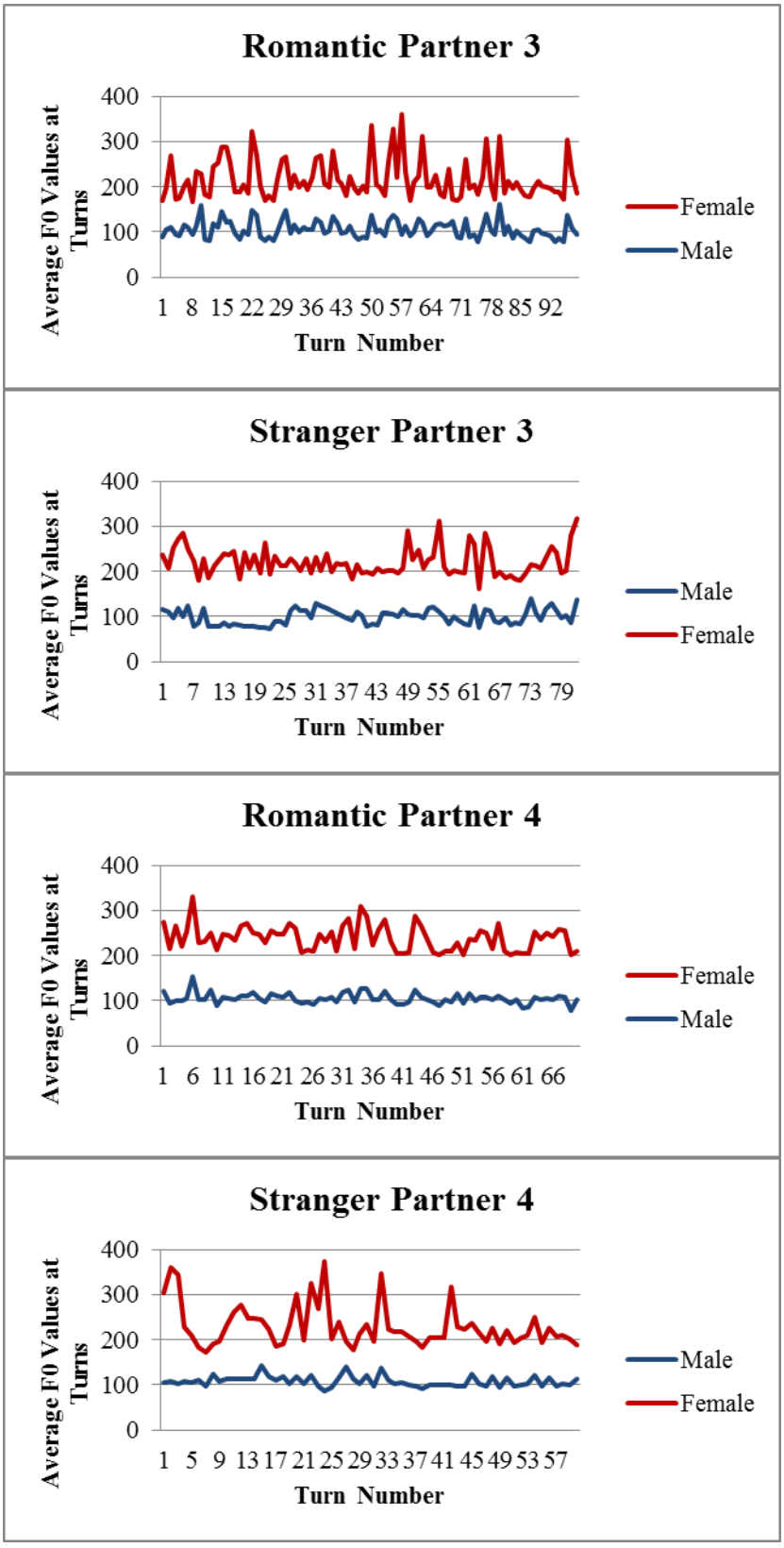
6.5.1.3. Turn-Level Correlation Analysis

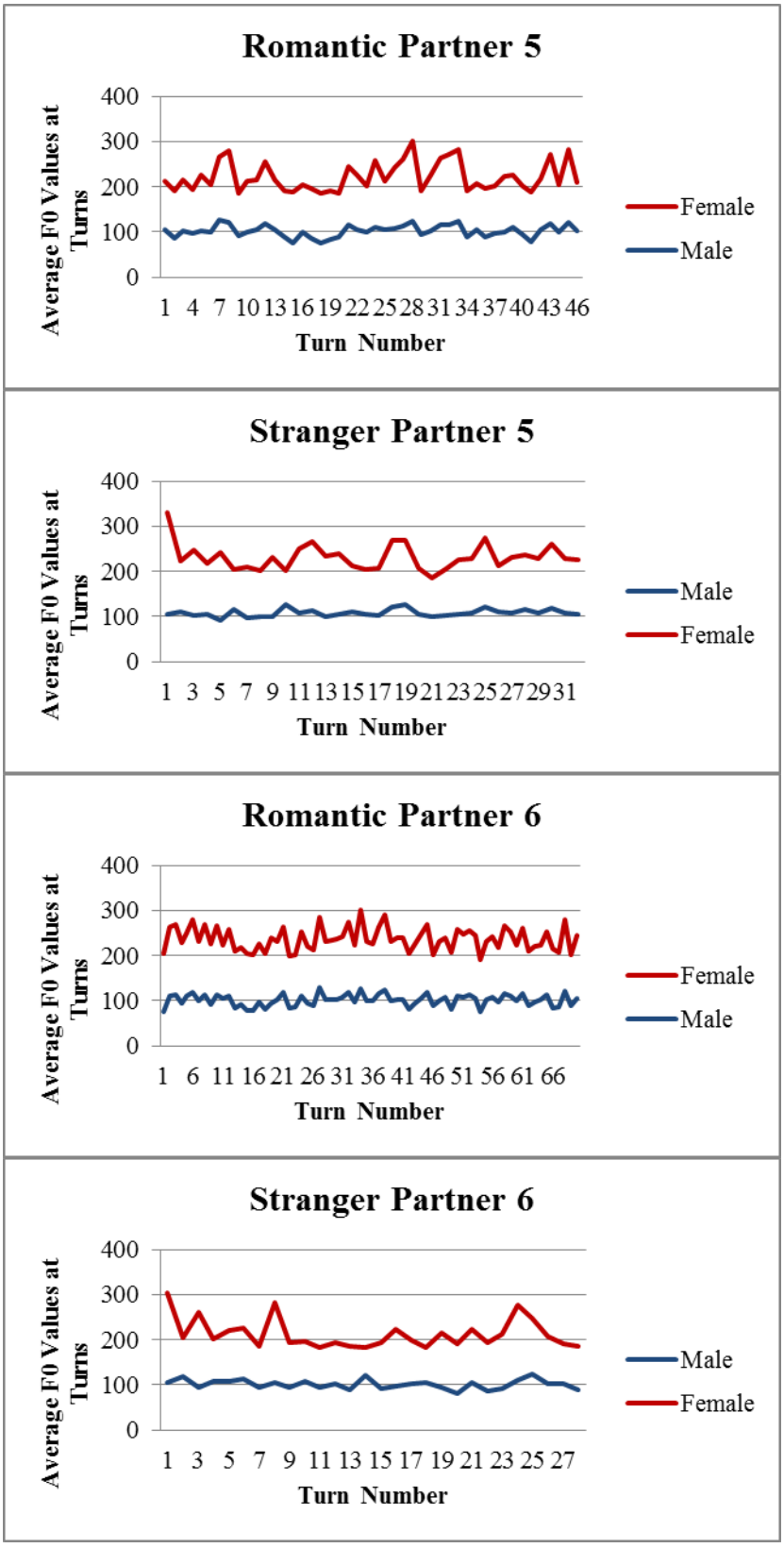
Correlations using *turn level analysis* units were computed. Specifically, F0 series of each participant were extracted for each turn separately (see Data Extraction and Automated Turn-Taking Detection Algorithm section for details) and these within conversation series were correlated later. This analysis aims to assess co-occurrence of partners' vocal activity in time domain. In sum, at this stage, each participant had F0 series and mean F0 values for each turn in conversations with romantic and stranger partner. First, the mean F0 values were plotted (see Figure 6) to visualize the co-occurance of F0 activities, and then, within conversation time-series F0 values were correlated to investigate how close partner and stranger partner F0 values are linked to each other in time domain. For close partner conversation series, 74% of

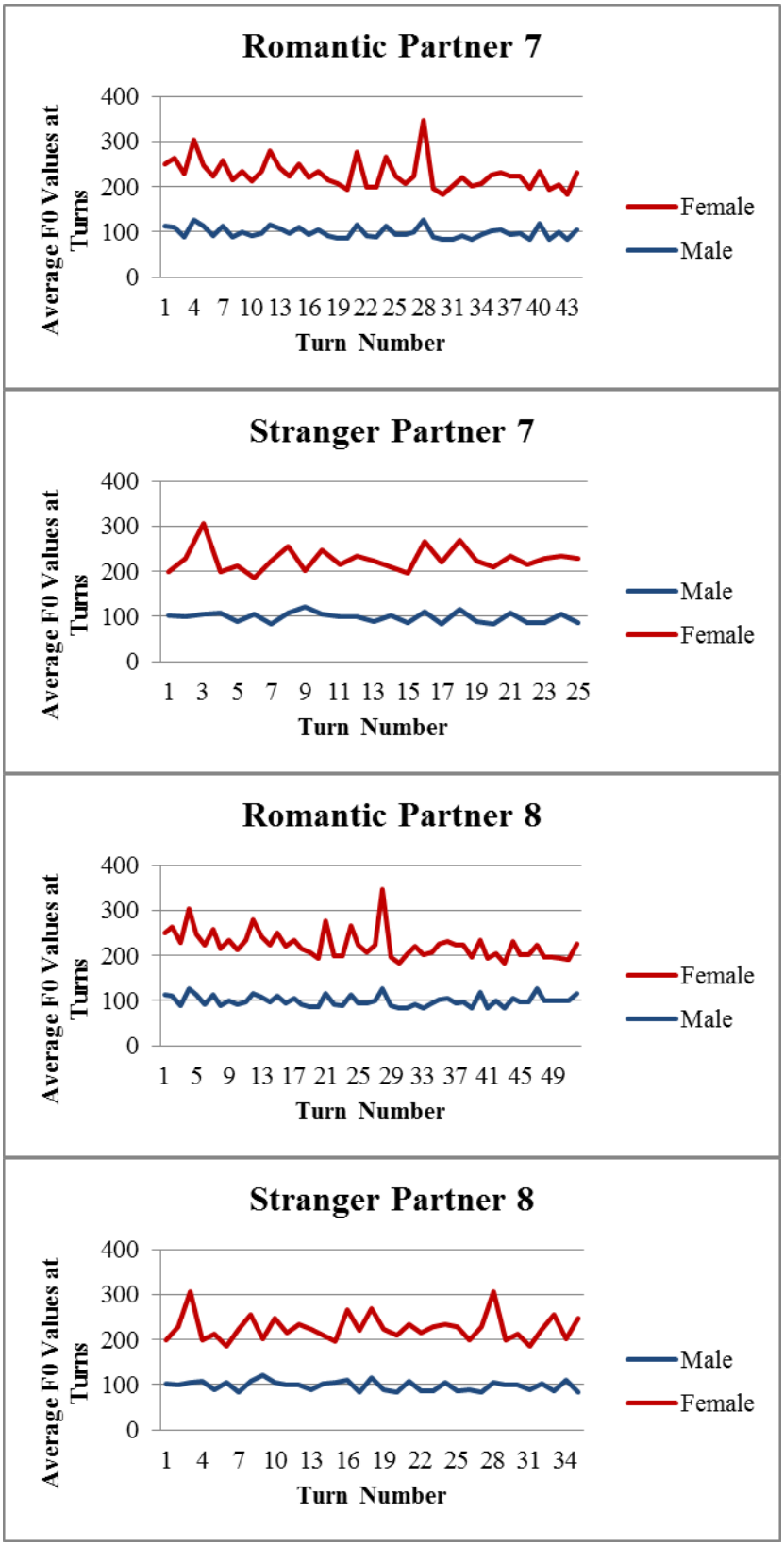
the correlations were significant at the .05 level and above, far more than would be expected by chance. For stranger partner conversation series, there were significant correlations between partners' F0 values. However, the proportion of the significant correlations was low, compared to chance level: 38% of the possible correlations between partners were significant. These turn-by-turn correlation analyses yielded the potential co-variance of F0 values in close partner conversations.

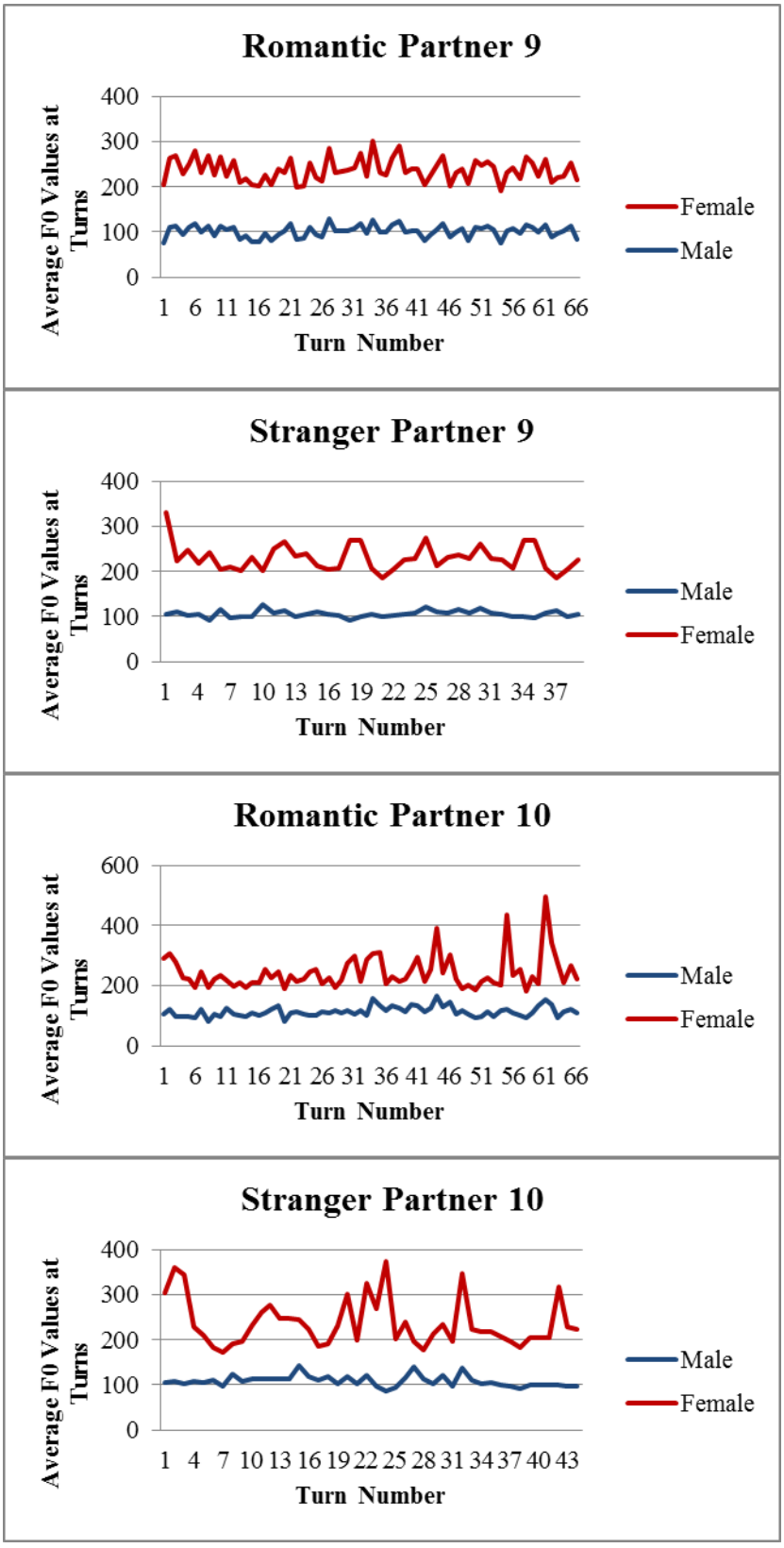
Figure 6. Plotted Averaged F0 values for turn based conversations

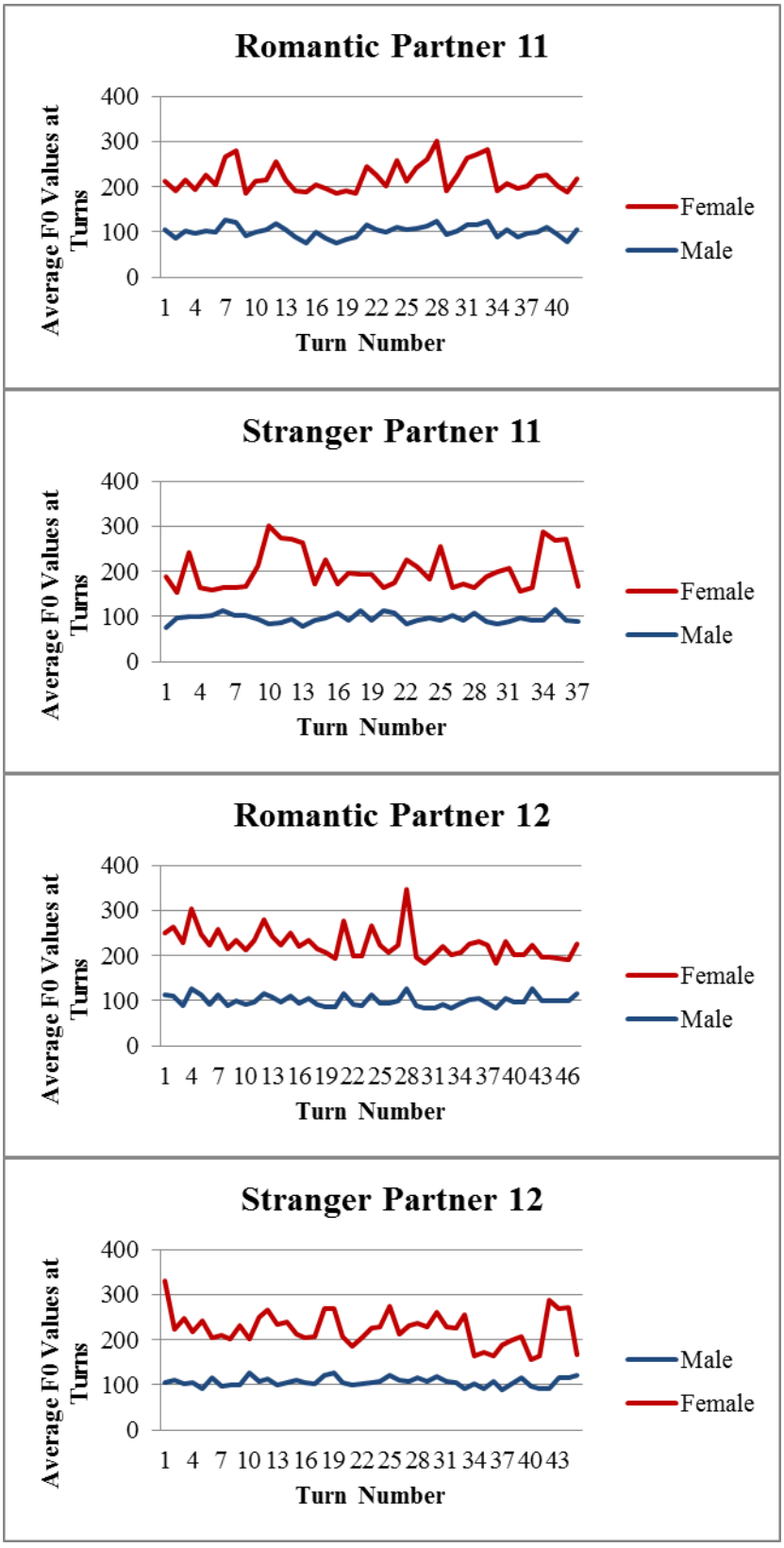



Romantic Partner 3
Average F0 Values at Turns
400
300
200
100
0
1 8 15 22 29 36 43 50 57 64 71 78 85 92
Turn Number
Female
Male
Stranger Partner 3
Average F0 Values at Turns
400
300
200
100
0
1 7 13 19 25 31 37 43 49 55 61 67 73 79
Turn Number
Male
Female
Romantic Partner 4
Average F0 Values at Turns
400
300
200
100
0
1 6 11 16 21 26 31 36 41 46 51 56 61 66
Turn Number
Female
Male
Stranger Partner 4
Average F0 Values at Turns
400
300
200
100
0
1 5 9 13 17 21 25 29 33 37 41 45 49 53 57
Turn Number
Male
Female


Romantic Partner 5
Average F0 Values at Turns
400
300
200
100
0
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46
Turn Number
Female
Male
Stranger Partner 5
Average F0 Values at Turns
400
300
200
100
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31
Turn Number
Male
Female
Romantic Partner 6
Average F0 Values at Turns
400
300
200
100
0
1 6 11 16 21 26 31 36 41 46 51 56 61 66
Turn Number
Female
Male
Stranger Partner 6
Average F0 Values at Turns
400
300
200
100
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27
Turn Number
Male
Female


Romantic Partner 7
Average F0 Values at Turns
400
300
200
100
0
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43
Turn Number
Female
Male
Stranger Partner 7
Average F0 Values at Turns
400
300
200
100
0
1 3 5 7 9 11 13 15 17 19 21 23 25
Turn Number
Male
Female
Romantic Partner 8
Average F0 Values at Turns
400
300
200
100
0
1 5 9 13 17 21 25 29 33 37 41 45 49
Turn Number
Female
Male
Stranger Partner 8
Average F0 Values at Turns
400
300
200
100
0
1 4 7 10 13 16 19 22 25 28 31 34
Turn Number
Male
Female


Romantic Partner 9
Average F0 Values at Turns
400
300
200
100
0
1 6 11 16 21 26 31 36 41 46 51 56 61 66
Turn Number
Female
Male
Stranger Partner 9
Average F0 Values at Turns
400
300
200
100
0
1 4 7 10 13 16 19 22 25 28 31 34 37
Turn Number
Male
Female
Romantic Partner 10
Average F0 Values at Turns
600
400
200
0
1 6 11 16 21 26 31 36 41 46 51 56 61 66
Turn Number
Male
Female
Stranger Partner 10
Average F0 Values at Turns
400
300
200
100
0
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43
Turn Number
Male
Female


Romantic Partner 11
Average F0 Values at Turns
400
300
200
100
0
1 4 7 10 13 16 19 22 25 28 31 34 37 40
Turn Number
Female
Male
Stranger Partner 11
Average F0 Values at Turns
400
300
200
100
0
1 4 7 10 13 16 19 22 25 28 31 34 37
Turn Number
Female
Male
Romantic Partner 12
Average F0 Values at Turns
400
300
200
100
0
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46
Turn Number
Female
Male
Stranger Partner 12
Average F0 Values at Turns
400
300
200
100
0
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43
Turn Number
Male
Female

6.5.2. Granger causality analysis of voice data

Granger causality analyses were conducted on male and female participants' F0 series, reflecting voice activities while speaking with romantic partner and stranger partner separately. Although bivariate correlations show associations between time series of F0 for close partner and stranger partner conversation, Granger causality approach enables us to move beyond the detection of significant causal connections between male and female time series of F0 activity. It allows the examination of the direction of causality for close and stranger partners. Therefore, it can shed new light on the potential mechanisms underlying synchrony: "who affect whom in which direction".

The first step in this analysis concerns the stationary of the female and male participants' F0 series. Granger causality requires that the series have to be covariance stationary, so an Augmented Dickey-Fuller (ADF) test has been calculated by using MATLAB (see Appendix 4). For all of the series (i.e., 48 individual F0 series), the null hypothesis H_0 of non-stationary can be rejected at a 5% confidence level (Brooks, 2008). ADF tests yielded that all the time series of F0 under testing in this study were stationary.

The second step in this analysis concerns producing new F0 series based on the raw F0 series. Because the raw series include residuals and shocks, the number of lags to input in the model was calculated to obtain autocorrelation-free distributions. Since the Granger-causality test is very sensitive to the number of lags (i.e., turns in this case) included in the regression, the Akaike Information Criteria (AIC) have been used in order to find an appropriate number of lags in the each series. In other words, 48 unique time series (i.e., 12 male & female close partners; 12 female & male close partners; 12 male & female stranger partners; and 12 female & male stranger partners) were produced on the basis of ARIMA modeling. Table 3 represents the best model parameters for ARIMA modeling of F0 series. Based on Table 3, for example, F0 series of subject 1 (male speaking with his romantic partner) was produced based on the ARIMA (4,0,1) modeling. Similarly, F0 series of subject 40

(female speaking with stranger male partner) was computed by using ARIMA (2,0,3). The new series for used for further Granger Causality analyses.

Table 3. ARIMA modeling parameter estimates

Subject #		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Male & Close P.	**p**	4	2	3	4	8	2	5	2	1	4	3	2
	d	0	0	1	0	0	0	1	0	1	0	0	0
	q	1	3	4	1	6	3	5	1	8	1	1	6
Subject #		**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Male & Stranger P.	**p**	1	2	3	2	3	3	1	2	2	2	4	2
	d	1	1	1	0	0	0	1	0	0	1	0	0
	q	1	2	5	3	1	1	7	7	1	3	1	1
Subject #		**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**
Female & Close P.	**p**	2	1	2	2	4	7	2	4	2	2	3	2
	d	1	1	0	0	1	1	1	0	0	0	0	1
	q	5	1	1	1	4	2	4	1	1	2	1	3
Subject #		**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**
Female & Stranger P.	**p**	2	1	3	2	3	3	2	2	2	3	2	2
	d	0	1	1	0	0	0	0	0	0	0	0	0
	q	1	7	5	3	1	1	1	1	3	1	6	3

The third step in this analysis concerns matching two series as close partner conversation or stranger partner conversation. For example, subject 1 (Male), as placed in Table 3, was matched with subject 25 (Female) to see whether one of the romantic partners Granger-causes to other participant's responses in F0 domain. This procedure was completed for all other alternatives (24 conversations). After these requirements were satisfied, Granger-causality tests were computed. The results of Granger Causality were presented in Table 4.

Table 4. Testing Granger-causality of F0 series

		Null Hypothesis	F-Statistics	R^2			Null Hypothesis	F-Statistics	R^2
Close Partner	**Pair 1 Obs=5216**	F≠>M	4.58**	.08	**Stranger Partner**	**Pair 13 Obs=3213**	F≠>M	1.09	.02
		M≠>F	3.29*				M≠>F	0.63	
	Pair 2 Obs=5944	F≠>M	6.23**	.12		**Pair 14 Obs=2439**	F≠>M	4.11*	.14
		M≠>F	3.22*				M≠>F	1.51	
	Pair 3 Obs=1930	F≠>M	3.79*	.11		**Pair 15 Obs=3186**	F≠>M	4.99**	.25
		M≠>F	2.36*				M≠>F	0.28	
	Pair 4 Obs=3173	F≠>M	5.75**	.13		**Pair 16 Obs=474**	F≠>M	2.13	.13
		M≠>F	4.19**				M≠>F	0.45	
	Pair 5 Obs=3861	F≠>M	4.01*	.11		**Pair 17 Obs=2955**	F≠>M	4.80**	.28
		M≠>F	3.12*				M≠>F	0.41	
	Pair 6 Obs=3443	F≠>M	0.50	.08		**Pair 18 Obs=980**	F≠>M	3.22*	.11
		M≠>F	1.85				M≠>F	1.18	
	Pair 7 Obs=2202	F≠>M	4.42**	.24		**Pair 19 Obs=1838**	F≠>M	4.53**	.18
		M≠>F	3.71*				M≠>F	1.19	
	Pair 8 Obs=2181	F≠>M	4.14*	.11		**Pair 20 Obs=836**	F≠>M	3.44*	.22
		M≠>F	2.57*				M≠>F	0.39	
	Pair 9 Obs=3073	F≠>M	2.55*	.19		**Pair 21 Obs=2778**	F≠>M	2.96†	.19
		M≠>F	4.14*				M≠>F	1.01	
	Pair 10 Obs=2433	F≠>M	6.17**	.13		**Pair 22 Obs=1027**	F≠>M	5.03**	.11
		M≠>F	3.78*				M≠>F	1.15	
	Pair 11 Obs=1813	F≠>M	4.19**	.26		**Pair 23 Obs=873**	F≠>M	4.77*	.29
		M≠>F	4.67**				M≠>F	0.98	
	Pair 12 Obs=3423	F≠>M	2.54*	.21		**Pair 24 Obs=1217**	F≠>M	3.52*	.16
		M≠>F	3.21*				M≠>F	1.89	
			Mean R^2	**.15**				**Mean R^2**	**.17**

** p < .01; * p < .05; † p < .07

Obs = Number of observation in F0 time series

Granger causality analyses yielded significant results on co-occurrence of F0 activity of romantic couples, except for only one conversation highlighted in grey. Accordingly, the values of F statistic suggest that female F0 Granger-causes male F0, and similarly, male F0 Granger-causes female F0, correspondingly (see Table 4). In other words, there was ***bidirectionality*** among romantic partners in terms of their F0 activity (*Average* R^2 = .15). Specifically, past values of female voice contributed to the prediction of the present value of male voice even when past values of male own F0 values were controlled for. Similarly, past values of male voice also contributed to the estimation of the present value of female voice even when the previous values of female own F0 values were taken into account. As previous work on EEG signals

using Granger-causality analysis suggested (e.g., Barrett, et al., 2012), bidirectionality in Granger-causality possibly indicates a cyclical process and based on this argument, these findings suggest synchronous patterns between close partner conversations.

As in the case of romantic partners' analyses, two hypotheses were tested for stranger partner conversations: (a) whether there is causality from earlier male F0 to later female F0, and (b) whether there is causality from earlier female F0 to later male F0. Contrary to the findings of romantic partners, Granger-causality analyses for the stranger partner conversations yielded a different pattern. There was only a significant causality from earlier female F0s to later male F0s (except for two cases highlighted in grey) (*Average* R^2 = .17). In other words, stranger female participants' earlier F0 Granger-caused stranger male participants' subsequent F0 values in their conversations. There was no Granger-causality from past values of male F0 to future values of female F0. In short, there was Granger-causality from female to male only in stranger partner conversations indicating that female participants' previous F0 responses influenced male participants' F0 responses subsequently. However, male participants' F0 responses had no impact on female participants' subsequent F0 responses.

Consistent with the results of bivariate correlation analyses, Granger-causality analyses signified that romantic partners, but not stranger dyads, influence each other's speech features synchronically. This approach enables us to move beyond the simple correlations between close partner and stranger dyad voice activity in a conversation and to investigate how partner's previous F0 activity and individual's previous own voice features have been connected. As a result, in conversation with close partner, individuals' F0 level has been influenced by their romantic partners' previous voice features in cyclical process. In contrast, different from close partner conversations, stranger male participants' F0 level were affected by a stranger female conversation partner, but female participants' F0 level was not affected by stranger male participants' previous F0 values. In other words, this pattern suggests a convergence of male stranger participants toward female stranger participants.

Although this analysis provided information regarding turn-based synchrony, it does not allow examining potential moderators influencing synchrony process. The most efficient way to model partners' F0 level in conversation is to utilize dyadic multilevel modeling in which within-couple speech features (i.e., F0 values in time domain) and gender Level 1 and between-couple variables (i.e., covariates) are modeled in Level 2 (Laurenceau & Bolger, 2005). Conducting dyadic data analysis of F0 synchrony requires both spouses' F0 time-series in conversation with either close partner or stranger partner (see Barnett, Marshall, Raudenbush, & Brennan, 1993 for similar procedure in dyadic HLM).

6.5.3. Dyadic HLM: Testing potential moderators in coregulation

In order to examine the within-dyad level (i.e., participant's sex and relationship type) and between-dyad predictors (i.e., attachment anxiety, avoidance, and relationship satisfaction) of F0 variability (F0V) in each turn, a HLM analysis, taking into account the hierarchically organized nature of the conversation data, was conducted. A two-level model was used in which within-dyad variables entered at the Level 1 and between-dyads variables at Level 2. At level 1, participants' sex and relationship status (romantic vs. stranger partner) were dummy coded in the equation. Model estimation followed the guidelines set forth by Raudenbush, Brennan, and Barnett (1995) using HLM 7.0. The restricted maximum likelihood estimation method was used in the analysis. Level 1 random intercepts (fixed slopes) were estimated in the model due to the different baseline values in F0 and F0V scores among females and males. All variables were also group centered.

6.5.3.1. Predicting F0 variability at within- and between-dyad levels

Previous work on prosody indicated that higher F0 variability associated with asynchronous communication (LaGasse, Neal, & Lesser, 2005). To examine within and between dyad differences in F0 variability, a HLM analysis was conducted. A fully unconditional model was first estimated to determine whether the variability in F0 was significantly different from zero (e.g., model fit). The model was significant, $\chi^2(6, N=48) = 251.70$, $p < .001$, with 19% of the variance in F0 variability (ICC = 0.19), indicating that HLM was warranted. To test the question of whether

relationship status and participants' sex predict variability in F0, a Level 1 model was specified, whereby dummy coded sex and relationship status were entered as within-dyad predictor. No evidence of multicollinearity was observed (Mean VIF = 2.24).

For the Level 1 model, as can be seen in Table 5, participants' sex and relationship-type were significant predictors of F0 variability in turn-based conversations indicating that female participants had higher F0 variability and romantic partners showed lower F0 variability in each turn. These results support the idea that individuals speaking with their partners show lower rates of F0 variability indicating morphostatic (stable) pattern in communication. As mentioned in the introduction, morphostatic pattern refers to coordinated variation of psychological and biological systems that optimize performance and minimize costs (Sterling, 2003). Level 1 model suggested that this coordination was observed in vocal cues at each turn for close partner conversations. Overall, this model explained 19% of the F0 variability; a case indicating that there was still considerable variation in the intercept to be explained. So, Level 2 predictors were entered into the model.

Table 5. Hierarchical linear modeling results predicting F0V in turn-based conversations

	F0 Variability at Turns			
	Coefficient	df	SE	t-ratio
Level 1: Within Dyads				
Intercept	3.39***	1139	0.75	4.50
Sex (*1 = Male*)	0.82***	1139	0.09	9.48
Relationship Status (*1 = Romantic*)	-0.19**	1139	0.08	2.62
Level 2: Between Couples				
Relationship Duration	-0.01	43	0.07	1.21
Attachment Anxiety	0.17*	43	0.04	2.01
Attachment Avoidance	-0.13	43	0.09	-1.57
Relationship Satisfaction	-0.18*	43	0.08	-2.10
Random Effects	*Variance*	χ^2		
τ (Between Couples)	0.07	251.70***		
σ^2 (Within Dyads)	0.30			

*p < .05; **p < .01; ***p < .001

Level 2 model aimed to examine potential moderators in prediction F0 variability at each turn in the conversations and the model included between-dyad variables: attachment anxiety, avoidance, and relationship satisfaction. Besides, as a potential covariate, relationship duration was also added to the Level 2 model. As seen in Table 5, relationship duration did not significantly contribute to the F0 variability at each turn. However, attachment anxiety and relationship satisfaction predicted F0 variability in turn-based conversations in the opposite directions. Accordingly, attachment related anxiety positively predicted F0 variability in each turn, indicating that as the level of attachment related anxiety increased, the more asynchrony were experienced. Relationship satisfaction negatively predicted F0 variability in turn-based close partner conversation, suggesting that higher relationship satisfaction predicted lower asynchronous communication with the partner (see Table 4 for coefficients).

In sum, the results of the dyadic HLM analysis yielded that individuals speaking with their romantic partner showed lower rate of F0 variability in each turn, compared to individuals speaking with s stranger partner. Participants' sex was also significant predictor of F0V in conversations, meaning that female participants showed higher rate of F0 variability in turns than male participants. Level 2 model yielded significant between-dyad effects of attachment anxiety and relationship satisfaction in predicting F0V in conversations.

Overall, Study 1 examined whether coregulation process could be observed via vocal cues in conversations and whether the individual and couple level variables influence this process. Session level analyses yielded that stranger partner conversations had characteristically different pattern than close partner conversations. Specifically, whereas stranger partners converged their conversations in the second half of their exchange, close partner vocal cues did not converge rather their vocal features indexed by mean F0 were continuously correlated through the conversation. Turn level analyses aiming to examine cross-partner associations of vocal cues at each turn showed that there were bidirectional associations between close partner F0 responses. Moreover, there were unidirectional associations between stranger partner F0 responses in conversations. Specifically, regardless of sex, individuals' previous

F0 responses had an effect on their close partners' subsequent F0 responses. However, it was only female participants who influenced stranger male participants' subsequent F0 responses implying that romantic and stranger partner conversation had divergent patterns even in such a neutral context.

6.6. Discussion

Study 1provided evidence for a previously unexamined form of coregulation in adult attachment relationships: vocal synchrony in a short period of neutral conversation. As a new perspective, one of the important features of speech was assessed in dyadic conversations and the question of how F0 covaries between partners during conversation episodes was examined. Previous work on prosody indicated that F0 conveys emotional changes and can be used as a reliable marker of physiological responses to emotional cases (Scherer, 2005). Thus, to observe both within individual changes and between partners in a covariation, F0 and its variations were selected as an indicator of interpersonal coregulation. The data were analyzed by using multiple conversation parameters (i.e., session level analyses), and separated into meaningful linguistic components (i.e., turn-level analyses) (see Levitan & Hirschberg, 2011, for a similar analytic strategy). Next, it will be discussed how the present findings contribute to an understanding of coregulation patterns within couples, and how coregulation patterns can be moderated by different variables.

6.1. Descriptive statistics and bivariate analyses

A majority of the research on emotional coregulation or synchrony has been conducted in early development (e.g. Feldman, 2003; Field, 1994). In this work, vocal markers of coregulation in romantic relationships were examined. This research basically suggested that female and male adult partners had different levels of F0 values in speaking with their close romantic partners and stranger partners. This finding is consistent with the sex differences in F0 due to the anatomical differences in vocal folds. As mentioned before, men robustly have a lower F0 than women (Titze, 1989).

Separate ANOVA analyses indicated that turn taking behaviors were more frequent in close partner conversations than the stranger partner condition. Moreover, as would be expected, individuals spoke with their romantic partners longer than stranger

partner since they have common bases, shared experiences etc. to engage in a longer duration of talk.

Analyses showed that mean F0 values in stranger partner conversation, but not close partner conversation became convergent in the second part. Specifically, the distance between stranger pairs' F0 values was significantly closer in the second half of the conversation. This finding was consistent with the prediction of communication accommodation theory indicating that people have a tendency to converge their features of speech such as the use of paralanguage, pronunciation, pause and utterance lengths, vocal intensities, nonverbal behaviors, and intimacy of self-disclosures (Giles & Ogay, 2007). Another explanation about why stranger partners converged their F0 responses in the second half of the conversation can be explained by Chartland and Bargh's (1999) finding about the perception-behavior link. They suggested that the act of observing another's behavior increases the likelihood of the observer's engaging in that behavior in time. Thus, convergence between the strangers' talk in the second half of their conversation can be interpreted as a tendency to mimic conversation partner.

Butler (2011) reported that there are different ways in which partners' emotions can be synchronous and it can be produced either an in-phase (changes in similar directions or positive correlation) or anti-phase (changes in opposite directions or negative correlation) pattern. In this vein, the results of the correlation analyses suggested that intimate partners produced in-phase pattern of synchrony. The changes in F0 responses were similar and positively correlated. According to Butler (2011), one of the specific forms emotional coordination can be morphostatic pattern, in which an individual's emotions at one time are used to predict their partner's emotions at a later time, while controlling for the first individual's prior emotions. This form of coordination, in which partner's emotions vary concurrently, was assessed as synchrony or coregulation indicator in this study. Supporting this, initially, session level cross-correlations were computed for two series. Although Fisher's r-to-z transformation test yielded no significant differences between mean of stranger pairs and close partner correlation coefficients (z=0.40; p=0.34), this nonsignificant difference seems to stem from the small sample size for this analysis.

However, as seen Table 2, there were significant positive cross-correlations among close partner pairs, but not stranger pairs. These results cannot show causality or bidirectionality which is indicator of synchronous F0 responses. Granger-causality analyses provided further understandings about the nature of communication patterns of interaction partners.

6.2. Granger causality analysis of voice data: Cyclic and unidirectional effects

Granger-causality analyses yielded that close partner F0 responses were bidirectional. In other words, in close partner conversation, previous female F0 responses cause to subsequent male F0 responses and vice versa (see Table 4). However, Granger-causality analyses for stranger partner conversations yielded unidirectional relationships between male and female partners. Accordingly, only female F0 responses lead to subsequent male F0 responses, but male participants did not lead to female participants. To interpret these findings, it is important to keep in mind that bidirectional relationships in close partner F0 responses implicitly refer to coregulation process. A majority of past studies on emotional coordination or synchrony between romantic partners have shown that partners' emotions are positively correlated – their emotions change in unison (in-phase coordination) (e.g., Butner et al., 2007; Saxbe & Repetti, 2010; Schoebi, 2008). The concept of synchrony or coregulation possesses have critical implications in understanding the underlying mechanisms of attachment formation. As shown in previous work (e.g., Reite & Field, 1985; Jaffe et al., 2001), infants and their mothers show considerable coherence in responses (attunement) at both biological (e.g., heart rate synchrony) and behavioral levels (e.g., vocal synchrony) within the attachment relationship. Researchers have suggested that romantic partners may serve similar regulatory function (Sbarra & Hazan, 2008). Once attachment is formed between romantic partners, their physiological and behavioral systems are synchronized to each other and their relationship provides regulatory source to each individual. From this perspective, synchronized systems support partners' psychological and physiological homeostatic set-point from which they can function effectively (Sbarra & Hazan, 2008). Similarly, the manifestation of these synchronized systems may be parallel with infant-mother studies: reciprocal associations of behavioral or physiological

systems. The findings of reciprocal influences of close partners in conversation are consistent with this idea. In the conversation, partners showed reciprocal responses at vocal level and this bidirectionality may be due to their attuned prosody over time.

The finding on the bidirectional associations of F0 responses between romantic partners also highlights the differences between coregulation and stress buffering function of attachment relationships. Coregulation is a defining feature of normative attachment, whereas stress buffering is a necessary but not a sufficient element of clear-cut attachment relationship (Sbarra & Hazan, 2008). Stress buffering has been described as a unidirectional mechanism whereby one partner down-regulates the other partner's stress reactivity. Coregulation, however, is a bidirectional mechanism whereby both partners influence each other's physiological and psychological states (Selcuk, Zayas, & Hazan, 2010) as what Granger-causality analyses showed. Therefore, synchrony in F0 responses indexing coregulation can be seen as a vocal marker of attachment relationships.

Another important finding from Granger-causality analyses is that previous F0 responses of female participants leads to subsequent F0 responses of males in stranger partner conversation. Different from close partner conversation, F0 responses are unidirectional in stranger partner conversation. In other words, male participants seem to mimic female participants in terms of the F0 responses. This finding has two important implications. First, individuals seem to have a sustained synchrony with their close partner but not stranger partners. Second, only men, but not women initiating a conversation with the opposite sex stranger partners have a tendency to mimic their vocalizations with the female partner.

The observed sex difference seems to be inconsistent with the previous work in communication accommodation. For example, Stupka (2011) showed that female participants accommodate their speech style more frequently than male participants. Accommodation was calculated using the incidence of the conversational indicators. In that study, individual accommodation was determined via the adherence to or deviation from gender stereotypical indicators including verbal content of communication. This finding suggests sex differences in vocal accommodation might be due to social or affiliative motives during social interactions. Sex differences in

social experience and social reinforcement render women more sensitive to verbal content in vocal communication than men. However, Stupka's (2011) study did not focus on the voice related features such as intonation or vocalizations. Most of the previous research has focused on the role of deliberative and conscious processes on conversation style and has implicitly or explicitly assumed that such communication strategies are driven by deliberative processes (e.g., Cohen, 2009; Namy, Nygaard, & Sauerteig, 2002). Investigating accommodation using relatively unconscious cues, such as physiologically moderated cues may provide different information about mating behaviors of males and females. Consistently, previous research focusing on the impact of relationship status on mimicking (i.e., face rubbing) opposite sex indicated that male participants showed more mimicry than female participants (Karremans & Verwijmeren, 2008). It should be noted that these results were obtained for participants who had romantic relationship currently. Similar to Karremans and Verwijmeren's (2008) study, the results of the current study indicated that male participants converge their voice features to stranger female participants' rhythms.

The present finding about female leads male F0 responses also partially consistent with evolutionary perspective which suggests that male of various species change their behavior if they try to find or keep a mate. This can be manifested in different ways: males can align their non-linguistic behaviors such as intonation with the members of opposite sex for the sake of their mating goals (Pickering & Garrod, 2004). For example, Coyle and Kaschak (2012) showed that male participants had a tendency to mimic female participants' sentence structure which is unintentional changes in language usage however; female participants do not adopt linguistic behavior of male participants. In parallel with this study results, male participants had a tendency to mimic vocal features of both intimate and stranger female partners. However, female participants were only affected by their close partners.

6.3. The impact of attachment anxiety, avoidance, and relationship satisfaction on vocal synchrony

One of the critical contributions of this study to the current research on close relationship is that vocal synchrony has been shown to be associated chronic

attachment anxiety and relations satisfaction. Specifically, results revealed that attachment related anxiety and relationship satisfaction moderated the form of synchrony, suggesting that the vocal cues can be used as a marker of attachment (in)security and relationship satisfaction. Individuals' F0 responses varied as a function of their attachment-anxiety (but not avoidance) and relationship satisfaction in conversations. Specifically, higher attachment anxiety was associated decreased synchrony in turn-by-turn conversation as indicated by increased F0 variability in neutral conversations. This finding is partially consistent with the findings of Butner, Diamond, and Hicks's (2007) study showing that high anxious partners have the lowest level of coordination in negative affect states. Overall, majority of the previous studies have demonstrated that attachment anxiety and avoidance are linked with low levels positive emotions and high levels of negative emotions (e.g., Feeney, 1999; Simpson, 1990). Attachment anxiety may involve being hypervigilant in terms of proximity seeking and need for reassurance. It would be the "fight" activation in the fight-or-flight analogy. This reflects high attachment anxiety-ambivalence, and is categorized by intense self-focus, clinginess, and overall hyperactivation of the attachment system (Mikulincer & Shaver, 2003). Due to the intense self-focus and clinginess, individuals with high attachment anxiety may not follow the partner's vocal cues and in turn, they might miss prosodic cues even in neutral conversations.

It is also notable that attachment avoidance has not an impact on variability in F0 while speaking with intimate partner, such that changes in F0 responses did not function of attachment avoidance. Although this finding seem to be inconsistent with the previous result indicating that attachment avoidance is associated with increased negative affect covariation with partner (Butner, Diamond, & Hicks, 2007), this study showed that attachment avoidance is not related with vocal synchrony. Given that this study examined the vocal synchrony in neutral states only, attachment avoidance may not have any effect under non-distressed neutral context. Besides, this result seem to be partially inconsistent with a pattern of emotional deactivation, in which avoidant individuals pay disproportionately low attention to a partner's affective cues (Mikulincer & Shaver, 2003). Attachment avoidance characterized by deactivation strategies and it is described by being distant for social support and self-isolation in response to distress or partner demands instead of seeking outside help,

assurance or caregiving. It is similar to the "flight" activation in the fight-or-flight analogy. High attachment avoidance is associated with avoiding expressing one's emotions and having strained interpersonal relationships, especially romantic relationships (Mikulincer & Shaver, 2007). Future studies should examine if vocal synchrony of those avoidance and anxious attachment orientations change under stressful or conflictual communications.

Results showed that higher relationship satisfaction was linked with decreased F0 variability suggesting that the more satisfaction couple perceived, the more synchrony with close partner performed in conversation. Conversely, Saxbe and Repetti (2010) investigated the role of marital satisfaction on synchrony and they found negative associations between the covariation in cortisol levels and relationship satisfaction. Recently, Liu, Rovine, Klein, and Almedia (2013) also showed a negative relationship between the covariation is physiological systems and satisfaction. These results have been explained with two possible mechanisms: high marital satisfaction may be protective factor for the transmission of negative physiological stimulus or couples who are more satisfied in their relationships may be less influenced by fluctuations in physiological systems than couples who are less satisfied (Selcuk, Zayas, & Hazan, 2010).

Although this line of research finding seems to be inconsistent with the results of the Study 1, there are differences in stimulus under regulating (i.e., neutral conversation, not negative or positive affect regulation) and covariation level (i.e., F0 variability not physiological fluctuations). In interpreting the findings of the Study 1, it is important to remember that the synchrony detected coordinated patterns in neutral context, not positive or negative affect states. Accordingly, couples who are high in satisfaction may successfully coordinate their F0 responses in neutral context. Alternatively, partners who successfully coordinate their vocal features may feel more satisfied in their relationships.

6.4. Implications and limitations

The findings of this dissertation hold several important implications for relationship researchers and clinicians who work with romantic couples. First of all, Study 1

offers a new methodology to extend previous literature on interconnectedness of physiological systems by using vocal markers. It was proposed that using vocal cues can be used in examining cross-partner associations at behavioral level. Based on the linguistic alignment and prosody research, it was assumed that physiological states directly influence voice features such as F0 and F0 variability. To show bidirectional, cyclic relationship in vocal responses, a series of statistical modeling were used and results provided information regarding vocal responses can be used as one of the reliable markers of coregulation and this coregulation process is moderated by attachment anxiety and relationship satisfaction. Because this is the first empirical examination of vocal synchrony within romantic partners, it is difficult to offer firm conclusions about their implications for couple functioning but this research direction is promising regarding reliable markers of attachment relationships using vocal features.

Results from Study 1 also provide further evidence for the need to understand how intrapersonal perspectives on vocal synchrony need to be understood in the context of an interpersonal system (for an additional review see Butler, 2011). As we know from existing research, emotions between partners become linked over time (Butler, 2011), and this dissertation sheds light on when this can occur and under what conditions. Specifically, this work suggests that different emotional patterns may be occurring for close and stranger partners. Taken together, understanding *how* partners engage in emotional connectedness, and when this occurs, provides us with a unique perspective of the role of interpersonal processes in emotional coordination, and ultimately, normative attachment processes.

Future research should employ more sophisticated research design to better understand the underlying mechanisms in vocal behaviors by examining different types of conversation contents, such as the discussion of problematic or conflictual relationship issues that may elicit negative affect or happy memories promoting positive affect. Couples may show divergent vocal patterns in the conversations under negative or positive moods. Testing such processes can help generalize the idea of vocal markers of coregulation and their implications for couple functioning in different settings including friendship and coworkers. Second, further studies should

also compare physiological responses and vocal behaviors concurrently during the couple interactions. Thus, the correlates or multiple indicators of vocal behaviors as markers of coregulation can be systematically investigated. Besides, observing synchrony in the other communication parameters, such as facial cues, body movements or posture can be very informative to better understand the normative attachment behaviors at multiple levels and the process of attachment-in-the-making in adult relationships. Third, longitudinal analyses including the critical stages of a romatic relationship is neccasery in the future studies to understand when and how coregulation emerges. Finally, the results documented in the current study should be extended and tested in different cultural settings which may have specific communication patters.

CHAPTER 7

STUDY 2

Study 1 aimed to measure coregulation between close partners using vocal cues reflecting F0 and F0 variability. Turn base conversations indicated that whereas unidirectionality was the characteristic of stranger partner conversations (i.e., male participants were getting converged to female participants), bidirectionality in the speech features was the characteristic of close partners, However, Study 1 did not answer the question of whether a third person could accurately estimate close partner conversation from the intonation or vocalization. Limited research showed that when people talk to various people, their words, rhythms, and other vocal features combine to form a sort of speech that is easily identifiable by others who are listening (Montepare & Vega, 1988). For example, Montepare and Vega (1988) found that participants listening only to one end of a conversation of woman talking to a man can tell from just a few seconds of woman's speech whether the man is a casual or intimate friend. Similarly, young women's telephone conversations with their grandparents were successfully discriminated from conversations with their parents by a third person (Montepare, Steinberg, & Rosenberg, 1992). This work emphasized that verbal content might differ based on whether a participants talked to a close or stranger partner. However, the differences in intonation without verbal content have not been investigated up to now.

Study 2 aimed to examine the discriminability of the affectionate components of conversations with close partner. Following Dehaene-Lambertz and Houston's (1997) procedure, 1-min episodes from conversation were extracted and voice records were low-passed filtered, which reduces the some properties of speech but retains the prosodic properties. In other words, listeners could hear only intonation and vocalizations from 1-min conversation episodes after low-pass filtering applied to the voice records. The 24 pairs of conversations were run through a digitized low-

pass filter which removed all frequencies above 400 Hz (Butterworth filter) by using PRAAT (Boersma & Weenink, 2013). The verbal content was not identifiable after low-pass filtering applied (see Dehaene-Lambertz & Houston, 1997 for detailed information). After stimuli for the Study 2 was prepared, data were analyzed by using Signal Detection Theory.

7.1. Methods

7.1.1. Participants

Experiment tasks were posted to the Amazon Mechanical Turk (MTurk) and participants were requested to complete the given tasks following the instructions step by step. One hundred fifty six participants were recruited for the study (M_{age}=34.75 yrs, SD=13.06). The 24 pairs of conversations used in Study 1 were uploaded to Qualtrics, a web-based tool for building and conducting surveys. Fifty one males and 105 females completed the task. Relationship status varied, with about half (n=79) having a romantic partner. They were paid $0.5 as compensation.

7.1.2. Procedure and Task

One-minute length segments were extracted from each conversation and pass-filtered to prevent awareness of the content of conversation. One-minute segments were chosen from the second part of the conversation because Study 1 findings revealed that the distance between stranger pairs' F0 value became significantly closer in the second half of the conversation. In other words, to eliminate apparent cues of stranger partner conversation, we selected one-minute segments from the second part of every conversation. Participants were asked to listen to these recordings from the beginning to the end and then to guess whether the pair of speakers are romantic partners or strangers in a balanced order. After listening to each vocalization, participants were asked to respond to a series of questions regarding the reason they choose that option and the degree of confidence in their choice.

7.2. Data analytic strategy: Signal detection theory

We measured classification accuracy using A-prime score (Stanislaw & Todorov, 1999), a nonparametric measure of signal sensitivity. A' measures sensitivity in

categorizing vocalizations as romantic partner or stranger pairs. A′ is interpreted on a probability scale, with chance responding indexed by an A' of .5; accordingly, A′ may be interpreted as a bias-adjusted accuracy score. A' scores were computed for each participant. We conducted the same analysis using d' (a parametric index of signal detection) as the dependent measure; the results were unchanged (for detailed discussion on A' and d' see Stanislaw & Todorov, 1999). In signal detection analyses (e.g., the computation of A' or d'), there are two components of accuracy: the hit rate, or the proportion of close partner vocalizations correctly classified as romantic parnter, and the false alarm rate, or the proportion of stranger pair vocalizations incorrectly perceived as romantic partners.

7.3. Results

A preliminary mixed-model analysis of variance (ANOVA) on accuracy with vocalization type (close vs stranger) as a repeated-measure factor included participant sex (i.e., male vs female) and relationship status (single vs.in a romantic relationship) as a between-subject factor. Participant's sex and relationship status did not produce any significant main effects or interactions and they were dropped from the analyses (*F (1, 152)* = .42, *ns*; *F (1, 152)* = .91, *ns*, *respectively*). Besides, participants' age did not correlate with A' score. Thus, one-sample t-tests examined whether accuracy of judging conversation intonation from 1-min episodes was better than chance.

One-tailed t-test analyses revealed that participants were significantly better than chance in recognizing the close partners' vocalizations (*Mean A'*=.55), *t(155)*=3.75, $p<.001$, Cohen's (1992) effect size $d=0.60$). The recognition of close partner vocalization is intriguing; a finding supporting the idea that close partner vocalizations carry their own characteristics that could be readily recognized. However, stranger partner conversations seem to have uniform or homogenous vocal features in all conversation partners.

Overall, Study 2 aimed to show close partner conversation has its own vocalization or intonation features and it readily differs from stranger partner conversation. The analysis using signal detection theory demonstared that intonation of 1-min close partner conversation without any verbal content was accurately recognized by the third person above the change. Moreover, these effects were independent from participants' age, sex, and their relationship status.

To further examine the features of close partner vocalization, open ended questions were asked to participants to probe their judgments. Responses to the question were analyzed using directed content analysis in which initial coding started with research findings on recognizing vocalization. Emerged categories and related exemplars were presented in Table 6.

Table 6. Responses to the question, "What made you think the conversant were partners/strangers?"

Explanations for Close Partner Vocalizations	Explanations for Stranger Partner Vocalizations
• Conversation flowed well, excitement [Covariance]	• Sounds awkard. Long pauses. [Asynchrony]
• They seemed very comfortable with each other and there was some flirty laughter and loving emotion between them. [Warmth]	• Pauses in conversation [Stability]
• Woman giggled. Whole conversation seemed light. [Warmth]	• There was a point of awkward silence[Asynchrony]
• Many tonal changes and the females voice tone goes down in a playful way. [Covariance]	• The conversation was cool. [Coldness]
• They seemed very comfortable talking to each other. [Comfort]	• The woman sounds high-pitched and hurried. The man sounds as if he is just trying to get through a brief contact. The silences make me think they are awkward with each other. [Asynchrony]
• They seemed to enjoy one another [Warmth]	• There were no romantic or loving emotions in the voices. [Coldness]
• They sounded like they were relaxed and used to talking to each other. [Comfort]	• Very friendly conversation but very little rise and fall in tones[Warmth & Stability]
• Seems like that is helping her with something [Support]	• No emotion in the voice [Coldness]
• Same level of emotion throughout the conversation [Covariance]	• Sounded more business than friendly [Coldness]
• The tones of their voices are pretty relaxed. [Comfort]	• Sounded like they were discussing options on a list..maybe a buyer/seller. [Coldness]
• She was laughing and flirting[Warmth]&[Comfort]	• Formal conversation with no laughter or warmth. [Coldness]

Note: Emerged category names were presented in square brackets

The results of directed content analysis demonstrated significant categories for distinguishing close partner vocalizations. As seen in Table 6, emotional tone of vocalizations, comforting partners, perceived supportiveness, and co-variances in the

vocalization could be detected intuitively by naïve listeners. Moreover, they described stranger pairs on the basis of silences, pauses and stable pitch levels manifested as “cool conversations”. It is notable that these classifications were based on one-minute conversation without verbal content. The findings lend support to the view that when it comes to recognizing and interpreting non-linguistic speech cues, people have very good intuitions. Moreover, they can perceive more successfully in their close relationships and affects in those conversations could be easily communicated between them.

7.4. Discussion

Study 2 showed that participants recognized close partner conversation vocalization by listening one-minute episodes without any verbal content. Besides, individuals recognized close partner vocalization above the chance level. Participants' recognition rates were independent from their age, sex, and relationship status. These results seem to be consistent with previous work on speech registers investigating unique vocal characteristics of conversations such as words, rhythm, timing tone, and other vocal and paralinguistic features (Montepare & Vega, 1988; Montepare, Steinberg, & Rosenberg, 1992). The implicit idea behind these findings is that individuals prone to distinguish vocal behaviors and these changes are associated with certain kinds of attributes in communication.

Consistent with communication accommodation theory (Giles & Ogay, 2007), one possible explanation about the accurate recognizing of close partner intonations is that synchronous vocal communication has unique properties (Montepare & Vega, 1988). Synchrony has been shown to occur for numerous aspects of spoken language, including speakers' choice of referring expressions (Brennan & Clark, 1996); linguistic style (Niederhoffer & Pennebaker, 2002); speaking rate (Levitan & Hirschberg, 2011); acoustic/prosodic features such as fundamental frequency, intensity, voice quality (Levitan & Hirschberg, 2011); and phonetics (Pardo, 2006). Additionally, Levitan, Granavo, and Hirsberg (2011) showed that synchrony is characterized with shorter latency between turns, and fewer interruptions in a given conversations. Previous research indirectly showed that individuals have capacity to detect aforementioned subtle vocal cues and recognize the meaning of those vocal cues for intimate relationships (Montepare & Vega, 1988; Montepare, Steinberg, & Rosenberg, 1992).

Tendency to detect synchronous nonverbal cues appears to be relatively automatic and spontaneous. Supporting this argument, Sauter, Panattoni, and Happè (2013) examined recognition of vocal affective cues among children ranging between 5 to 10 years old. They found that children as young as 5 years were proficient in interpreting a range of emotional cues and non-verbal vocalizations. Based on this

demonstration of early ability to recognize non-verbal vocalizations, it is not surprising to expect that participants successfully recognized close partner vocalizations. Besides, the findings on the successful detection of romantic partner vocalizations have implications on accurate caregiving soothing behaviors. If individuals can successfully recognize romantic partner vocalization cues, they can provide proximal soothing behaviors (e.g., cuddling, hugging, or patting) subsequently. Further studies should also focus on whether synchronous vocalizations provoke or prime soothing behaviors to gain deeper understanding about caregiving behaviors.

7.4.1. Contributions and limitations

The Study 2 contributes to the literature in a number of important ways. First, previous studies have tried to control verbal content and examined accuracy of judgments based on the paralinguistic features, but they did not fully extract verbal content from the stimulus. This study did control verbal content in the conversations and examined the accuracy of recognizing intimate partner conversation by using a novel technique: low-pass filtering. Second, the signal detection theory was applied to the data set where stimuli (i.e., one-minute length vocalizations) were either close partner or stranger partner, and participants categorized each trial as having the stimulus close or stranger partner vocalization. Based on this technique, numerical estimates of sensitivity were obtained with statistics based on the sensitivity index (i.e., d' and A'), and thus, response bias was estimated.

Future research should examine the potential moderators those may have an effect on the accuracy of classification, such as attachment orientations, the degree of social closeness, and emotion contagion skills. The Study 2 focused on a sample of American and further studies should replicate these findings with non-English speakers to show universality of recognizing intimate relationship vocalization. Third, the question of whether other relationship type vocalizations (e.g., conversations with close friends or colleagues) have different detectable vocalization should also be examined. Results of such study would provide important information regarding unique properties of intimate relationship vocalizations.

CHAPTER 8

CONCLUDING REMARKS

Two studies were conducted and the recent methodological advancements in linguistics and communication science were employed to further our understanding of the functioning in romantic relationships. This dissertation provides initial empirical evidence on the coregulation at vocal level between romantic partners. Besides, results confirmed the moderating role of attachment related anxiety and relationship satisfaction on vocal synchrony between partners. The current study has contributed to the literature by investigating the vocal markers of attachment characterized by synchrony in vocal behaviors first time. Another important contribution of this dissertation was that investigating synchrony in neutral conversation rather than focusing only positive or negative affect context. Study 1 showed bidirectional associations between intimate partners at vocal level, whereas strange partners showed unidirectional causality from female to male. Study 2 also highlights the unique features of close partner conversation vocalization. These studies shed light on (as well as providing the groundwork for) by highlighting the ways in which emotional coordination can occur and can be observed via vocal cue s.

This dissertation makes an important contribution to our knowledge of the processes through which relationship partners influence one another's affective states and affective changes. This study also highlights new questions regarding the mechanisms through which attachment relationships regulate affective dynamics in daily life and how these dynamics are moderated by attachment dimensions (i.e., attachment anxiety and avoidance) and relationship satisfaction. Identifying the underlying mechanisms governing covariation and their long-term implications for both individual's well-being and couple functioning should be the next critical step.

Results of this dissertation underline the importance of coregulation in attachment relationships. The ability to modulate emotional responding in a way that supports one partner's goal and maintains physiological balance is crucial for both psychological and physiological well-being across the lifespan. Coregulation (especially regulating negative emotions) has been shown to be linked with intrapersonal and interpersonal benefits via promoting stable arousal zone. For example, cumulative studies showed that regulating extreme emotions such as anxiety or fear and experiencing stable arousal zone promote more broad-minded forms of coping with problems, such as generating multiple potential solutions to one's problems (Fredrickson & Joiner, 2002). These properties of coregulation sustain both current and future coping and problem solving abilities by promoting the close partner as a regulation resource. Further research in this area should integrate and investigate complex nature of human coregulation and synchrony by using multivariate models that approximate the complexity of human interactions.

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APPENDICES

Appendix 1: MATLAB Code for detecting on off voice activity and creating 10 ms analysis windows

```
function [Ton,Toff]= DetcetVoiceActivity(Input,PLOT,Thresh)
%Input: name of input wav file
%PLOT: (optional), if set ot 'onset' or 'offset' the detected
onsets/ offsets are plotted if
%Ton: detected oset times
%Toff: detcted offset times

if nargin==1
    PLOT=0;
    Thresh=500/1000;
end
if nargin==2
    Thresh=500/1000;
end


[V,fs]= wavread(Input); %read imput file

%some filtering of the signal
Vf=abs(V);
Vf(Vf<.2)=0;

%window size =10ms
W=fs*10/1000; %10 ms

%initialize paramteres
Ton=[];
Toff=[];
flag=0;
laston=0;
Threshold =fs*Thresh; % 1000 ms
for i=1:W:length(V)-W
    if(~flag)
        if(sum(Vf(i:i+W-1))>0)
            if((i-laston)>Threshold)
                Ton=[Ton,i];
                flag=1;
                laston=i;
            end
        end
    else
        if(sum(Vf(i:min(i+10*W-1,length(Vf))))==0)
            flag=0;
            Toff=[Toff,i];
        end
    end
end

if PLOT
    V2=V(1:10:end);
    plot(V2)
    hold on
```

```
    for i=1:length(Ton)
        if strcmp(PLOT,'onset')
            X=round([Ton(i)/10,Ton(i)/10]);
            COL='r';
        elseif strcmp(PLOT,'offset')
            X=round([Toff(i)/10,Toff(i)/10]);
            COL='g';
        end
        Y=[min(V2),max(V2)];
        plot(X,Y,COL)
    end
end

Ton=Ton/fs;
Toff=Toff/fs;
```

Appendix 2: MATLAB Code for detecting turn-taking behaviors in the conversation

```
%% Moving Avarages Identify Turn-Taking
v9=find(vec2(:,2)==999999999);
v99=0;
for i=1:length(v9)-1
    if v9(i+1)-v9(i)>1
    v99(end+1:end+2,1)=[v9(i);v9(i+1)];
%     elseif v9(i+1)-v9(i)>1&&v99(end)==v9(i)
%     v99(end+1,1)=v9(i+1);
    end
end
v99(end+1,1)=v9(end);
    v99=v99(2:end);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
NewVec=0;
for j=1:2:length(v99)-1
    Add=vec2(v99(j)+1:v99(j+1)-1,2);
NewVec(end+1:end+length(Add),1)=Add;
end
Add=vec2(v99(end)+1:size(vec2,1),2);
NewVec(end+1:end+length(Add),1)=Add;
NewVec=NewVec(2:end);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
NewVec2=NewVec;
NewVec=NewVec2;
param1=143; param2=174;NumSigma=1.6449;
MeanG1=mean(NewVec(1:param1-1));
StdG1=std(NewVec(1:param1-1));
UG1=MeanG1+NumSigma*StdG1;DG1=MeanG1-NumSigma*StdG1;


MeanG2=mean(NewVec(param1:param2));
StdG2=std(NewVec(param1:param2));
DG2=MeanG2-NumSigma*StdG2;UG2=MeanG2+NumSigma*StdG2;
SubTurn(1:param1,1)=ones(param1,1);
SubTurn(end+1:param2,1)=2*ones(param2-param1,1);
for k=param2+1:367

    TurnPrev=find(SubTurn==(SubTurn(end)-1));
%     TurnPrev2=find(SubTurn==2);
       MeanG1=mean(NewVec(TurnPrev(1):TurnPrev(end)));
       StdG1=std(NewVec(TurnPrev(1):TurnPrev(end)));
       UG1=MeanG1+NumSigma*StdG1;DG1=MeanG1-NumSigma*StdG1;
       %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
       TurnPrev2=find(SubTurn==(SubTurn(end)));
       MeanG2=mean(NewVec(TurnPrev2(1):TurnPrev2(end)));
       StdG2=std(NewVec(TurnPrev2(1):TurnPrev2(end)));
       UG2=MeanG2+NumSigma*StdG2;DG2=MeanG2-NumSigma*StdG2;
    if DG1<=NewVec(k)&&NewVec(k)<=UG1&&NewVec(k)<DG2
        SubTurn(k)=SubTurn(k-1)+1;
        h=1;
    elseif DG2<=NewVec(k)&&NewVec(k)<=UG2&&NewVec(k)<DG1
         SubTurn(k)=SubTurn(k-1);
         m=1;
    else
```

```
        NewVec(k)=0; SubTurn(k)=SubTurn(k-1);
        n=1;
    end
end

VecVec=[NewVec SubTurn];
```

Appendix 3: MATLAB Code for global F0 correlation estimation

```
% global pitch correlation estimation

clear all
tic
data=xlsread('synch.xlsx','synch2');
dataSample=[data(:,1) data(:,3:4)];
Store=zeros(14,1);CoupleCorrs=zeros(14,1);
CoupleH=zeros(14,1); Pval=zeros(14,1);
CorrSonuc=zeros(14,2);
for i=1:14
    num=find(dataSample(:,1)==i);
    Store(i)=num(end);
    EndPoint=num(end);
    if i==1
    CoupleSample=dataSample(1:EndPoint,2:3);
        else
    CoupleSample=dataSample(Store(i-1)+1:EndPoint,2:3);
    end
%        xlswrite('sonucCouple.xlsx',CoupleSample,i)


    [CoupleCorrs
Pval]=corrcoef(CoupleSample(:,1),CoupleSample(:,2));
    CorrSonuc(i,:)=[CoupleCorrs(2,1) Pval(2,1)];
    [h,pValue,stat,cValue,reg1,reg2] =
egcitest(CoupleSample);
    CoupleH(i)=h;
end
toc
```

Appendix 4: MATLAB Code for AR(I)MA modeling of F0 series and stationarity testing

```
function [Har H R C R2 C2]=modelresults()
tic
Har=zeros(48,1);H=zeros(48,1);
R2=zeros(48,1);C2=zeros(48,1);R=zeros(48,1);C=zeros(48,1)
;
for s=1:48
data=xlsread('matlab_data2.xls',s);
harma=data(:,2);


Hsub=adftest(harma);
    if Hsub==1
        H(s)=0;
    else
    harma=diff(harma);
    Hsub=adftest(harma);
    Hsub=adftest(harma);
    if Hsub==1
        H(s)=1;
    else
    harma=diff(harma);
    Hsub=adftest(harma);
    Hsub=adftest(harma);
    if Hsub==1
        H(s)=2;
    else
    harma=diff(harma);
    Hsub=adftest(harma);
    Hsub=adftest(harma);
    if Hsub==1
        H(s)=3;
    else
    harma=diff(harma);
    Hsub=adftest(harma);
    Hsub=adftest(harma);
    if Hsub==1
        H(s)=4;
    else
    harma=diff(harma);
    Hsub=adftest(harma);
    Hsub=adftest(harma);
    if Hsub==1
        H(s)=5;
    else
        H(s)=100;
```

```
    end
    end
    end
    end
    end
    end
MatAIC=zeros(4,4);
% if H(s)==1
%%
for i=1:8
    for j=1:8
spec =
garchset('VarianceModel','GARCH','P',i,'Q',j,'Distributio
n','T','Display','off');
[coeff,errors,LLF,eFit,sFit] = garchfit(spec,harma);
garchdisp(coeff,errors)
NumParam=garchcount(coeff);
[AIC,BIC]=aicbic(LLF,NumParam,size(harma,1));
MatAIC(i,j)=AIC;
    end
end
MinVal=min(min(MatAIC));


[r,c]=find(MatAIC==MinVal);


spec =
garchset('VarianceModel','GARCH','P',r,'Q',c,'Distributio
n','T','Display','off');
[coeff,errors,LLF,eFit,sFit] = garchfit(spec,harma);
garchdisp(coeff,errors)
Efit=eFit;
Sfit=sFit;
for i=1:8
    for j=1:8
spec =
garchset('VarianceModel','GARCH','R',i,'M',j,'P',r,'Q',c,
'Distribution','T','Display','off');
% [coeff,errors,LLF] =
garchfit(spec,harma,[],Efit,Sfit,harma);
[coeff,errors,LLF] = garchfit(spec,harma);
garchdisp(coeff,errors)
NumParam=garchcount(coeff);
[AIC,BIC]=aicbic(LLF,NumParam,size(harma,1));
MatAIC(i,j)=AIC;
    end
end
MinVal=min(min(MatAIC));
```

```
[r2,c2]=find(MatAIC==MinVal);


spec =
garchset('VarianceModel','GARCH','R',r2,'M',c2,'P',r,'Q',
c,'Distribution','T','Display','off');
[coeff,errors,LLF,eFit,sFit] =
garchfit(spec,harma,[],Efit,Sfit,harma);
garchdisp(coeff,errors)
Har(s)=lbqtest(eFit);
R2(s)=r2;C2(s)=c2;
R(s)=r;C(s)=c;
%%
M=max(r2,c2);New=zeros(size(harma,1)-(M),1);
for i=1:size(harma,1)-M
    Ar=0;Ma=0;
    for j=1:r2
      Ar= Ar+coeff.AR(j)*harma((i+M-j));
    end


    for k=1:c2
      Ma= Ma+coeff.MA(k)*eFit((i+M-k));
    end
    New(i)=coeff.C+Ar+Ma;
end
%%
% else
%     harma=diff(harma);
%     Hsub=adftest(harma);
%     if Hsub==1
%         H(s)=2;
%     else
%     end
%  for i=1:8
%     for j=1:8
% spec =
garchset('VarianceModel','GARCH','P',i,'Q',j,'Distributio
n','T','Display','off');
% [coeff,errors,LLF,eFit,sFit] = garchfit(spec,harma);
% garchdisp(coeff,errors)
% NumParam=garchcount(coeff);
% [AIC,BIC]=aicbic(LLF,NumParam,size(harma,1));
% MatAIC(i,j)=AIC;
%     end
% end
% MinVal=min(min(MatAIC));
%
```

```
% [r,c]=find(MatAIC==MinVal);
%
% spec =
garchset('VarianceModel','GARCH','P',r,'Q',c,'Distributio
n','T','Display','off');
% [coeff,errors,LLF,eFit,sFit] = garchfit(spec,harma);
% garchdisp(coeff,errors)
% Efit=eFit;
% Sfit=sFit;
% for i=1:8
%     for j=1:8
% spec =
garchset('VarianceModel','GARCH','R',i,'M',j,'P',r,'Q',c,
'Distribution','T','Display','off');
% [coeff,errors,LLF] = garchfit(spec,harma);
% garchdisp(coeff,errors)
% NumParam=garchcount(coeff);
% [AIC,BIC]=aicbic(LLF,NumParam,size(harma,1));
% MatAIC(i,j)=AIC;
%     end
% end
% MinVal=min(min(MatAIC));
%
% [r2,c2]=find(MatAIC==MinVal);
%
% spec =
garchset('VarianceModel','GARCH','R',r2,'M',c2,'P',r,'Q',
c,'Distribution','T','Display','off');
% [coeff,errors,LLF,eFit,sFit] =
garchfit(spec,harma,[],eFit,sFit,harma);
% garchdisp(coeff,errors)
% Har(s)=lbqtest(eFit);
% R2(s)=r2;C2(s)=c2;
% R(s)=r;C(s)=c;
% %%
% M=max(r2,c2);New=zeros(size(harma,1)-(M),1);
% for i=1:size(harma,1)-M
%     Ar=0;Ma=0;
%     for j=1:r2
%       Ar= Ar+coeff.AR(j)*harma((i+M-j));
%     end
%
%     for k=1:c2
%       Ma= Ma+coeff.MA(k)*eFit((i+M-k));
%     end
%     New(i)=coeff.C+Ar+Ma;
% end
% end
xlswrite('resultsHarma.xls',New,s);
```

```
end
xlswrite('resultsHarma.xls',H,'H');xlswrite('resultsHarma
.xls',Har,'Har');
xlswrite('resultsHarma.xls',R,'R');xlswrite('resultsHarma
.xls',C,'C');
xlswrite('resultsHarma.xls',R2,'R2');xlswrite('resultsHar
ma.xls',C2,'C2');
toc
end
%%
```

Appendix 5: Consent Form, Debriefing Form, Experiment Stimuli, and Self-Report Battery

We are asking you to participate in a research study. This form is designed to give you information about this study. We will describe this study to you and answer any of your questions.

Project Title: Measuring Interpersonal Synchrony Using Prosodic Entrainment and its Implications for
Romantic Relationship Functioning

Principal Investigator: Mehmet Harma
Human Development
G78 Martha Van Rensselaer Hall
mh947@cornell.edu

Faculty Advisor: Cynthia Hazan
Associate Professor
G63, Martha Van Rensselaer Hall
ch34@cornell.edu

What the study is about

The purpose of this research is to investigate communication patterns of couples. How they speak with each other, how they respond partners' reactions, and how they listen each other will be basic questions of this study.

What we will ask you to do

First, we will ask you to talk with your partner about provided abstract pictures. Then you will also be asked to talk about same pictures with another person waiting outside. These two sessions will take approximately 20 minutes. You are not expected your conversation in a structured way, please talk with your partner as in your daily life. When your time is up, researcher will come back to room and notify you kindly. Second you will be asked to complete a series of self-report scales, including questions about your relationship. This section will take approximately 15 minutes. After completion of these stage, you will get 10$ for your invaluable collaboration and help.

Risks and discomforts

We do not anticipate any risks from participating in this research.

Benefits

This study may have no direct benefits to you and your partner. However, your help for this study will be important contribution for scientific knowledge. Information obtained from this study may benefit understanding about other couples' communication processes and its impacts for

individuals. We hope to learn more about communication processes in close relationships and its impacts on each individual.

Payment for participation

Participants attending this study will get 10$ for taking part in the study at the end of all sessions.

Audio/Video Recording

For this study, we want to record your voices during the conversation. To analyze communication patterns of couples later, we need to keep your audio recordings and we will use a specific voice recorder. Your recordings will be stored in an anonymous ID and kept in a password protected storage device. For publication and scientific presentation your sound records will be stored but your records will still be anonymous.

Privacy/Confidentiality

Your voice records and self-report responses will be protected by assigning new ID numbers that are not related your actual ID and the data will be encrypted for security of your records.

Taking part is voluntary

Your involvement to the study is voluntary, you may refuse to participate before the study begins, discontinue at any time, or skip any questions/procedures that may make you feel uncomfortable, with no penalty, and no effect on the compensation earned before withdrawing, or your academic standing, record, or relationship with the university or other organization or service that may be involved with the research.

Please note that all research materials (e.g., conversation with your partner, answering questionnaires) are required for participation.

If you have questions

The main researcher conducting this study is Mehmet Harma, a visiting graduate student at Cornell University. Please ask any questions you have now. If you have questions later, you may contact Mehmet Harma at mh947@cornell.edu or at (607) 379-5778. If you have any questions or concerns regarding your rights as a subject in this study, you may contact the Institutional Review Board (IRB) for Human Participants at 607-255-
5138 or access their website at http://www.irb.cornell.edu. You may also report your concerns or complaints anonymously through Ethicspoint online at www.hotline.cornell.edu or by calling toll free at 1-866-293-3077. Ethicspoint is an independent organization that serves as a liaison between the University and the person bringing the complaint so that anonymity can be ensured.

You will be given a copy of this form to keep for your records.

Statement of Consent

I have read the above information, and have received answers to any questions I asked. I consent to take part in the study.

Your Signature_____ Date_

Your Name (printed)_____

Signature of person obtaining consent_____Date_

Printed name of person obtaining consent_____

This consent form will be kept by the researcher for at least five years beyond the end of the study.

Approved by Cornell University
Institutional Review Board

Approval Date		Expiration Date
20 OCT 2011	to	19 OCT 2012

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Institutional Review Board for Human Participants

NOTICE OF EXPEDITED APPROVAL

To: Mehmet Harma
From: Jenny Gerner, IRB Chairperson

Protocol ID#: 1110002494

Project(s): Measuring Interpersonal Synchrony Using Prosodic Entrainment and its Implications for Romantic Relationship Functioning

Date of Approval: October 20, 2011

Expiration Date: October 19, 2012

The above-referenced protocol has been reviewed and given expedited approval by the Institutional Review Board for Human Participants (IRB) for the inclusion of human participants in research. **This approval shall remain in effect until October 19, 2012.**

The following personnel are approved to perform research activities on your protocol:

- Mehmet Harma
- Cynthia Hazan

The terms of Cornell University's Federalwide Assurance (FWA) with the federal government mandate the following important conditions for investigators:

1. All consent forms, records of study participation, and other consent materials **must** be held by the investigator for **five years** after the close of the study.
2. Investigators must submit to the IRB any **proposed amendment** to the study protocol, consent forms, interviews, recruiting strategies, and other materials. Investigators may not use these materials with human participants until the IRB has reviewed them. For information about study amendment procedures and access to the Amendments application form, please refer to the IRB website: http://www.irb.cornell.edu/forms.
3. Investigators must promptly report to the IRB any **unexpected events** involving human participants.

The definition of prompt reporting depends upon the seriousness of the unexpected event. For guidance on recognizing, defining, and reporting unexpected events to the IRB, please refer to the IRB website: http://www.irb.cornell.edu/forms.

If the use of human participants is to continue beyond the assigned approval period, federal requirements mandate that the protocol be re-reviewed and receive continuing approval. As the Principal Investigator it is your responsibility to obtain review and continued approval before the expiration date. Applications for renewal of approval must be submitted sufficiently in advance of the expiration date to permit the IRB to conduct its review before the current approval expires. Please allow three weeks for the review.

Any research-related activities -- including recruitment and/or consent of participants,
research-related interventions, data collection, and analysis of identifiable data -- conducted during a period of lapsed approval is unapproved research and can never be reported or published as research data. If research-related activities occur during a lapse in the protocol approval, the activities become a research compliance issue and must be reported to the IRB via an unexpected event form (www.irb.cornell.edu/forms).

Note: Forms should be downloaded from the IRB website at www.irb.cornell.edu/forms for each use.

****If you do not plan to renew your protocol approval at the end of the year, you must provide the IRB with a Project Closure form. A link to the Project Closure form can be found at http://www.irb.cornell.edu/forms/.**

c: Cynthia Hazan

Cornell University
College of Human Ecology

Dear Participant,

For the final part of the study, please complete the following.

1. Your Initials: _____
2. Your Age: _____
3. Gender: _____
4. Relationship Duration with your current partner: _____(in months)
5. Your Native Language: English ( )
   Other ( ). Please specify _____
6. Do you currently have any medical condition that impairs your voice or speech?

   No ( ) Yes ( ) If Yes, please specify_____

7. Have you ever had any medical condition that impairs your voice or speech?

   No ( ) Yes ( ) If Yes, please specify_____

8. *Based on our interaction in this study, I think the other participant (not my partner) and I have a lot in common.*

1----------2----------3----------4----------5----------6----------7----------8----------9

Strongly Disagree Strongly Agree

9. *Based on our interaction in this study, I think the other participant (not my partner) and I have similar personalities.*

1----------2----------3----------4----------5----------6----------7----------8----------9

Strongly Strongly

Disagree
Agree

10. How well did you know the other participant before this study?

_____

_____

Experimenter will fill out
Participants ID:

Important People in Your Life

Below you are asked to list people who are significant in your life. Rather than providing their names, answer with a term that defines how they are related to you (e.g., mother, boyfriend, sister). If you write in more than one person, list them in order of significance, starting with the most significant.

Note:

1. Please DO NOT use terms like "family" or "friends" that refer to more than one person.

2. If you are including more than one "friend"/"housemate"/etc. on your list, please specify which individual you are referring to (i.e., friend1, friend2, and so on).

3. There is no need to fill in all of the boxes.

1. Person(s) you make sure to see or talk to frequently.

A.	B.	C.	D.

2. Person(s) you seek out when worried or upset.

A.	B.	C.	D.

3. Person(s) you miss when they are away.

A.	B.	C.	D.

4. Person(s) you immediately think of contacting when something bad happens.

A.	B.	C.	D.

5. Person(s) you know always wants the best for you.

A.	B.	C.	D.

6. Person(s) who should be contacted in case of an emergency involving you.

A.	B.	C.	D.

7. Person(s) whose absence makes you feel like something is not quite right.

A.	B.	C.	D.

8. Person(s) you know will always be there for you.

A.	B.	C.	D.

9. Person(s) you are most likely to tell when something good happens to you.

A.	B.	C.	D.

Person(s) you can hardly imagine your life without.

A.	B.	C.	D.

You & Your Romantic Partner

The following statements concern how you feel in close relationship with your romantic partner. Respond to each statement by indicating how much you agree or disagree with it.

		Strongly Disagree	Somewhat Disagree	Slightly Disagree	Neither agree nor disagree	Slightly Agree	Somewhat Agree	Agree strongly
1	I worry that my partner thinks that I don't measure up to other people.	1	2	3	4	5	6	7
2	I feel comfortable sharing my private thoughts and feelings with my partner.	1	2	3	4	5	6	7
3	I worry a lot about my relationship with my partner.	1	2	3	4	5	6	7
4	I find it difficult to allow myself to depend on my partner.	1	2	3	4	5	6	7
5	I often worry that my partner doesn't really love me.	1	2	3	4	5	6	7
6	I am very comfortable being close to my partner.	1	2	3	4	5	6	7
7	I worry that my partner doesn't care about me.	1	2	3	4	5	6	7
8	I don't feel comfortable opening up to my partner.	1	2	3	4	5	6	7
9	My partner makes me doubt myself.	1	2	3	4	5	6	7
10	I prefer not to show my partner how I feel deep down.	1	2	3	4	5	6	7

You & Your Partner

The following statements concern how you generally feel with your romantic partner. Respond to each statement by indicating how much you agree or disagree with it.

		Not at all						Extremely
1	How satisfied are you with your relationship?	1	2	3	4	5	6	7
2	How content are you with your relationship?	1	2	3	4	5	6	7
3	How happy are you with your relationship?	1	2	3	4	5	6	7
4	How committed are you to your relationship?	1	2	3	4	5	6	7
5	How dedicated are you to your relationship?	1	2	3	4	5	6	7
6	How devoted are you to your relationship?	1	2	3	4	5	6	7
7	How intimate is your relationship?	1	2	3	4	5	6	7
8	How close is your relationship?	1	2	3	4	5	6	7
9	How connected are you to your partner?	1	2	3	4	5	6	7
10	How much do you trust your partner?	1	2	3	4	5	6	7
11	How much can you count on your partner?	1	2	3	4	5	6	7
12	How dependable is your partner?	1	2	3	4	5	6	7
13	How passionate is your relationship?	1	2	3	4	5	6	7
14	How lustful is your relationship?	1	2	3	4	5	6	7
15	How sexually intense is your relationship?	1	2	3	4	5	6	7
16	How much do you love your partner?	1	2	3	4	5	6	7
17	How much do you adore your partner?	1	2	3	4	5	6	7
18	How much do you cherish your partner?	1	2	3	4	5	6	7

About You

Please respond to each statement by indicating how much it describe you

	Never	Rarely	Often	Always
1. I feel relaxed even in unfamiliar social situations.	1	2	3	4
2. I try to avoid situations that force me to be very sociable.	1	2	3	4
3. It is easy for me to relax when I am with strangers.	1	2	3	4
4. I have no particular desire to avoid people.	1	2	3	4
5. I often find social occasions upsetting.	1	2	3	4
6. I usually feel calm and comfortable at social occasions.	1	2	3	4
7. I am usually at ease when talking to someone of the opposite sex.	1	2	3	4
8. I try to avoid talking to people unless I know them well.	1	2	3	4
9. If the chance comes to meet new people, I often take it.	1	2	3	4
10. I often feel nervous or tense in casual get-togethers in which both sexes are present.	1	2	3	4
11. I am usually nervous with people unless I know them well.	1	2	3	4
12. I usually feel relaxed when I am with a group of people.	1	2	3	4
13. I often want to get away from people.	1	2	3	4
14. I usually feel uncomfortable when I am in a group of people I don't know.	1	2	3	4
15. I usually feel relaxed when I meet someone for the first time.	1	2	3	4
16. Being introduced to people makes me tense and nervous.	1	2	3	4
17. Even though a room is full of strangers, I may enter it anyway.	1	2	3	4
18. I would avoid walking up and joining a large group of people.	1	2	3	4
19. When my superiors want to talk with me, I talk willingly.	1	2	3	4
20. I often feel on edge when I am with a group of people.	1	2	3	4
21. I tend to withdraw from people.	1	2	3	4
22. I don't mind talking to people at parties or social gatherings.	1	2	3	4
23. I am seldom at ease in a large group of people.	1	2	3	4
24. I often think up excuses in order to avoid social engagements.	1	2	3	4
25. I sometimes take the responsibility for introducing people to each other.	1	2	3	4
26. I try to avoid formal social occasions.	1	2	3	4
27. I usually go to whatever social engagements I have.	1	2	3	4
28. I find it easy to relax with other people.	1	2	3	4

You & Your Life

Please read each statement and indicate the frequency with which it applies to you.

Use the following key:
4. Always = Always true for me.
3. Often = Often true for me.
2. Rarely = Rarely true for me.
1. Never = Never true for me.

		Never	Rarely	Often	Always
1	If someone I'm talking with begins to cry, I get teary-eyed.	1	2	3	4
2	Being with a happy person picks me up when I'm feeling down.	1	2	3	4
3	When someone smiles warmly at me, I smile back and feel warm inside.	1	2	3	4
4	I get filled with sorrow when people talk about the death of their loved ones.	1	2	3	4
5	I clench my jaws and my shoulders get tight when I see the angry faces on the news.	1	2	3	4
6	When I look into the eyes of the one I love, my mind is filled with thoughts of romance.	1	2	3	4
7	It irritates me to be around angry people.	1	2	3	4
8	Watching the fearful faces of victims on the news makes me try to imagine how they might be feeling.	1	2	3	4
9	I melt when the one I love holds me close.	1	2	3	4
10	I tense when overhearing an angry quarrel.	1	2	3	4
11	Being around happy people fills my mind with happy thoughts.	1	2	3	4
12	I sense my body responding when the one I love touches me.	1	2	3	4
13	I notice myself getting tense when I'm around people who are stressed out.	1	2	3	4
14	I cry at sad movies.	1	2	3	4
15	Listening to the shrill screams of a terrified child in a dentist's waiting room makes me feel nervous.	1	2	3	4

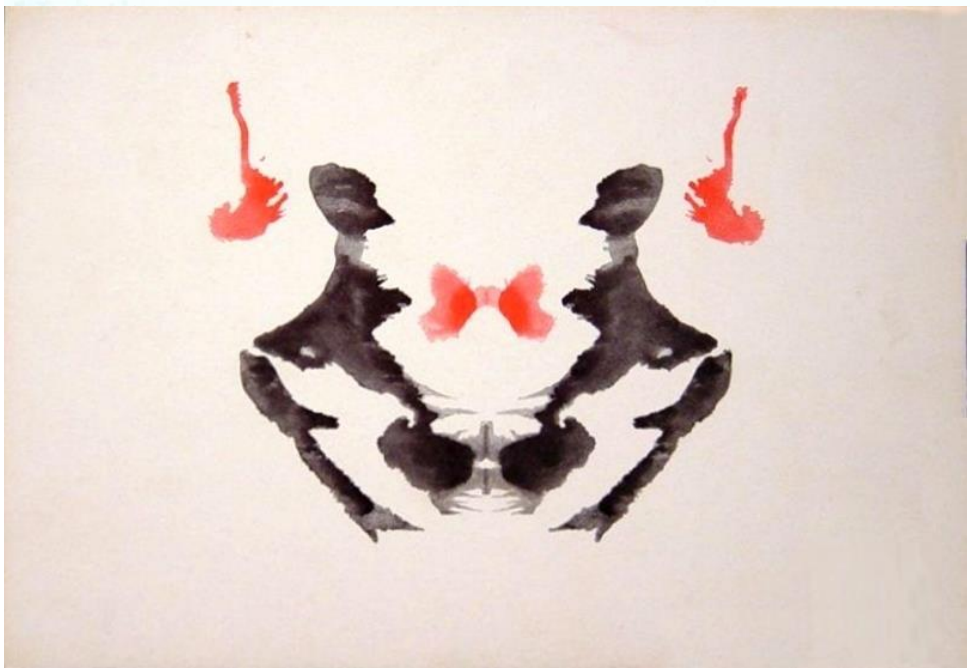
END OF THE QUESTIONNAIRE
THANK YOU **!**

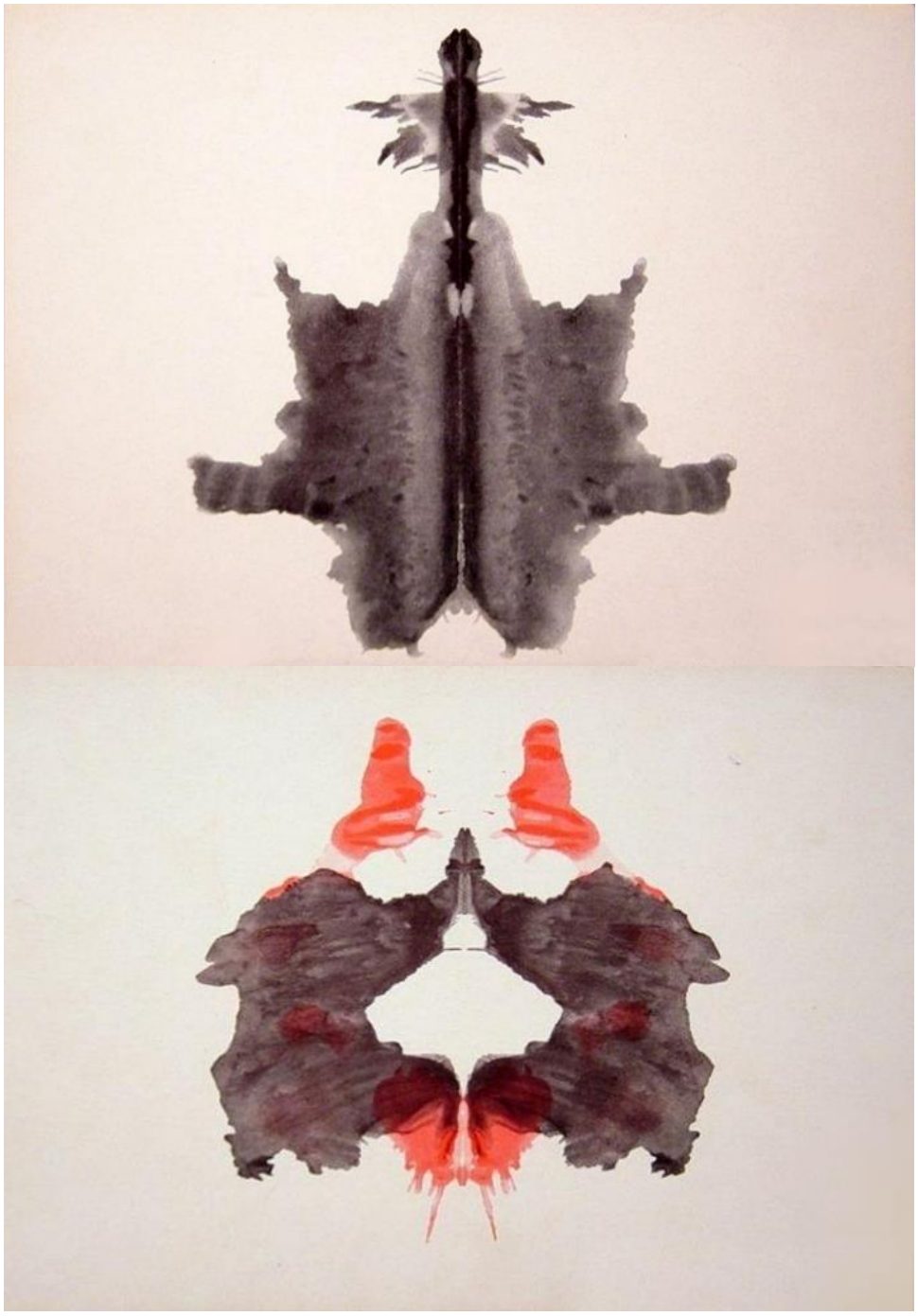
Dear Participant,

Please discuss with your partner the following six inkblots. Specifically, what do you see when you look at the pictures? What memories or associations do the images or patterns evoke?

Clearly, there are no correct or incorrect answers.

Go ahead!





Now please read the following dialogue with your partner: [Please note that your lines are bolded]

You: And what will you do now?
She: Hide in the mountains I saw from the valley.
You:And how do you think you'll survive there?
She: I don't know. But I'll figure something out.
You: What if I said you could stay here?
She: Even if you really meant it, it would be impossible. After all, this is a small town. I have to hide. People would ask questions.
You: That might not matter. If they wanted to help you too.
She: Are you saying that everyone in this town is like you?
You: The folks who live here are good people. They aren't quite like me, granted, but they're honest people who've been in need themselves. They might turn you down, but I certainly think it'd be worth the trouble to ask.
She: I've nothing to offer them in return.
You: I'm not sure that's the case. In my view you've got plenty to offer to Dogville. Now you get some sleep and I'll wake you early, before pop gets up.

Now please read the following dialogue with your partner: [Please note that your lines are bolded]

He: And what will you do now?

You: Hide in the mountains I saw from the valley.

He:And how do you think you'll survive there?

You: I don't know. But I'll figure something out.

He: What if I said you could stay here?

You: Even if you really meant it, it would be impossible. After all, this is a small town. I have to hide. People would ask questions.

He: That might not matter. If they wanted to help you too.

You: Are you saying that everyone in this town is like you?

He: The folks who live here are good people. They aren't quite like me, granted, but they're honest people who've been in need themselves. They might turn you down, but I certainly think it'd be worth the trouble to ask.

You: I've nothing to offer them in return.

He: I'm not sure that's the case. In my view you've got plenty to offer to Dogville. Now you get some sleep and I'll wake you early, before pop gets up.

Please read the following paragraph to your partner:

When the sunlight strikes raindrops in the air, they act as a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look, but no one ever finds it. When a man looks for something beyond his reach, his friends say he is looking for the pot of gold at the end of the rainbow.

PLEASE NOTIFY THE EXPERIMENTER THAT YOU HAVE COMPLETED THIS PART OF THE EXPERIMENT...

CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: Harma, Mehmet
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EDUCATION

Degree	Institution	Year of Graduation
MS	METU Psychology	2008
BS	Mersin University Psychology	2004
High School	Tevfik Sırrı Gür High School, Mersin	1998

WORK EXPERIENCE

Year	Place/Enrollment
11/2012 – present	Senior researcher in Koc University, Dept. of Psychology, Istanbul, Turkey
8/2012 – present	Visiting lecturer, Dogus University, Istanbul
08/2011 – 08/2012	Visiting Researcher, Cornell University, Dept. of Human Development, Ithaca, NY, USA
12/2005 – 07/2011	Research Assistant, Relationship Research Lab, METU, Psychology Department, Ankara
01/2009 – 07/2011	Research Assistant, Safety Research Lab, METU, Psychology Department, Ankara
02/2010 – 07/2010	Teaching Assistant, METU Psychology Department, Advance d Design and Statistical Procedures in the Assessment of Psychological Change; Graduate Course

09/2009 – 01/2010 Teaching Assistant, METU Psychology Department, Attachment and Cultural Parenting; Undergraduate Course

02/2009 – 07/2009 Teaching Assistant, METU Psychology Department, Advanced Design and Statistical Procedures in the Assessment of Psychological Change; Graduate Course

01/2009 – 07/2011 Social Interaction Specialist and Social Media Director, Pixofun Videogame Design Group

FOREIGN LANGUAGES

Advanced English,

PUBLICATIONS

Selcuk, E., Gunaydin, G., Sumer, N., **Harma, M**., Salman, S., Hazan, C., Dogruyol, B., & Ozturk, A. (2010). Self-reported romantic attachment style predicts everyday maternal caregiving behavior at home. *Journal of Research in Personality. 44*, 544-549.

Sumer, N., Solak, N., & **Harma, M.** (2013). *İşsizYaşam: İşsizliğinPsikososyalEtkileri*. Koç University Press: İstanbul.

Harma, M. (2010). Attachment, marital satisfaction, and conflict, in T. Solmuş (Ed.), *Attachment, Marriage, and Family Psychology,* Sistem Press, Istanbul.

ÖZET

Yakın ilişkiler konusunda yapılan araştırmalar ilişkide olan çiftlerin (örn., anne-çocuk, sevgili, arkadaş vb.) duygularının zaman içinde birbiri ile koordine olduğunu ve bu durumun çiftlerin duygu durumlarını doğrudan etkilediğini göstermiştir (Butler, 2011). Çiftler arasındaki bu duygusal "içiçeliğin" (ya da bir diğer anlamda genişlemenin) kişilerin fiziksel ve psikolojik iyi olma durumları açısından kritik öneme sahip esnek ve uyumlarına yönelik duygusal dengeleri ile ilişkili olduğu bulunmuştur (Thayer & Lane, 2007; Thayer & Sternberg, 2006). Anne-bebek ilişkisindeki duygusal eşgüdümlülük (emotional coordination) yazında ayrıntılı olarak çalışılmış olmasında karşın, yetişkinlikteki duygusal eşgüdümlülük farklı nedenlerle aynı ilgiyi görmemiştir. Bunun en önemli nedenlerinden birisi, yetişkinlikteki duygusal eşgüdümlülüğün muhtemelen çok daha karmaşık süreçleri içermesi ve görgül olarak test edilmesinin zorluğudur. Bu tür görgül çalışmalar ayrıca karmaşık ve çok sayıda değişkenin kontrol edildiği ileri istatistiksel modellemeleri gerektirmektedir. Yazında ilgili alandaki araştırmaya olan ihtiyaç göz önüne alınarak, bu tezde temel olarak (1) romantik ilişki içindeki çiftlerin birbirlerinin duygusal durumlarını karşılıklı olarak etkilemesini içeren duygusal eşdüzenleme (emotional coregulation) kavramına odaklanılmıştır. (2) Bununla birlikte söz konusu eşdüzenleme sürecine etki edecek olası üçüncü değişkenlerden bağlanma temelli kaygı ve kaçınma ile ilişki doyumunun rolü incelenmiştir. Bu amaçla, yetişkin bağlanma kuramı (Sbarra & Hazan, 2008), kişiler arası duygu düzenleme (Butler, 2011; Diamond, 2011), doğal diyalogda etkileşimli senkroni ve doğal dilde konuşmacılar arası adaptasyon (Giles & Ogay, 2007) gibi farklı kuramsal yaklaşımlar ve onların önerdiği yöntemler bir arada süreci en iyi anlamayı sağlayacak şekilde kullanılmıştır.

Bunlara ek olarak, bu tezde kişilerarası duygu düzenlemeyi vokal düzeyde anlamayı sağlayacak yeni bir yöntem önerilmiştir. Psikolinguistik alanındaki çalışmalar vokal davranışın doğrudan fizyolojik değişimlerin sese yansıması olarak görülmektedir (Juslin & Scherer, 2005). Dolayısla, eşler arası duygusal eşdüzenlemeyi anlayabilmek amacıyla gerçek zamanlı diyaloglar analiz edilmiştir ve çiftler

arasındaki vokal uyum test edilmiştir. Buna göre, romantik ilişkide olan çiftlerden birisinin konuşmadaki tonlama ve vurgular gibi vokal özellikleri diğerinin aynı özellikleri ile ilişkili olması beklenmekte ve bu ilişkinin görece kısa süreli diyaloglarda bile gözlenebileceği düşünülmektedir. Ortaya çıkacak eşgüdümlü vokal özelliklerin aynı zamanda bağlanma kaygısı ve kaçınma, ilişki doyumu ve ilişki süresi gibi bireysel ve ilişki farklılıklardan etkileneceği beklenmektedir.

Duygusal eşdüzenleme genellikle ilişkideki karşılıklı psiko-fizyolojik dengeye denk gelmekte ve bu anlamda bağlanma ilişkisinin temel yapı taşı olarak görülmektedir (Hazan, Gur-Yaish, & Campa, 2004). İlgili yazında önceki çalışmalar bireysel duygu düzenleme becerisinin kişinin fizyolojik dengesini kolaylaştırdığını, hedeflerini gerçekleştirmede yardımcı olduğunu ve bu bağlamda da fiziksel ve psikoloji iyi olma haline katkıda bulunduğunu göstermiştir (Eisenberg, Fabes, Guthrie ve Reiser, 2000; Gross, 2002; John ve Gross, 2004). Bakım veren (anne)-bebek arasındaki ilişkinin kalitesinin de kendini düzenleme becerisi üzerinde merkezi bir öneme sahip olduğu ve bebeğin daha sonraki yaşamında da bunun olumlu etkilerinin görüldüğü bulunmuştur (Bkz., Jaffe, Beebe, Feldstein, Crown ve Jasnow, 2001). Annenin bebeğinin duygularını düzenleyebilmesinde, dış dünyaya uyum sağlamasında hayati bir rolü bulunduğu ve gelişmekte olan bebeğe dışardan "gizil düzenleyici" olarak işlev gördüğü gösterilmiştir (Hofer, 1994). Erken dönem çocukluk yazını eşdüzenleme kavramını bebek ve bakım veren arasındaki karşılıklı duygusal sistem oluşturma ve sosyal ilişkilerde ideal duygulanım düzeyini oluşturma süreci olarak tanımlamaktadır (Feldman, 2003; Tronick, 1989).

Her ne kadar bu sürecin oluşumu ve sonraki yaşam dönemlerine etkisi erken dönem yazınında sistematik olarak çalışılmış olsa da, yetişkinlikteki yakın ilişkilerde eşdüzenleme sürecinin oluşumu uzun yıllar yukarıda bahsedilen pratik nedenlerden dolayı ihmal edilmiştir. Ancak son yıllarda eşdüzenleme sürecine yetişkin bağlanma yazınında artan bir ilgi gözlenmektedir (Butner, Diamond ve Hicks, 2007; Saxbe ve Repetti, 2010; Sbarra ve Hazan, 2008; Schoebi, 2008). Bu alandaki ilk bulgular karşılıklı duygusal etkilerin kişilerin hem günlük hem de anlık duygusal ve fizyolojik deneyimlerini etkilediğini göstermektedir (Sbarra ve Hazan, 2008). Erken dönemdeki anne-bebek ilişkisinde olduğu gibi, romantik partnerin bireylerin duygu düzenleme

kaynakları için adeta bir yedekleme ünitesi olarak görev yaptığı, günlük yaşamdaki duygusal dalgalanmaları fizyolojik boyutta kabul edilebilir sabit bir aralıkta tuttuğu öne sürülmektedir.

İlgili yazında eşdüzenleme kavramı genel olarak belli başlı psiko-fizyolojik süreçlere işaret etmektedir. Bunlardan bir tanesi eşdüzenlemeyi romantik partnerlerin gün içinde ve günden güne birlikte değişen duygusal deneyimleri olarak görmektedir (Butner ve ark., 2007). Bir diğer yaklaşım ise eşdüzenleme sürecini bir partnerin duygusal deneyimlerinin diğer partnere aktarılması olarak değerlendirmektedir (Schoebi, 2008). Diğer bir deyişle, stresli bir partnerin stresli olmayan partneri etkileyerek birlikte stres düzeylerini arttırabileceği öne sürülmektedir. Bunlara ek olarak, Saxbe ve Repetti (2010) eşdüzenleme sürecini duygusal deneyimlerin bir göstergesi olan fizyolojik süreçlerin karşılıklı salınımı ve dinamik bir karşılıklı etkileşim olarak tanımlamaktadır. Schoebi'nin (2008) tanımlamasından farklı olarak bu yaklaşım eşdüzenleme süreci ile eşlerin birbirlerini optimal bir duygu durumuna çektiğini, stres düzeyi yüksek olan partner ile stres düzeyi düşük olan partnerin stres düzeylerinin birbirini dengelediği ve bir orta noktada buluştuğunu önermekte ve bunu fizyolojik göstergelerle desteklemişlerdir. Eşdüzenleme sürecine ilişkin duygusal göstergeleri farklı düzeylerde görgül olarak göstermek hem kuramsal hem de pratik açıdan kritik önem taşımaktadır. Özellikle eşdüzenleme kavramını vokal göstergelere odaklanarak çalışmak son dönemdeki bağlanma yazınındaki kişilerarası duygusal bağın çoklu düzeylerde (örn., fizyolojik, davranışsal vb.) incelenmesi gerektiği önermesiyle paralellik göstermektedir (Hazan et al., 2004).

Vokal göstergeler neden önemlidir? Vokal göstergeler (örn., bireylerin ses frekansları) kişilerin anlık duygusal durumlarındaki küçük değişimleri bile yansıtabilen önemli bir fiziksel ipucudur (Juslin & Scherer, 2005). Spesifik olarak, bu çalışmada eşdüzenleme sürecine işaret edebilecek olası göstergelerinden biri olarak çiftlerin vokal davranışlarındaki salınımın birlikte değişimi incelenmiştir (örn., çiftlerin konuşma esnasında tonlamasının, frekansının birlikte azalması ve artmasının ölçülmesi gibi). Aslında senkronik vokal tepkilerin (frekans temelinde) partnerler arasında eşgüdüm gösterip göstermediği fikri tamamıyla yeni bir fikir değildir. İletişim ve psikolinguistik alanındaki çalışmalar eşdüzenleme ya da

senkroniyi partnerlerin vokal ritimleri (McGarva, 2003), bilgisayar aracılı iletişimde kelime kullanımı (Nenkova, 2008), sözel olmayan iletişim ipuçlarının kullanımı (Richardson, Marsh, & Schmit, 2005) ve dil kullanım tarzlarının benzerliği (Ireland et al., 2010) gibi çalışmalarla incelemişlerdir. Her ne kadar ilgili yazındaki bu çalışmalar iletişim içindeki partnerlerin dil kullanımı ve konuşma örüntülerinin birbiriyle benzeştiğini gösterse de, bu çalışmaların neredeyse hepsinde ya arkadaş çiftleri, yeni tanışan kişiler ya da yabancılar katılımcı olarak kullanılmış, romantik partnerler arasındaki vokal senkroniye bakılmamıştır. Buna ek olarak, geçmiş çalışmalar daha çok partnerler arası benzerliğe odaklanmış, senkronik bir örüntünün olup olmadığı test etmemiştir.

Benzerlik (similarity) ve senkroninin (synchrony) birbirinden faklı süreçler olduğunu gösteren çalışmalar bulunmaktadır (örn., Levitan & Hirschberg, 2011). Bu açıdan romantik partnerlerin gerçek zamanlı diyaloglarındaki konuşma örüntülerini inceleyerek eşdüzenleme kavramını anlamaya çalışmak önem taşımaktadır. Tonlama ve vurgulama gibi konuşma düzeyindeki frekans özelliklerinin fizyolojik ve duygusal değişimleri hassas bir şekilde gösterdiği bilinmektedir ve bu özellikler son gelişen yöntemlerle başarılı bir şekilde elde edilebilmektedir (Scherer, 2005). Bu çalışmada psikolinguistik alanda kullanılan ve konuşan kişinin ses frekansı gibi önemli parametrelerini elde etmeyi sağlayan algoritmalar kullanılarak (örn., Talkin, 1995) çiftlerin günlük konuşmalarındaki ses özelliklerinin birlikte değişimleri incelenmiştir.

Özetle, bu tezin birinci amacı, romantik ilişkideki partnerlerin ses parametrelerindeki uyumlarının eşdüzenleme becerisinin bir göstergesi olarak kullanılıp kullanılamayacağı sorusuna cevap aramaktır. Katılımcıların ses parametrelerinden biri olarak gösterilen temel frekans değerleri (fundamental frequency; F0) çalışmanın temel girdisi olarak kullanılmıştır. Buna göre, romantik partner ile yapılan diyaloglardaki ses örüntüsünün yabancı biriyle yapılan diyologlardaki ses örüntüsünden anlamlı düzeyde farklı olması beklenmektedir. Romantik partnerin diyalog sırasındaki F0 değerlerinin diğer partnerin konuşmasındaki F0 değerlerini etkilemesi beklenmektedir. Daha spesifik olarak, diyalogdaki konuşmalar iki kişinin birbiri ile sırayla konuşması olarak görülmektedir ve her sıradaki F0 değeri partnerin daha sonraki sıradaki F0 değerini etkilemesi, yani yönlendirmesi beklenmektedir.

Ayrıca bu etki kişinin kendi konuşmasındaki daha önceki sıralardaki etkiden bağımsız olarak gerçekleşeceği öngörülmüştür. Söz konusu karşılıklı salınımın yabancı konuşma partnerleri için geçerli olmaması, daha bağımsız bir örüntünün oluşması beklenmektedir.

Bağlanma kuramı temelinde yapılan çoğu çalışma ilişkide bağlanma örüntüsünden kaynaklanan kaygı ve kaçınma yöneliminin ve ilişki doyumunun önemli eşdüzenleme sürecinde kritik değişkenler olduğunu göstermiştir (Butner, Diamond, & Hicks, 2007; Mikulincer et al., 2004). Buradan yola çıkarak, yakın ilişkideki duygusal eşdüzenleme süreçlerine sözkonusu bireysel farklılıkların etki edebileceği düşünülmektedir. Bu çalışmada bağlanma temelli kaygı ve kaçınmanın partnerler arası diyaloglardaki senkroniyi olumsuz yönde, ilişki doyumunun ise olumlu yönde etkilemesi beklenmektedir. Diyaloglardaki senkroni bireylerin konuşmasındaki frekans değişkenliği (fundamental frequency variability) ile ölçülmüş olup, düşük düzeydeki değişkenlikler yüksek düzeydeki senkroniye işaret etmektedir (benzer değişkenleri kullanan çalışmalar için bkz. Scherer, 2005). Özetle, bu tezin ikinci amacı, yakın ilişkideki partnerler arası eşdüzenleme sürecine işaret edebilecek, yani vokal senkroniyi etkileyebilecek olası bireysel farklılıkların incelenmesidir.

Yakın ilişkideki partnerlerin (anne-çocuk gibi) ses uyumlarının yabancı kişilerin uyumlarına göre farklı olması beklentisini ilgili yazındaki araştırmalarla da dolaylı olarak desteklenmektedir. Yakın ilişkide olan çiftlerin konuşmalarının kendine özgü tonlama ve seslendirme özellikleri içerdiği düşünülmektedir (bkz., Montepare, Steinberg ve Rosenberg, 1992). Bu bulgular ışığında, tezin üçüncü amacı olarak, katılımcıların dinledikleri bir konuşmadaki ses özelliklerinin içerdiği duygusal bileşenleri ne oranda ayırt edebildiğini incelemektir.

Çalışma 1
Veri İşleme ve Analiz Stratejisi

Vokal özelliklerle tanımlanan fizyolojik sistemlerin birlikte salınımını inceleyebilmek için partnerler arası değişimin düzeyini gösterebilecek uygun istatistiksel modellere ihtiyaç bulunmaktadır. Bu tür modeller hem bireyin konuşma parametrelerindeki zamansal değişimi başarılı bir şekilde temsil edebilmeli hem de bireylerin partneri ile konuşması sırasındaki değişimi ortaya koyabilmelidir. Bu

amaçla ilk olarak kişilerin ses özelliklerinden temel frekans değerleri (F0) elde edilmiştir. Frekans değerlerine ulaşmak ses dalgalarından sayısal verilere ulaşmayı ifade etmektedir. Daha önceki çalışmalarda kullanılan algoritmalar temel alınarak (örn., Buder & Eriksson, 1997), her katılımcının diyaloglardaki F0 değerleri elde edilmiştir. Bu elde edilen veriler hem bütün diyalogdaki veriler halinde hem de konuşma sırasına göre parçalara ayrılmış kümeler halinde kaydedilmiş ve daha sonraki genel ve sıraya dayalı analizlerde kullanılmıştır.

Genel analizler diyalogda konuşmacılarının sırasını gözetmeksizin, bir bütün olarak kullanılan verilerin analizlerine denk gelmekte, sıra temelli analizler ise diyalogda konuşmacıların sırasını göz önüne alarak elde edilen verilerin analizlerine işaret etmektedir.

Bu bölümde öncelikli olarak F0 kavramının tanımına kısaca değinilecek, daha sonra analiz birimleri (genel ve sıra temelli birimler) kısaca ele alınmıştır. Son olarak Çalışma 1'de kullanılan veriyi analiz etmek için kullanılan istatistiksel yöntemler tanımlanacaktır.

Temel Frekansın (F0) Tanımı ve Hesaplanması

Konuşma genel olarak sesli (örn., ünlü harfler) ve sessiz (örn., ünsüz harfler) seslerden oluşmakta ve tanımlanabilir periyodik örüntülerden meydana gelmektedir. Her tanımlanabilir periyodik örüntü "döngü" olarak ifade edilmekte ve bu döngülerin süresi seste perde olarak tanımlanmaktadır. Bir diğer deyişle, frekans veya titreşim sayısı bir olayın birim zaman içinde hangi sıklıkla, kaç defa tekrarlandığının ölçümüdür. Yani matematiksel ifadeyle periyodun çarpmaya göre tersidir.

Veri Çekme ve Doğal Diyalogda Otomatik Sıraya Atama Algoritması

Bu tezde ses kayıtlarından sayısal veri alma süreci iki temel yöntemle gerçekleşmiştir. İlk olarak, bireysel ses kayıtlarından susma ve sessizlik içeren kısımlar ayıklanmıştır. Bunun için kadın ve erkeğin kendi sesinin frekansının ortalamasının iki standart sapma altı ve üstü değerler belirlenmiş ve bu değerler dışında kalan kısımlar (on/off voice activity detection algorithm) MATLAB kullanılarak yazılan bir algoritma ile ayıklanmıştır (bkz., Ek 1). Daha sonra sessiz

olan kısımları ayıklanmış ses dosyaları 10 saliselik kümelere ayrılarak, PRAAT bilgisayar programı yardımıyla (Boersma & Weenink, 2013) otokorelasyon işlevi kullanılarak her birimden temel frekans değerleri hesaplanmıştır.

İkinci olarak, diyaloglarda kadın ve erkeğin konuşma ve susma sıralarını otomatik olarak tanımlayacak bir algoritma tanımlanmıştır. MATLAB kullanılarak hazırlanan bu algoritma öncelikle her bir konuşma sırasındaki F0 değerini belirleyip o sıra için aritmetik ortalama ve standart sapmayı hesaplamaktadır. Daha sonra bu ortalamanın altı ve üstü iki standart sapma değer aralığındaki değerleri o kişinin kendi konuşma sırası olarak belirlenmekte, eğer F0 değeri bu limitleri geçerse konuşma sırasının diğer konuşmacıya geçtiğini belirtmekte ve veri dosyasına bu şekilde kaydetmektedir (kadın ya da erkek sırası gibi; 0 - 1). Diyalogdaki örtüşen konuşma kesitleri ise analize dahil edilmemiştir (overlapping frames). Otomatik sıraya atama algoritması daha sonra elle kontrol edilmiş ve algoritmanın sıraları doğru sınıflandırdığı görülmüştür (bkz., Ek 2).

Analiz Stratejileri

Doğal diyaloglardan elde edilen verileri analiz etmek için farklı istatistiksel yöntemler kullanılmıştır. İlk olarak, cinsiyet ve ilişki türü (romantik ya da yabancı partner) bakımından ses özelliklerinin nasıl farklılaştığını incelemek için betimleyici istatistikler yapılmıştır. İkinci olarak doğal diyalogda sıralı konuşma esnasında çiftlerin birbirlerini nasıl etkilediğini ortaya çıkarmak amacıyla Granger-nedensellik testi yapılmıştır. Bir diğer anlamda konuşma esnasında kadının önceki F0 değerlerinin erkeğin sonraki F0 değerlerini etkileyip etkilemediği (aynı şekilde erkeğin kadını) test edilmiştir. Son olarak, kişilerarası iletişimde vokal senkroninin bireysel farklılıklardan (bağlanma boyutları ve ilişki doyumu) etkilenip etkilenmediğini incelemek amacıyla ikili Hiyerarşik Doğrusal Modelleme yöntemi (dyadic Hierarchical Linear Modeling-HLM) kullanılmıştır.

Yöntem

Katılımcılar

Çalışmaya Cornell Üniversite'nde lisans eğitimlerini sürdürmekte olan 12 Amerikan heteroseksüel çift katılmıştır (N = 24). Çalışmaya katılanların ortama yaşı 21.25'dir (SS = 1.03). Örneklemdeki kadın katılımcıların yaş aralığı 19 – 22 (M = 21.17, SS =

.94) arasında, erkek katılımcıların yaş aralığı ise 19 – 24 (M = 21.33, SS = 1.15) aralığında değişmektedir. Katılımcıların çalışmaya dahil olma ölçütleri: (a) anadili İngilizce olmak, (b) konuşma ile ilgili herhangi bir bozukluk yaşamamış ya da çalışma esnasında yaşamıyor olmak ve (c) çalışmaya katıldıkları partnerleri ile en az 3 aydır romantik ilişkide olmak şeklinde belirlenmiştir. Çiftlerin ortalama ilişki süresi 16.04 aydır (SS=6.17). Katılımcılara Cornell Üniversitesi Psikoloji bölümü katılımcı havuzu kullanılarak ya da kampüsün farklı yerlerine asılan ilanlarla ulaşılmıştır. Her katılımcıya katılımları karşılığı kendi isteklerine bağlı olarak 5$ ya da ders kredisi verilmiştir.

İşlem ve Araçlar

Oturumları iki erkek deneyci yürütmüştür. Çalışmaya katılan çiftlere ilk olarak çalışma hakkında kısa bilgilendirme yapılmıştır (Bilgilendirilmiş Onam Formu için bkz. Ek 5). Oturumlar genel olarak üç aşamadan oluşmaktadır: (1) laboratuar donanımının katılımcılar gelmeden hazır hale getirilmesi, (2) katılımcıları karşılama ve bilgilendirilmiş onam formunun okunması ve uygulamaların yapılması ve (3) ölçek uygulamalarının yapılması ve bilgilendirme. Çalışmaya başlanmadan önce Cornell Üniversitesi etik kurul izinleri alınmıştır.

Hazırlık aşamasında deneyciler çalışmada kullanılacak donanımları hazırlamış, konuşmanın yapılacağı odalardaki mikrofon ve kulaklıkların seviyesini her oturumdan önce aynı düzeye ayarlamıştır. Çalışma oturumları her zaman iki çiftle (4 kişi) aynı zamanda yapılmıştır. Konuşma görevlerinde her katılımcı karışık sırayla hem kendi romantik partnerleri hem de diğer çiftin partneri ile konuşmaları istenmiştir. Diyaloglar Rorschach mürekkep lekesi testinde yer alan 6 şekil üzerinde yapılmıştır (çalışmada kullanılan uyaranlar için bkz Ek 5).

Katılımcıların ayrı odalarda yaptıkları konuşmalar SHURE marka dinamik mikrofonlarla kaydedilmiş, geri plan sesini en aza indirecek şekilde kayıtlar yapılmıştır. İki farklı odada gerçekleşen konuşmaları katılımcılar herhangi bir zaman atlama sorunu yaşamadan gerçek zamanlı olarak birbirlerini duyabilmeleri sağlanmıştır. Konuşmalar Audacity isimli program kullanılarak kaydedilmiştir. Her katılımcı partneri ile konuşmasını bitirdikten sonra diğer çiftin parteri ile yer değiştirilerek her katılımcının iki diyalogda rol alması sağlanmıştır. Diyaloglar

yaklaşık olarak 8 dakika sürmüştür (*Ort.* = 7.54 dakika, *SS*=4.78). Bütün konuşma görevleri tamamlandıktan sonra diğer değişkenlerin ölçümlerini almak amacıyla katılımcılara bağlanma, ilişki doyumu ve temel demografik değişkenlere ilişkin ölçekler verilmiştir. Ölçek doldurma aşamasını takiben katılımcılara çalışmanın amacı hakkında bilgi verilmiş ve katılımları karşılığı 5$ ya da ders kredisi verilmiştir.

Bağlanma temelli kaygı ve kaçınma boyutları Brennan, Clark ve Shaver'in (1998) Yakın İlişkilerdeki Yaşantılar Envanteri'nin 10 maddelik kısa formu kullanılmıştır (Wei, Russell, Mallinckrodt, & Vodel, 2007). Ölçek maddeleri 7li likert tipi ölçek kullanılarak değerlendirilmiştir. Bağlanma kaygı ve kaçınma boyutu beşer soru ile temsil edilmiştir. Ölçeğin alt boyutlarının içtutarlık katsayısı kabul edilebilir düzeydedir (Kaygı; α = 78 ve kaçınma, α =.84).

İlişki Doyumu ise Fletcher, Simpson ve Thomas'ın (2000) 18 maddelik Algılanan İlişki Kalitesi ölçeği ile ölçülmüştür. Ölçek, ilişki doyumu, sadakat, güven, yakınlık, tutku ve aşk olmak üzere 6 boyuttan oluşan ve her biri 3'er madde ile temsil edilen sorulardan oluşmuştur. Bu çalışma için bütün maddelerin ortalaması alınarak genel bir ilişki doyumu puanı hesaplanmıştır. Ölçek maddeleri 7li likert tipi ölçek kullanılarak değerlendirilmiştir ve içtutarlık katsayısı kabul edilebilir düzeydedir (α =.86). Son olarak katılımcılar yaş, ilişki süresi, cinsiyet gibi bilgilerin olduğu demografik bilgiler sorularının yer aldığı kısmı tamamlamışlardır.

Bulgular

Betimleyici İstatistikler ve Grup Karşılaştırmaları

Tablo 1'de çalışmada kullanılan temel değişkenlerin betimleyici istatistikleri sunulmuştur. İlk olarak, ses özellikleri (F0 değerleri) ve konuşma yapısal özellikleri özellikleri (konuşma süresi, konuşmadaki sıra sayısı gibi) bakımından cinsiyet ve ilişki tipi farklılıkları incelenmiştir. İki yönlü ANOVA (ilişki türü grup-içi faktör) sonuçlarına göre, ortalama frekansın (F0) cinsiyetlere göre farklılaştığı bulunmuştur ($F\ (1, 22) = 990.71$, $p < .01$, $\eta^2 = .79$). Biyolojik farklılıklardan kaynaklı olarak beklendik şekilde, kadın katılımcıların ortalama ses frekansı (F0) erkeklere göre, ,daha yüksek bulunmuştur. Buna ek olarak, ilişki türü ana etkisinin diyalogdaki konuşma sırası sayısı üzerinde anlamlı etkiye sahip olduğu bulunmuştur ($F\ (1, 22) =$

17.58, $p < .001$). Yine beklendiği üzere, katılımcılar romantik partnerleri ile (M = 33.50, SS = 2.05) diyologlarında yabancı konuşma partnerine (M = 24.54, SS = 1.31) göre daha çok konuşma sırası almışlardır. Son olarak, konuşma süresi üzerinde hem cinsiyet ($F\ (1, 22)$ = 5.92, $p < .05$) hem de ilişki türü ($F\ (1, 22)$ = 14.41, $p < .001$) ana etkisinin anlamlı olduğu bulunmuştur. Katılımcılar romantik partnerleri ile (M = 291.17 saniye, SS = 18.92) yabancılara göre (M = 237.67 saniye, SS = 12.64); kadınlar da (M = 299.63saniye, SS = 20.46) erkeklere göre (M = 229.21saniye, SS = 20.46) daha uzun süre konuşmuşlardır. ANOVA analizlerinde anlamlı düzeyde etkileşim etkisi bulunmamıştır.

Tablo 1. Betimleyici İstatistikler

	Romantik Partner							
	Erkek				Kadın			
	Ort	SS	Min	Maks	Ort	SS	Min	Maks
Ortalama F0 (Hz.)	108.13	9.48	95.51	120.47	199.75	32.99	120.31	241.22
Ortalama konuşma süresi (saniye.)	253.42	83.86	168	424	328.92	100.76	204	497
Diyaloglardaki konuşma sırası ortalaması	33.75	10.1	22	60	33.25	9.97	22	59
Bağlanma Kaygısı	1.71	0.8	1	3.4	2.89	1.79	1	6.2
Bağlanma Kaçınması	1.73	1.05	1	4.6	1.64	0.68	1	3.2
İlişki Doyumu	6.03	0.94	3.39	6.94	6.26	0.46	5.44	6.89
İlişki Süresi (ay)	16.04	6.17	6	26	16.04	6.17	6	26
	Yabancı Partner							
	Erkek				Kadın			
	Ort	SS	Min	Maks	Ort	SS	Min	Maks
Ort. F0 (Hz.)	110.46	6.84	98.5	119.04	200.46	35.74	115.11	259.03
Ortalama konuşma süresi (saniye.)	205	38.41	163	287	270.33	78.73	164	472
Ortalama konuşma sırası sayısı	25.08	6.37	13	37	24	6.45	12	36
Bağlanma Kaygısı	-	-	-	-	-	-	-	-
Bağlanma Kaçınması	-	-	-	-	-	-	-	-
İlişki Doyumu	-	-	-	-	-	-	-	-
İlişki süresi (ay)								

Genel düzeydeki analizlere ek olarak, diyaloğun ilk kısmı ile ikinci kısmı arasındaki değişimi incelemek için t-testleri yapılmıştır. Bu tür bir analiz genel olarak zaman içinde konuşma partnerlerinin konuşma özelliklerinin değişip değişmediği hakkında

bilgi vermesi beklenir. Eğer konuşma partnerleri konuşma özelliklerini yakınlaştırıyorsa diyaloğun iki eşit parçası arasındaki F0 değerleri arasındaki fark anlamlı bir şekilde düşüş göstermesi beklenir. Bu amaçla katılımcıların diyalogun iki parçasındaki ortalama F0 değerleri hesaplanmıştır. Tekrarlı ölçüm t-test analizi (paired sample t-test) sonuçlarına göre yabancı konuşma partnerlerinin ortalama F0 değerlerinin diyaloğun birinci ve ikinci aşamasında birbirinden farklı olduğu bulunmuştur ($t\ (11)$ = 2.90, p < 0.01). Fakat aynı etki romantik partnerlerin konuşmaları için anlamlı bulunmamıştır ($t\ (11)$=0.29, *ns*). Diğer bir deyişle, yabancı partnerlerin konuşmalarının ikinci kısmındaki ortalama F0 değerleri birinci kısmında göre birbirine daha yakın bulunmuştur ($M_{1.\ kısım}$ = 105.51; $M_{2.\ kısım}$ = 99.63). Yabancı partnerler konuştukça ses frekansları birbirine yakınlık göstermeye başlamıştır.

Yabancı partnerlerden kadın mı yoksa erkek mi diğerine daha yaklaşıyor sorunun cevabı sıra temelli analizlerle ortaya konulmuştur. Bu analizlere ilerleyen aşamalarda değinilecektir. Bir başka bulgu ise, konuşmanın iki parçası arasındaki farkın romantik partnerler için anlamlı bulunmamasıdır ($M_{1.kısım} = 104.60;\ M_{2.kısım} = 103.75$). Bu bulguya olası bir açıklama, romantik partnerlerin zamansal olarak çok daha önceden yakınlaştığı ya da yakınlaşma (benzeme) yerine başka bir örüntü göstermiş olabileceğidir.

Temel frekans değerleri arasındaki genel korelasyonlar

Çalışmaya katılan katılımcıların diyalog sırasındaki ses frekanslarının her 10 salisede kaydedildiği ve her katılımcının hem romantik partneri hem de yabancı partnerle konuşurken kaydedilmiş F0 değerler serisi olduğu dile getirilmişti. Bu noktada, katılımcıların romantik partneri ve yabancı partner ile konuşurken elde edilen F0 serilerinin global düzeyde karşılaştırılması yapılmıştır. Bunun için iki F0 serisi arasındaki korelasyon katsayıları her diyalog için (toplam 24 diyalog) hesaplanmıştır. Tablo 2'de iki F0 serisi için elde edilen korelasyon katsayılarını verilmiştir. Tabloda da görüleceği üzere, ortalama korelasyon katsayıları romantik partnerler için .25, yabancı partnerler için ise .07 olarak bulunmuştur (bkz. Tablo 2).

Tablo2. Her çiftin konuşmasında F0 serilerinin korelasyon katsayıları

101 F	**102 F**	**103 F**	**104 F**	**105 F**	**106 F**	**107 F**	**108 F**	**109 F**	**110 F**	**111 F**	**112 F**

101 M	0.22	0.06										
102 M	0.02	0.18										
103 M			0.25	0.10								
104 M			0.07	0.21								
105 M					0.32	0.05						
106 M					0.12	0.23						
107 M							0.36	0.02				
108 M							0.03	0.19				
109 M									0.27	0.04		
110 M									0.12	0.34		
111 M											0.25	0.08
112 M											0.10	0.20
Mean Close Relationships	0.25											
Mean Stranger Pairs	0.07											

M. Erkek Katılımcı; F.Kadın Katılımcı

Not: Çaprazdaki gölgelendirilmiş kutucuklar romantik partnerler arası korelasyonu göstermektedir.

Her ne kadar romantik partnerler arası korelasyon katsayılarının büyüklüğü göze çarpsa da Fisher'in r-den-z ye döndürme testi sonucuna göre yabancı partner ve romantik partner arasındaki korelasyon katsayıları anlamlı olarak birbirinden farklılaşmamaktadır (z=0.40; p=0.34). Ancak Fisher'in r-den-z ye döndürme testi'nin örneklem büyüklüğünden etkilenen bir analiz tekniği olduğu göz önüne alınarak (Preacher, 2002) söz konusu anlamsız ilişki daha büyük örneklemlerde tekrar test edilmelidir.

Granger nedensellik analizi: Diyaloglarda sıra temelli analizler

Diyaloglardaki partnerlerin sıra ile konuşma esnasında birbirlerini nasıl etkilediğini anlamak konuşmadaki senkroni sürecini kestirebilmek açısından önemlidir. Granger-nedensellik analizi konuşma yapan kadın ve erkek katılımcılar arası nedensel ilişkileri ortaya çıkarma açısından kullanışlı bir analizdir.. Başka bir deyişle, kadın katılımcının kendi konuşma sırasındaki (ve önceki sıralardaki) ortalama F0 değeri erkek katılımcının daha sonra takip eden sıradaki F0 değerini etkiler mi sorusunun

cevabını Granger-nedensellik testi sonuçları verecektir. Bu bakımdan analiz bulguları senkronik bir süreçten bahsedilip bahsedilmeyeceği sorusuna cevap vermiş olacaktır. Özetle, kim kimi nasıl etkiler sorusuna cevap verilmiş olacaktır.

İlk olarak, Grager-nedensellik testinin bir gerekliliği olan kullanılacak veri serisinin durağan (stationary) olup olmadığı test edilmiştir. Bu amaçla MATLAB kullanılarak Augmented Dickey-Fuller (ADF) test hesaplanmıştır (Brooks, 2008). Bütün tekil seriler için (bu çalışmada 24 kişinin toplamda 48 F0 serisi) ADF testi sonucunda F0 serilerinin durağan olduğu bulunmuştur.

İkinci adımda, ham F0 serilerinin şoklar ve aşırı ölçümlerden arındırıldığı yeni F0 serileri hesaplanmıştır. Bunun için zaman serileri analizi kullanılarak otokorelasyondan bağımsız seriler hesaplanmıştır. Her diyalog için yeri seriler eşleştirilmiş ve Granger-nedensellik testi uygulanmıştır. Örneğin 1 nolu erkek katılımcının F0 serisi ile romantik partnerinin F0 serisi eşlenmiş, partnerlerden hangisinin diğerini etkilediği zamansal olarak test edilmiştir. Aynı işlem diğer bütün olası eşleşmeler için de yapılmıştır (toplam 24 diyalog). Granger-nedensellik testi F0 değerlerinin romantik partner diyaloglarında iki yönlü etkisine (bidirectional) işaret etmektedir. Granger-nedensellik testi F istatistiklerine göre, kadın katılımcının romantik partneri ile konuşurken diyalogdaki önceki sıralardaki F0 değerleri erkek katılımcının sırası geldiğinde konuşurken ürettiği F0 değerlerini etkilemektedir. Bunu tam tersi de geçerlidir. Yani erkek katılımcının diyalogdaki F0 değerleri romantik partnerinin daha sonraki F0 değerlerini etkilemiş, üstelik bu etkiler kişinin daha önceki kendi F0 değerleri kontrol edildikten sonra da gözlenmiştirr (*Ortalama* R^2 = .15). Daha önce Granger-nedensellik testini kullanan EEG çalışmalarında da önerildiği üzere, ikiyönlülük (bidirectionality) döngüsel ve senkronik süreçlere işaret etmektedir (örn., Barrett ve ark., 2012). Dolayısıyla, romantik partner diyaloglarındaki Granger-nedensellik testi romantik partnerlerin diyaloglarında senkronik bir örüntü önermektedir.

Betimleyici istatistikler kısmındaki bulgularla paralel olarak, yabancı partnerler arası diyalogları test eden Granger-nedensellik analizi sonuçlarına göre ise ikiyönlülük değil, tekyönlülük (unidirectionality) söz konusudur. Kadın katılımcıların konuşmada kullandığı F0 düzeyi yabancı erkek partnerin takip eden konuşmada F0 düzeyini

etkilemekte, ancak erkek katılımcıların F0 düzeylerinin yabancı kadın partnerlerinin takip eden F0 değerlerini etkilemediği bulunmuştur (*Ortalama* R^2 = .17). Özetle, romantik partner ile diyalogda kadının F0 düzeyi erkeğin daha sonraki F0 düzeylerini, erkeğin F0 düzeyi de kadının daha sonraki F0 düzeylerini karşılıklı olarak etkilerken, yabancı partner diyalogunda sadece kadının F0 düzeyi erkeğin daha sonraki F0 düzeylerini anlamlı olarak etkilemektedir. Bu açıdan bulgular, romantik partnerin diyalogda döngüsel bir ilişki gösterdiklerini, yabancıların F0 değerlerinin ise kadının etkileri ile devam ettiğini göstermektedir.

Vokal Senkroniyi etkileyen farklılıklar: İkili Hiyerarşik Doğrusal Modelleme (HDM)

Psikolinguistik alanındaki daha önceki çalışmalar bir konuşmada F0 düzeyindeki yüksek değişkenliğin asenkron iletişimin bir göstergesi olabileceğini ileri sürmüşlerdir (örn., LaGasse, Neal, ve Lesser, 2005). Vokal senkroniyi etkileyebilecek olası değişkenleri incelemek amacıyla çift-içi düzey (within-dyad level) ve çiftler-arası düzey (between dyad level) olmak üzere 2-düzeyli HDM kullanılmıştır. Çift-içi düzey (Düzey 1) değişkenleri katılımcının cinsiyeti ve ilişki türünden (romantik ya da yabancı partner) oluşmaktadır. Çiftler –arası düzey (Düzey 2) ise bağlanma temelli kaygı ve kaçınma, ilişki doyumu ve ilişki süresinden oluşmaktadır. Buna göre katılımcıların diyalogdaki her sıradaki F0 değişkenliği çıktısı (outcome) incelenmiş ve bu değişkenliği yordayan çift-içi ve çiftler-arası değişkenlerin değişkenlik üzerindeki rolü HDM ile test edilmiştir. Model testi Raudenbush, Brennan ve Barnett'in (1995) önerdiği yöntemle hesaplanmıştır. Hesaplamalar HLM 7.0 paket programı kullanılarak gerçekleştirilmiştir.

Test edilen 2 düzeyli modelin F0 düzeyindeki değişkenliği anlamlı bir şekilde açıkladı bulunmuştur, $\chi^2(6, N=48) = 251.70$, $p < .001$ ve diyaloglarda her sıradaki F0 değişkenliğin % 19'unu açıklamaktadır (ICC = 0.19). İlişki türü ve cinsiyetin F0 düzeyindeki değişimi yordayıp yordamadığını test etmek amacıyla cinsiyet ve ilişki türü "dummy" kodlama ile denkleme Düzey 1 değişkenleri olarak dahil edilmiştir. Modelde analizin varsayımlarından bir olan çoklu doğrusallık bulunmaması koşulu sağlanmıştır (Ortalama VIF = 2.24).

Çiftler-arası düzey olan Düzey 2 model ise diyalogdaki her sırada katılımcının F0 değişkenliğini etkileyebilecek olası değişkenlerden oluşmaktadır. Bunlar bağlanma temelli kaygı, kaçınma, ilişki doyumu ve ilişki süresidir.

HDM sonuçlarına göre, hem Düzey 1 değişkenleri hem de Düzey 2 değişkenleri konuşmadaki F0 değişkenliğini anlamlı bir şekilde yordamaktadır. Buna göre, romantik partneri ile konuşan katılımcılar yabancı partner ile konuşanlara oranla daha az F0 değişkenliği göstermektedir. Katılımcıların cinsiyeti de aynı zamanda F0 değişkenliğini anlamlı olarak yordamaktadır: kadın katılımcılar erkeklere oranla daha fazla F0 değişkenliği göstermektedir. Düzey 2 modeli ise bağlanma temelli kaygı ve ilişki doyumun diyaloglardaki konuşma sıralarında F0 değişkenliği yordadığını göstermiştir. Bağlanma temelli kaygı arttıkça F0 değişkenliği artmakta, ilişki doyumu arttıkça da F0 değişkenliği azalmaktadır. Bağlanma temelli kaçınma eğiliminin ise anlamlı bir etkisi gözlenmemiştir. Sonuçlar özetle, romantik partnerlerin, düşük bağlanma kaygısı olanların (güvenli bağlananlar) ve yüksek ilişki doyumu olanların F0 düzeylerinin diyaloglarda daha senkronik bir yol izlediğini göstermiştir.

Çalışma 2

Birinci çalışma vokal ipuçlarını kullanarak romantik partnerler arası eşdüzenleme kavramının incelemeyi amaçlamıştır. Sıra temelli analizler romantik partnerler arası F0 düzeylerinin birbirini iki yönlü olarak etkilediğini, yabancı partner diyaloglarında ise sadece kadınların erkekleri etkilediğini göstermiştir. Bunlara ek olarak vokal senkroni sürecine etki edebilecek bireysel farklılıkları incelemiştir. Birinci çalışmanın bulgularına dayanarak romantik partnerlerin diyaloglarındaki tonlama özelliklerinin kendilerine özgü ipuçları içermesi gerektiği öne sürülebilir. İkinci çalışmada bu tonlama özelliklerinin üçüncü kişiler tarafından ayırt edici bir şekiklde algılanıp algılanmadığını test etmektedir. Sınırlı sayıda çalışma insanların başkaları ile konuşmalarını, kelimelerini, ritimlerini dinleyerek kiminle konuştukları hakkındaki kestirimlerinin doğruluğunu ve bu kestirimlerin hangi temellere dayandırıldığını incelemiştir (Örn., Montepare ve Vega, 1988). Bu çalışmalar konuşma partnerlerinin konuşmalarının içeriğine odaklanmış, tonlama ve vurgulama gibi sözel olmayan iletişim ipuçlarının tanınabilirliği ve/veya ayırt ediciliğine odaklanmamıştır. İkinci çalışmada hiçbir sözel içerik olmadan, konuşma partnerlerinin sadece tonlamasından yola çıkarak üçüncü kişilerin romantik partner konuşmasındaki tonlamaları ne oranda ayırt edebildiği incelenmiştir. Bu çalışmanın sonucunda romantik partner tonlamasının ayıredilebilirlik düzeyi hakkında bilgi edinilmiş olacaktır.

Bu amaçla, Dehaene-Lambertz ve Houston'ın (1997) yöntemi kullanılarak, kayıt edilmiş diyaloglardan birer dakikalık kesitler alınmış ve bu kayıtlara PRAAT paket programı (Boersma & Weenink, 2013) aracılığıyla "low-pass" filtreleme uygulanmıştır. Böylece, low-pass filtreleme sonucu kayıttaki sözel içerik tamamen tanınmaz hale gelmiş, sadece konuşmanın tonlaması kalmıştır. Buna göre, 24 adet birer dakikalık ses dosyaları oluşturulmuştur.

Yöntem

Katılımcılar

Çalışmaya Amazon Mechanical Turk sitesi aracılığıyla 156 kişi katılmıştır ($M_{yaş}$=34.75 yıl, *SS*=13.06). Yirmi dört adet filtrelenmiş ses kaydı Qualtrics aracılığıyla Amazon Mechanical Turk sitesine yüklenmiştir. Çalışmada 51 erkek, 105 kadın katılımcı yer almıştır. Katılımcıların yaklaşık yarısının halihazirda bir ilişkisi bulunmaktadır (*n*=79). Çalışmaya katılımları karşılığında katılımcılara 50 cent ödenmiştir.

İşlem

Katılımcılardan 24 adet bir dakikalık kesitleri sonuna kadar dinlemeleri ve dinledikleri kesitin romantik partner mi yoksa yabancı partner diyaloğuna mı ait olduğunu beyan etmeleri istenmiştir. Bütün kayıtları dinledikten neden bu yargıya vardığını, verdiği karardan ne kadar emin olduğu hakkında sonra bir seri soruya cevap vermeleri istenmiştir.

Analiz stratejisi: Signal tanıma kuramı

Katılımcıların sınıflandırma doğruluğunu A-prime (A') puanı kullanılarak hesaplanmıştır (Stanislaw & Todorov, 1999). A' romantic partner ya da yabancı partner sınıflandırmasının ne kadar başarılı bir şekilde geçekleştiği hakkında bir duyarlık (sensitivity) puanıdır. Genellikle A' olasılık skalasında yorumlanır ve şans olasılığı olan 0.5'ten yüksek bir rakam olması beklenir. Bütün katılımcılar için A' puanı hesaplanmıştır.

Bulgular

Tek yönlü t test sonuçları katılımcıların romantik partner tonlamasının başarılı bir şekilde sınıflandırma ya da ayırt etme olasılığının şanstan daha yüksek olduğu göstermiştir (*Ort A'* = .55), $t\ (155) = 3.75$, $p < .001$, Cohen'in (1992) etki büyüklüğü d=0.60). Romantik partner tonlamasının başarılı bir şekilde tanınması ilgili yazın açısından kritik öneme sahiptir: romantik partner tonlaması, vurgulaması kendine özgü özellikler barındırmakta ve bu özellikler üçüncü bir kişi tarafından da ayırt edilebilmektedir. Üstelik bu ayırt edicilik sözel içerik olmadan, sadece vokal özelliklerden yola çıkarak gerçekleşmektedir.

Genel Notlar

Bu tez çiftlerin birbirlerinin duygusal süreçlerine ilişkin karşılıklı etkilerinin vocal düzeyde de gözlenebileceğini göstermiştir. Bununla birlikte bu çalışma sözkonusu karşılıklı etkilenen duygusal mekanizmaları etkileyebilecek olası değişkenlerden bağlanma kaygısı, ilişki doyumu gibi değişkenlerin önemine vurgu yapmaktadır. Çiftler arasındaki birlikte değişimi, eşdüzenlemeyi ya da sekroniyi düzenleyen altta yatan mekanizmaları incelemek yakın ilişkilerinişlevini, özellikle de ilişki doyumu gibi süreçlerin dayandığı örtük fiziksel ve psikolojik süreçleri anlamak bakımından hem ilgili alana hem de uygulamaya önemli katkılar sağlayacaktır.

Bu tezden elde edilen bulgular eşdüzenleme sürecinin öneminin altını çizmektedir. Bir partnerin duygusal tepkilerini düzenlemesinin diğeri üzerindeki etkisi ve bu eşdüzenlemenin bireylerin fizyolojik dengesini sağladığını pek çok çalışma göstermiştir. Özellikle olumsuz duyguların başarılı bir şekilde eşdüzenlenmesi kişilerarası ve kişinin iç dünyasına ilişkin faydalar sağladığı düşünülmektedir. Bu anlamda bu tezden elde edilen bulgulan alana özgün bir katkı niteliğindedir.

TEZ FOTOKOPİSİ İZİN FORMU

ENSTİTÜ

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YAZARIN

Soyadı: HARMA
Adı : MEHMET
Bölümü: PSİKOLOJİ

TEZİN ADI (İngilizce): Vocal synchrony as a coregulation indicator of attachment bonds.

TEZİN TÜRÜ: Yüksek Lisans [ ] Doktora [X]

1. Tezimin tamamından kaynak gösterilmek şartıyla fotokopi alınabilir. [X]
2. Tezimin içindekiler sayfası, özet, indeks sayfalarından ve/veya bir bölümünden kaynak gösterilmek şartıyla fotokopi alınabilir. [ ]
3. Tezimden bir bir (1) yıl süreyle fotokopi alınamaz. [ ]

TEZİN KÜTÜPHANEYE TESLİM TARİHİ: