DISORDER-SPECIFIC PATTERNS OF EMOTION COREGULATION IN COUPLES: COMPARING OBSESSIVE-COMPULSIVE DISORDER AND ANOREXIA NERVOSA

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ABSTRACT

Melanie Sandy Fischer: Disorder-Specific Patterns of Emotion Coregulation in Couples: Comparing Obsessive Compulsive Disorder and Anorexia Nervosa
(Under the direction of Donald H. Baucom)

Impaired emotion regulation and maladaptive strategies to manage distress are central to psychopathology, including obsessive-compulsive disorder (OCD) and anorexia nervosa (AN). Emotion regulation can be fostered or thwarted by romantic partners, and the tendency to rely on interpersonal emotion regulation may vary by disorder. The current study examined disorder-specific patterns of emotion coregulation in couples in which one partner suffers from OCD or AN. Research suggests that patients with OCD heavily rely on partners to regulate distress while patients with AN shut partners out. It was hypothesized that OCD is associated with exaggerated and AN with diminished coregulation, and that OCD patients show greater overall emotional arousal than AN patients. Greater symptom severity was expected to exacerbate these opposing tendencies. Following treatment, emotional arousal and coregulation were expected to decrease in OCD patients and increase in AN patients. Vocally encoded emotional arousal (fundamental frequency) was measured during couple conversations before and after couple-based treatment among 52 couples in which one partner suffered from either OCD or AN. Two indicators of emotion coregulation from a dynamic systems perspective (covariation and coupling) were analyzed using cross-lagged actor-partner interdependence and coupled linear oscillator models. OCD patients showed greater overall emotional arousal than AN patients, and emotional arousal further decreased in AN patients with treatment. Covariation differed in the opposite direction of the hypothesis (greater in AN compared to OCD); there was no difference in coupling. AN patients exhibited consistent coregulation, indicating high reactivity to partners` emotional arousal which may contribute to interpersonal avoidance. OCD couples showed limited predictability of patients’ emotional arousal over time, while partners were affected by the patients’ arousal; thus, symptom accommodation may in part be partners’ attempts at managing their own distress. Symptom severity was not associated with emotional arousal or coregulation. As expected, coregulation decreased in OCD couples after treatment, but was mostly maintained in AN couples. This was the first investigation of emotion coregulation in couples relative to psychopathology, which adds to a more comprehensive understanding of interpersonal factors in OCD and AN. Ultimately, future insights could serve to identify interpersonally oriented targets to optimize treatment.

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LIST OF ABBREVIATIONS

AN	Anorexia nervosa
APIM	Actor-Partner Interdependence Model
BMI	Body mass index
EDE	Eating Disorders Examination
CLO	Coupled linear oscillator
f_0	Fundamental frequency
OCD	Obsessive-compulsive disorder
LLA	Local Linear Approximation
UCAN	Uniting Couples in the Treatment of Anorexia Nervosa
Y-BOCS	Yale-Brown Obsessive-Compulsive Scale

CHAPTER 1: INTRODUCTION

In recent decades, the field of clinical psychology has recognized a need to move beyond studies of symptoms, diagnoses, and their correlates towards a more functional understanding of the biological, psychological, and social factors that underlie individual disorders. Most recently, this shift to a focus on dimensions and mechanisms that cut across different disorders is prominently reflected in the National Institute of Mental Health's Research Domain Criteria (RDoC) initiative (Insel et al., 2010). In many ways, changes in the experience, expression, and regulation of emotions are central to most psychological disorders and, thus, warrant special consideration (Kring, 2010). Whereas the type of emotions that are most relevant may differ greatly across disorders, many disorders have in common that individuals experience increased negative emotions, which they may respond to in a variety of ways. Typically, individuals with a given disorder have developed strategies to respond in a way that (seemingly) reduces distress in the short term, even if this maintains the disorder at the same time. This is quite obvious in avoidance behavior in anxiety disorders but also relevant for the understanding of other behaviors such as non-suicidal self-injury, which can serve a powerful function in regulating severe emotional distress for some individuals (Klonsky, 2007; Nock, 2009). Even disorders that are not primarily thought of as mood or anxiety disorders are often closely tied to emotional disturbances and maladaptive strategies that individuals employ to regulate distress. For example, disordered eating and starvation in anorexia nervosa (AN) may serve to regulate negative emotions in individuals high in trait anxiety, harm avoidance, and biological factors that include a predisposition to experience dietary restraint as calming (Brockmeyer et al., 2012; Haynos & Fruzzetti, 2011; Kaye et al., 2003; Kaye et al., 2005; Thornton, Dellava, Root, Lichtenstein, & Bulik, 2011). Thus, emotion regulation is a construct that has important implications for different disorders and their maintenance. Indeed, transdiagnostic conceptualizations and treatment approaches that consider processes related to emotion regulation have become increasingly common, for example, with a focus on experiential avoidance in anxiety disorders, depression, and eating disorders (Barlow et al., 2011; 2007; Hayes, 2012; Hayes, Wilson, Gifford, Follette, & Strosahl, 1996; Haynos & Fruzzetti, 2011).

In order to understand the function of emotions in individual disorders more fully, it is critical to consider the interpersonal context in which emotions occur. Emotions play a highly adaptive social communicative function deeply rooted in evolution (Juslin & Scherer, 2005; Keltner & Haidt, 1999; Turner, 2000), and healthy emotional development is dependent upon interpersonal processes such as early attachment (Bowlby, 1969; Diamond & Aspinwall, 2003; Sbarra & Hazan, 2008). Despite the long tradition of understanding children and adolescents' emotion regulation in a social context in the developmental literature, this has only become a focus in research on adults more recently (Butler, 2011; Butner, Diamond, & Hicks, 2007; Diamond & Aspinwall, 2003; Ram, Shiyko, Lunkenheimer, Doerksen, & Conroy, 2014; Sbarra & Hazan, 2008). Arguably, romantic partners represent the primary close relationship for many adults. Most emotion research has been focused on normative processes in healthy couples, and, to some extent, in maritally distressed individuals but without a focus on psychopathology. Such investigations include, for example, findings that emotions and physiological arousal associated with emotions become coregulated in couples (Butler & Randall, 2013; Sbarra & Hazan, 2008), that romantic partners can serve an important stress buffering function for their significant other

(Coan, Schaefer, & Davidson, 2006), and that relationship distress is often associated with a pattern of negative reciprocity in which partners' negative communications incite the other person to react negatively in return, which also leads negative emotions to escalate (Levenson & Gottman, 1983; Pasch, Bradbury, & Davila, 1997).

Much less empirical evidence is available about interpersonal emotional processes as they relate to individual psychopathology. At the same time, on a broader level, close others are important in understanding and treating psychological disorders that are typically conceptualized as individual problems. Much of this research is focused on behavioral patterns among family members or partners and patients. For example, relapse rates in schizophrenia are greatly elevated if an individual returns to a family with high levels of expressed emotion (Brown, Birley, & Wing, 1972; Hooley, 2007); symptom accommodation can inadvertently thwart recovery from obsessive-compulsive disorder (Boeding et al., 2013), and social support has been linked to a host of positive outcomes including a better prognosis in individuals with psychological disorders (Dobkin, Civita, Paraherakis, & Gill, 2002; Peirce, Frone, Russell, Cooper, & Mudar, 2000). More specific to adult psychopathology in a couples context, there is evidence demonstrating both cross-sectional and longitudinal associations between relationship distress and individual psychopathology across disorders, benefits of including a romantic partner in treatment, and evidence that the effectiveness of individual psychotherapy is diminished if relationship distress is not addressed (see Whisman & Baucom, 2012 for a review). Taken together, multifaceted links between individual psychopathology and interpersonal relationships clearly exist, yet the role of emotions within this interpersonal context of psychopathology has been underemphasized.

Thus, it is clear that changes in the experience and regulation of negative emotions play a central role in psychopathology; that understanding basic emotional processes in an interpersonal context is critical in adults; and that on a behavioral level, the way that patients and partners interact is important for the maintenance and treatment of individual disorders. Yet, these three areas remain somewhat separate lines of research. Thus far, there has been limited investigation regarding interpersonal emotion systems in couples in the context of psychopathology, and which disorder-specific patterns of emotion coregulation may contribute to the maintenance of a problem.

The current study combined these lines of research to examine interpersonal emotion regulation processes in adult couples and the degree to which different patterns of coregulation that are specific to various disorders exist. For this initial application, obsessive-compulsive disorder (OCD) and anorexia nervosa (AN) were chosen for study because couples addressing these two disorders appear to interact around the disorders in different and somewhat opposite ways, despite the fact that both disorders are marked by high anxiety. A comparison of these two groups could, therefore, facilitate the identification of distinct patterns of interpersonal emotion regulation, which could then be attributed to truly disorder-specific processes rather than resulting from the mere presence of anxiety. Drawing on advances both in the methods available to measure emotional arousal in couple interactions (i.e., speech signal processing) and to model coregulation and related features of interpersonal emotion systems (time series and dynamic systems modeling), the current investigation also utilized methods and statistics that are seldom applied in psychopathology research but have the potential to make unique contributions.

In the following discussion, research on close relationships is addressed from a dynamic systems perspective in order to identify interpersonal emotional processes that may be particularly relevant in understanding psychopathology. Next, the selection of OCD and AN is discussed in more detail, along with a review of disorder-specific behavioral patterns in OCD and AN, as well as other factors that may affect interpersonal emotion regulation in the context of these disorders. Finally, speech signal processing is introduced as a method that allows for the measurement of emotional arousal in a way that has specific advantages in an interpersonal context.

Interpersonal Emotion Regulation as a Normative Process

Before turning to considerations about interpersonal emotion regulation in specific psychological disorders, it is important to understand relevant healthy emotional processes in couples that may become altered when one partner suffers from a disorder such as OCD or AN. A number of processes included under the umbrella of interpersonal emotion regulation have particular relevance in this context. The term *emotion regulation* is used in various ways throughout the literature (Gross, 2013). In the current context, emotion regulation is used to describe the processes by which "the occurrence, duration, and intensity of subjective experience, expression, and physiological arousal associated with emotions" are influenced (Butler & Randall, 2013, p. 367). Interpersonal emotion regulation, therefore, refers to processes through which each partner's occurrence, duration, and intensity of emotions are affected by the other partner and the interaction between partners. This could take the form of one person affecting the other partner through the one person's behaviors or emotions (e.g., emotion contagion, in which one partner might experience an increase in an emotion that the other partner displays), or the unique phenomena that evolve from the interplay of both partners' emotion systems (e.g., coregulation as described in more detail below).

This definition of interpersonal emotion regulation emphasizes that, in order to fully understand the ways in which emotions are interpersonally regulated, it is not sufficient to consider only the additive effects of each partner's individual emotion regulation efforts or responses of one partner to the other (Butler, 2011; Butler & Randall, 2013; Diamond &

Aspinwall, 2003; Sbarra & Hazan, 2008). Rather, it is particularly important to examine processes such as coregulation that result from the interactions of the two individuals as a self-organizing, self-stabilizing system that promotes homeostasis and adapts to internal and external demands (Sbarra & Hazan, 2008). This concept of a self-stabilizing unit aimed toward homeostasis is a notion with a long tradition in family systems theories (Papero, 1990) but also reflects similar thinking found in dynamic systems theories (Butler, 2011). Originally based in the natural sciences, dynamic systems theories have found an increasing number of applications in psychology, particularly in conceptualizations of relationships and emotions as dynamic systems (Butler, 2011; Grandjean, Sander, & Scherer, 2008; Scherer, 2009). This perspective goes hand in hand with many of the traditional family systems ideas, but dynamic systems theory contributes terminology and models that allow us to describe and investigate important processes in close relationships in a more specific manner (Butler, 2011; Ferrer & Helm, 2013; Gottman, Swanson, & Swanson, 2002; Helm, Sbarra, & Ferrer, 2012; Ram et al., 2014; Steele & Ferrer, 2011). This approach also includes a greater focus on research designs and statistical methods that map onto interpersonal dynamics in a meaningful way as they unfold over time (Boker & Laurenceau, 2006; Castro-Schilo & Ferrer, 2013; Deboeck, Boker, & Bergeman, 2008; Felmlee & Greenberg, 1999; Ferrer & Helm, 2013).

In a dynamic systems framework, each individual's emotions can be understood as a system itself, consisting of multiple components (such as experienced feelings, physiological arousal, neurological processes) that oscillate over time and self-regulate in a lawful manner (Grandjean et al., 2008; Scherer, 2009). In addition, relationships can also be conceptualized as dynamic systems characterized by each person's behaviors, cognitions, emotions, and physiological responses (Butler, 2011; Gottman et al., 2002; Sbarra & Hazan, 2008;

Vallacher, Nowak, & Zochowski, 2005). Combining the two individual and relational components, an interpersonal dynamic system of emotions is then characterized by the two parallel oscillating emotion channels of the two individuals, which not only affect each other but also interact in unique ways that lead to self-regulation of the system, and, ideally, can serve to promote homeostasis at an adaptive level in a way that reduces individual costs of allostasis (Butler & Randall, 2013; Diamond, Hicks, & Otter-Henderson, 2008; Field, 2012; Sbarra & Hazan, 2008). Another important aspect of this conceptualization is the temporal dimension and ongoing change, with the implications that the state of the interpersonal system results from the state of all its parts at a given moment, its past states, as well as its dynamic characteristics that can only be identified using repeated observations (Butler, 2011).

The application of dynamic systems models is not specific to the study of emotion processes and romantic relationships, and previous studies have focused, for example, on behavioral patterns in couples (e.g., Boker & Laurenceau, 2006; Felmlee & Greenberg, 1999) and emotion regulation in parent-child dyads (e.g., Feldman, 2003) in similar frameworks. An exhaustive review of the literature on relationships as dynamic systems is beyond the scope of the current study, but a number of empirical studies and theoretical considerations are particularly relevant to the understanding of interpersonal emotion regulation in couples from this perspective.

Coregulation as a form of interpersonal emotion regulation deserves particular attention, because of its basis for attachment, health, and emotional well-being across the life span, as well as its role in felt security in intimate adult relationships (see Butler & Randall, 2013; Field, 2012; Sbarra & Hazan, 2008 for comprehensive discussions and reviews). From a dynamic systems perspective on interpersonal emotion regulation, coregulation is defined as the “bidirectional linkage of oscillating emotional channels (...) between partners, which contributes to emotional and physiological stability for both partners in a close relationship” (Butler & Randall, 2013, p. 203). In this definition, the focus lies on coregulation of emotion components such as emotional arousal, psychophysiology, and consciously experienced feelings, but coregulation in couples also has been studied in broader emotional experiences and behaviors such as intimacy and self-disclosure (Boker & Laurenceau, 2006). Of note, the notion of oscillations around a stable level implies that there is an “equilibrium” specific to each person and couple, which reflects an optimal range of functioning (e.g., optimal levels of stimulation and arousal, Geen, 1984; Sterling, 2004) or a level that an individual naturally feels most comfortable at and seeks to return to (e.g., a comfortable level of intimacy, Laurenceau, Barrett, & Rovine, 2005).

By definition, coregulation can only be observed over repeated measures and can be studied by examining a combination of indicators including covariation and more complex links such as the degree to which oscillations are coupled (Butler, 2011). Covariation is concerned with the degree to which the two partners’ levels of emotion are linked and move in tandem, while coupling is focused on the question of whether the dynamics of the oscillations of one partner (e.g., how rapidly they occur, how long it takes to return to equilibrium) are coupled to the other partners’ emotions. For example, studies that examine coregulation as covariation find that psychophysiological variables (Levenson & Gottman, 1983; Saxbe & Repetti, 2010) and self-reported emotions (Butner et al., 2007; Randall, Post, Reed, & Butler, 2013; Saxbe & Repetti, 2010; Schoebi, 2008) covary during brief interaction tasks (Levenson & Gottman, 1983; Randall et al., 2013) and further spaced measures across several days to weeks (Butner et al., 2007; Saxbe & Repetti, 2010; Schoebi, 2008). Note that whereas these investigations demonstrate bidirectional linkage between levels of emotions of the partners, they do not explore whether the dynamic properties of each person's emotional oscillations are related to the other partner's emotions. Modeling these more complex aspects of the bidirectional linkage of the dynamics of each partner's emotional oscillations has become more feasible with the applications of differential equation models in this context. In particular, coupled linear oscillator models allow investigators to assess coupling as the interdependence of dynamic systems (Boker & Laurenceau, 2006; Boker & Nesselroade, 2002; Butner et al., 2007; Helm et al., 2012), but other applications of differential equation models for modeling regulatory processes have been described as well (e.g., Deboeck, Montpetit, Bergeman, & Boker, 2009; Ferrer & Helm, 2013). As described in more detail by Boker and Laurenceau (2006), coupled oscillators can be visualized as a set of two pendulums, each representing one partner's emotions. Each pendulum will swing back and forth through an equilibrium point, and the properties of each pendulum's swings can be described based on frequency, acceleration, and friction (leading to slowing of the swings). Thus, two pendulums (i.e., partners) may have their own patterns of oscillations, but in an interpersonal emotion system, these oscillations do not occur independently from one another. To represent this notion, one can imagine the two pendulums being connected by a set of springs. That is, the dynamics of each pendulum's motions are coupled to the other pendulum, leading to changes in the characteristics of both pendulums' oscillations (e.g., a pendulum may take longer to return back to equilibrium). The ways in which one partner's emotional oscillations are coupled to the other partner in a coregulated emotion system can be thought of as very similar to the main properties of the coupled pendulums, with the only exception that coupling in dyads may be asymmetric; that is, one person's emotional experience may be coupled more strongly to their partner than the reverse (Boker & Laurenceau, 2006).

A number of studies have applied this conceptualization to different components of emotions in couples. For example, Helm et al. (2012) reported coupling of respiration and heart rate in couples across three experimental tasks. Boker and Laurenceau (2006) found coupling of husbands' and wives' self-reported daily intimacy, and these models have also been applied to other dyadic settings using vocally encoded emotional arousal in parents and children (B. R. Baucom, Iturralde, et al., 2012). As Butler and Randall (2013) suggest, coregulation should ideally be assessed using multiple steps and models to assess covariation around a stable level as well as coupling, although this has rarely been explored thus far within a single investigation of couples. In a rare exception, Butner et al. (2007) found covariation of positive and negative self-reported daily affect and coupling of positive affect in couples.

Of course, other forms of interpersonal regulatory processes in couples can occur as well, including processes that imply an escalating or deescalating trajectory over time. Rather than fluctuations around a stable level, two partners' emotion channels can be linked in a way that leads to a shared overall increase or decrease in levels of emotions over time. This suggests that some form of "transmission" of emotional experience or mutual escalation/de-escalation occurs between partners (Butler, 2011), such as upon reunion of the couple after periods spent apart (Schoebi, 2008). Notably, the phenomenon of negative reciprocity during couple conflict involves negative communication behaviors of one partner being followed by negative responses of the second partner, and vice versa, which has also been consistently shown with a mutual escalation of physiological arousal associated with negative affect (Carstensen, Gottman, & Levenson, 1995; Gottman & Levenson 1992; Levenson & Gottman, 1983). Traditionally, processes involving transmission of emotional experiences has been thought to be most relevant in a negative context (e.g., stronger for negative emotions, during conflict, and in maritally distressed couples); however, there is also evidence for transmission of emotional experiences in a positive context, such as emotion contagion mediated by empathy (Butler, 2011).

Even though behavioral efforts (intentional or unintentional) to change interpersonal emotional experiences are not interpersonal emotional regulation per se, shifts in emotions and, ultimately, coregulation or covariation around changing levels are partially mediated by partners' behaviors. For example, such shifts in interpersonal emotions include experiences of greater intimacy and closeness following partners' behaviors including self-disclosure and responsiveness of the partner (Laurenceau et al., 2005) and greater covariation of emotions if couples show greater behavioral cooperation (Randall et al., 2013). Although empirical findings with regards to behavioral patterns in couples cannot be interpreted as direct evidence of the presence or absence of interpersonal emotion regulation, this information is nonetheless meaningful. Coregulation can only evolve through behavioral interactions between the two partners, and certain behaviors may be particularly important to the facilitation of interpersonal emotion regulation (Butler & Randall, 2013; Sbarra & Hazan, 2008). For example, physical closeness including affectionate touch or sexual behavior is thought to be a major contributor to physiological and emotional coregulation in couples (Sbarra & Hazan, 2008). Greater covariation of emotional states occurs when partners are together versus when they are physically apart (Diamond et al., 2008; Schoebi, 2008), and even physical proximity without interaction at times appears to be enough for partners' physiology to become more synchronized (Helm et al., 2012). In addition, certain interpersonal behaviors are directed at change in emotions, such as expressing empathy, compassion, and support (Goetz, Keltner, & Simon-Thomas, 2010; Verhofstadt, Buysse, Ickes, Davis, & Devoldre, 2008), or engaging in dyadic coping strategies (Revenson, Kayser,

& Bodenmann, 2005). Thus, many of the adaptive behaviors often emphasized in the couple literature are likely vehicles for the establishment of interpersonal emotion regulation.

Moving towards an application of the theoretical considerations presented here to the study of coregulation in the context of individual psychopathology requires some adaptation of underlying assumptions. In particular, the conceptualization of a stable level as an optimal or comfortable level may better be thought of as a typical level in the presence of a disorder, in other words, a maladaptive but “as good as can be” level under the constraints that one partner’s disorder imposes on the system.

In conclusion, interpersonal emotion regulation occurs through a number of normative processes in healthy couples, and coregulation of emotion is a form of interpersonal emotion regulation. When conceptualizing relationships as dynamic systems and emotion regulation processes as an important factor that could contribute to the maintenance of individual psychopathology, it becomes critical to understand psychopathology in the context of interpersonal emotion systems. This is not to imply that psychopathology is a result of maladaptive relationship dynamics (in contrast to traditional family systems theories), or that a disorder has unidirectional influences on how two partners interact. Instead, the presence of a disorder is believed to introduce changes in one of the elements of the system (the patient’s emotion system) as well as place unique demands on the relationship in such a way that the system’s dynamics should, over time, be altered until some sort of stability is achieved. The resulting dynamics may not necessarily be adaptive or effectively reduce distress over time, but the dynamics should become organized as a function of the demands and constraints associated with a given disorder. This set of circumstances could mean that certain couple dynamics regulate distress to a level that is as low as possible in the short term, even if the strategies employed serve to maintain the disorder in the long term. Understanding the central features of distinct interpersonal emotion regulation patterns that emerge in the presence of a disorder may ultimately be relevant for treatment.

Disorder-Specific Patterns of Interpersonal Emotion Regulation in OCD and AN

Despite recent interest in the interpersonal context of individual psychopathology and couple-based treatments (Whisman & Baucom, 2012), no studies to date examine interpersonal emotion regulation in couples in the context of psychopathology. However, there are clear differences between disorders in terms of how individuals have learned to manage emotional distress, and this has implications for how they interact with their partners. While no direct empirical findings are available that would identify the characteristics of interpersonal emotion regulation specific to any given disorder, these behavioral patterns should, on a broader level, be related to the degree to which individuals "bring in" or "shut out" the partner from the emotional experience of the disorder. For example, it appears that in OCD, close others are inadvertently brought in into the ways in which patients manage obsessional fears, in particular by reassurance seeking and symptom accommodation. On the contrary, research on behavioral patterns and emotion regulation in AN patients suggests that the opposite takes place; partners tend to feel shut out, and patients tend to rely heavily on individual strategies to manage distress. These tendencies will be further discussed below, focusing on the available evidence on behavioral strategies of managing distress with implications for interpersonal emotion regulation, as well as other features of each disorder that may influence the degree to which emotional arousal is interpersonally regulated in patients with OCD and AN.

In addition to these potential differences in interpersonal emotion regulation, OCD and AN were selected for the current study because of the overlap in the disorders in the sense that anxiety is a central negative emotion present in both disorders. In fact, many individuals with AN have a history of an anxiety disorder that precedes the onset of the eating disorder or tend to be anxious even in the absence of an anxiety disorder diagnosis (Kaye, Bulik, Thornton, Barbarich, & Masters, 2004). OCD is the most common comorbid anxiety disorder in AN (Kaye et al., 2004), and symptoms similar to OCD can emerge secondary to the eating disorder and starvation (Channon & de Silva, 1985; Keys, Brozek, & Henschel, 1950). This includes preoccupations and compulsive behaviors that are focused on eating, food, weight, and shape (Kaye, Bailer, & Klabunde, 2012). However, obsessional thinking and compulsive behaviors unrelated to AN -specific domains also can emerge secondary to starvation (Keys et al., 1950). Thus, given the central role of anxiety and the prevalence of obsessional thoughts and behaviors in both OCD and AN, differences in interpersonal emotion processes between the two disorders would suggest that there are important factors that go beyond the presence of anxiety in understanding emotion regulation in an interpersonal context.

Obsessive-compulsive disorder. OCD is a disorder that is characterized by intrusive, recurring thoughts that elicit fear (obsessions), and repetitive, ritualistic behaviors or mental act (compulsions) that serve a function of reducing obsessional fears (American Psychiatric Association, 2013). Obsessions can take on a wide range of content but are often categorized into the domains of contamination (e.g., fears of contracting a fatal illness from touching surfaces), responsibility for harm (e.g., fears of accidentally harming one's child), unacceptable thoughts (e.g., thoughts of blasphemy or sexual content), and symmetry/order (Abramowitz et al., 2010). Compulsions can take any form of overt behaviors such as excessive washing, ordering, and reassurance seeking, or mental acts such as "neutralizing" a "bad thought" with a "good thought" or compulsive prayer. In addition, patients often go to great length to avoid obsessional stimuli. Taken together, time spent on compulsions along with constraints due to avoidance behaviors, OCD can lead to severe impairment of functioning (Abramowitz, 2006).

Cognitive-behavioral theories of the maintenance of OCD and treatments based on this understanding (i.e., exposure and response prevention, ERP) are empirically well supported (Abramowitz, 2006; Eddy, Dutra, Bradley, & Westen, 2004; Olatunji, Davis, Powers, & Smits, 2012). Compulsive behaviors result in a (temporary) reduction in obsessional fear, which negatively reinforces the behaviors. In addition, compulsive behavior prevents anxiety from habituating in the presence of an obsessional stimulus, and new learning that would reduce obsessional fears cannot occur. In other words, the patient never learns that, (a) distress can be tolerated and/or would subside on its own and not just due to the performed compulsive behaviors, and, (b) the feared consequences are actually unlikely to occur and need not be prevented by rituals and avoidance (Taylor, Abramowitz, & McKay, 2007).

No research to date has examined interpersonal emotion regulation in individuals with OCD. However, on a behavioral level it is apparent that family members and partners become drawn into the ways in which patients try to manage anxiety, primarily in the form of symptom accommodation (Boeding et al., 2013; Calvocoressi et al., 1995; Calvocoressi et al., 1999; Lebowitz et al., 2013; Shafran, Ralph, & Tallis, 1995). The extensive strategies employed by partners to help the patient avoid or lower distress suggest unusually extensive interpersonal emotion regulation processes in patients with OCD and their partners. Even though individual CBT is an effective treatment for OCD, recent evidence suggests that including the partner in treatment can further improve treatment completion rates and outcomes (Abramowitz, Baucom, Boeding, et al., 2013) and reduce partner accommodation

(Boeding et al., 2013), which indicates that it may be useful to examine the degree to which changes in interpersonal emotion regulation processes occur as a result of a couple-based intervention.

Anorexia nervosa. AN is an eating disorder characterized by an inability to maintain a healthy body weight, extreme fear of weight gain or becoming fat, body image dissatisfaction and distortions, as well as a host of behaviors such as restricting, binge eating, purging, and excessive exercise (American Psychiatric Association, 2013). In addition, individuals with AN often overvalue weight and shape, do not recognize the severity of their condition, and frequently experience low motivation to change or ambivalence about recovery (American Psychiatric Association, 2013; Vitousek, Watson, & Wilson, 1998). Low motivation to change is in part thought to be a function of low levels of experienced negative consequences of AN, along with perceived advantages including thinness as a valued outcome and other functional consequences (Cockell, Geller, & Linden, 2003; Delinsky et al., 2011). Functional consequences that patients perceive as positive and attribute to AN include a sense of general control as a result of controlling food intake (Serpell, Treasure, Teasdale, & Sullivan, 1999; Shafran, Fairburn, Nelson, & Robinson, 2003). In addition, disordered eating and starvation may reduce negative emotions and emotion dysregulation (Brockmeyer, Grosse Holtforth, Bents, Herzog, & Friederich, 2013; Brockmeyer et al., 2012; Cockell et al., 2003; Kaye et al., 2003; Strober, 2004). Often, ambivalence about recovery can be quite puzzling and frustrating for close others, who may be in fear for the patient's life and have difficulty understanding the patient's reluctance to gain weight and recover (Bulik, Baucom, & Kirby, 2012; Graap et al., 2008). Individuals with AN may indeed be in great danger; starvation and eating disorder behaviors can lead to severe medical complications (Katzman, 2005; Sharp & Freeman, 1993), and AN is associated with the highest mortality rate of all psychological disorders (Birmingham, Su, Hlynsky, Goldner, & Gao, 2005; Papadopoulos, Ekbom, Brandt, & Ekselius, 2009 ; Sullivan, 1995; Zipfel, Lowe, Reas, Deter, & Herzog, 2000).

Similar to OCD, no investigations of AN have directly examined interpersonal emotion regulation as defined here. However, for a variety of reasons such as shame about their disordered eating or concerns that family members might force the patient to seek treatment or gain weight, individuals with AN often minimize, hide, or are deceitful regarding their disordered eating when interacting with others (Schmidt & Treasure, 2006; Vitousek et al., 1998). In addition, it appears that patients with AN generally revert to individual strategies (including disordered eating) to regulate negative emotions, attempt to suppress and control emotional arousal, and shut others out from their experience of the disorder (Bulik, Baucom, & Kirby, 2012). Taken together, this avoidance, minimizing the eating disorder, and individual focus for emotion regulation would suggest diminished interpersonal emotion regulation, at least regarding the eating disorder.

Whereas family-based interventions can be quite effective for the treatment of AN in adolescents (Couturier, Isserlin, & Lock, 2010; Eisler et al., 2000; Eisler et al., 1997; Eisler, Simic, Russell, & Dare, 2007; Lock, 2002; Lock, Couturier, & Agras, 2006; Loeb et al., 2007; Paulson-Karlsson, Engström, & Nevonen, 2009; Russell, Szmukler, Dare, & Eisler, 1987; Treasure, Schmidt, & Macdonald, 2010), no effective treatments are currently available for adults with AN (Berkman et al., 2006; NICE, 2004). Recent advances to include partners in the treatment show promise for improving effectiveness (Bulik, Baucom, & Kirby, 2012; Bulik, Baucom, Kirby, & Pisetsky, 2011; Bulik, Baucom, Kirby, & Pisetsky, 2012), which particularly highlights the need to better understand couple dynamics in adult patients with AN and their partners.

Empirical findings implicating disorder-specific patterns of interpersonal emotion regulation. In OCD, it is particularly apparent how partners become drawn into the patients' emotion regulation efforts. Individuals with OCD have learned to manage their disorder-related emotional distress by engaging in behaviors that provide at least some immediate decrease in distress, and by avoiding fear-provoking stimuli. Partners can become drawn into this pattern extensively and often engage in a wide range of behaviors described as symptom accommodation (Abramowitz, Baucom, Wheaton, et al., 2013; Boeding et al., 2013; Calvocoressi et al., 1995; Calvocoressi et al., 1999). Accommodation describes anything that partners might (knowingly or unknowingly) do in order to reduce or prevent the patients' obsessional fear. For example, partners might provide reassurance ("You're not a bad person; I am sure you would never do anything to harm our grandson"), actively participate in rituals (e.g., excessive cleaning), or help the patient avoid anxiety-provoking stimuli and situations (e.g., taking over roles and responsibilities such as driving). Often, patients may seek out accommodation explicitly, such as by asking for reassurance (Boeding et al., 2013; Calvocoressi et al., 1995; Calvocoressi et al., 1999; Shafran et al., 1995; Starcevic et al., 2012).

Partners may engage in these behaviors out of care and concern when seeing a loved one in distress, or because the patient would become angry or irritated if they did not do so; however, accommodation helps to maintain OCD in a similar way to compulsions. Accommodation is associated with more severe symptoms and poorer response to treatment (Van Noppen & Steketee, 2009), although only one study has focused exclusively on accommodation and romantic partners (Boeding et al., 2013). Thus, patients with OCD may involve their partners in their regulation of anxiety because (a) it is effective in reducing anxiety in the short term, and (b) reassurance seeking and accommodation are fairly consistent with their individual ways of managing obsessive fears (i.e., seeking fast-acting, short-term relief and/or extensive avoidance). In addition, given that accommodation provides short-term relief, patients with OCD typically have little motivation to exclude their partners from their experience of distress, unless they hide obsessions because they are ashamed about their nature. Obsessions and compulsions are usually experienced as unwanted and aversive by the patient. It appears that, in many cases, once partners are aware of the patients' worries and concerns, they are eager to help the patient, and it may also be rewarding for partners if they provide reassurance and experience themselves as "helpful" (Abramowitz, Baucom, Wheaton, et al., 2013). Even if obsessions may be illogical and partners may become irritated with the patients, partners might still be able to empathize with the experience of unwanted anxiety, thoughts, and behaviors. Empathic responding and compassion can facilitate coregulation of emotions, because these responses involve some degree of mirroring of the emotional experience (Goetz et al., 2010; Levenson & Ruef 1992; Verhofstadt et al., 2008).

On the other hand, within couples in which one partner suffers from AN, both individual emotion regulation patterns and motivational factors contribute to a very different interpersonal style. Individuals with AN may go to great lengths to hide eating disorder behaviors (Schmidt & Treasure, 2006), and symptoms such as caloric restriction can become strategies to manage distress and anxiety in isolation from close others. In fact, the secrecy surrounding the disorder can be so extensive that some partners know very little about the disorder and are effectively shut out from the patients' experiences (Bulik, Baucom, & Kirby, 2012). While the mechanisms thought to contribute to the maintenance of the symptoms, the role of anxiety and its regulation in AN are extremely complex and rooted in both biological and environmental factors, a few considerations are particularly relevant for the understanding of interpersonal patterns.

There is evidence that experiential and harm avoidance play an important role in the maintenance of AN (Bulik, Sullivan, Fear, & Pickering, 2000; Haynos & Fruzzetti, 2011), and that individuals seek to suppress and down-regulate negative emotions as much as possible, primarily through individually focused strategies such as caloric restriction, excessive exercise, and avoidance (Dellava et al., 2010; Kaye et al., 2003; Wildes, Ringham, & Marcus, 2010). In addition, interactions with others may also be a source of negative emotions (Lattimore, Gowers, & Wagner, 2000), and individuals with AN are found to be highly conflict avoidant, which is reflected in communication patterns in couples (Van den Broucke, Vandereycken, & Vertommen, 1995). Further, even well-intended comments of others e.g., about weight or eating behaviors, can lead to negative emotional reaction, and thus interpersonal avoidance may increase over the course of the disorder (Schmidt & Treasure, 2006). For example, reassurance about fears of becoming fat or positive comments about looks are ineffective and/or perceived as dishonest, and partners are often extremely unsure how to respond (Fischer, Kirby, Raney, Baucom, & Bulik, in press). Thus, quite contrary to OCD, individuals with AN may display greatly decreased levels of interpersonal emotion regulation in part because they do not experience an immediate benefit of distress reduction as patients with OCD may.

In addition, motivational factors regarding their disorder likely play a critical role for how patients interact with their romantic partners. While most patients with OCD would readily dispose of obsessions if they could, many patients with AN have a much more conflicted experience of the disorder. Patients often value core aspects of AN, including being thin as an indicator of self-worth and discipline, the emotion-regulatory functions of eating disordered behaviors, perfectionism, and a sense of control in general that many patients report to derive from AN (Cockell et al., 2003; Kaye, Fudge, & Paulus, 2009; Nordbø et al., 2012; Schmidt & Treasure, 2006; Serpell et al., 1999). In addition, patients with AN often fail to recognize the severity of the disorder and its negative consequences (American Psychiatric Association, 2013), which can further impede motivation to recover. Also, if patients were to openly disclose to partners what they experience and the dangerous behaviors they engage in, many partners might try to stop eating disordered behaviors or ask that the patient seek treatment. This could either lead to increased conflict, or interfere with eating disordered behaviors that are strongly reinforced for the patient.

A few exemplary findings can highlight how closely intertwined emotion regulation and AN symptoms are. As previously mentioned, patients often have a history of high anxiety that predates AN (Dellava et al., 2010), have been found to experience less emotion dysregulation and negative affect at more severe levels of starvation (e.g., Brockmeyer et al., 2012), and to experience dietary restraint as anxiety reducing (e.g., Kaye et al., 2003; Kaye et al., 2009). In addition, many patients experience greatly increased levels of anxiety during weight gain in treatment. It appears that this cannot be attributed to fears of weight gain alone but rather to the return of high levels of trait anxiety that were previously controlled by the effects of restraint, exercise, and starvation, and that become unmasked as weight and nutritional status improve (Dellava et al., 2010; Kaye, 2008; Kaye et al., 2003). Thus, these individually focused strategies can in some ways be quite effective in managing severe distress that patients do not know how to regulate otherwise, and it is understandable that patients are frightened to stop using these individual emotion regulation strategies (Haynos & Fruzzetti, 2011). At the same time, reliance on AN-related strategies for emotion regulation clearly poses a challenge for recovery and may again suggest that emotion coregulation in patients with AN is de-emphasized. Further, from the partners' perspective, it is likely much more difficult to empathize and respond compassionately to patients with AN than with OCD because reluctance to recover and positive attitudes towards AN may be extremely difficult to understand (Graap et al., 2008; Lock, Le Grange, Agras, & Dare, 2001); thereby interpersonal emotion regulation may be further impaired.

Attachment and associated features. Apart from the research presented thus far, additional insight can be gained from considering other psychological characteristics of individuals with OCD and AN that may impact someone's tendency or ability for interpersonal emotion regulation and coregulation in particular. One of these factors involves mechanisms related to attachment styles. Although attachment has mostly been studies in children, there is an increasing number of studies concerned with attachment styles in adults, which have important implications for emotion regulation (Butner et al., 2007; Mikulincer, Shaver, & Pereg, 2003). Whereas physiological coregulation between partners is thought to be an important mechanism for attachment overall (Sbarra & Hazan, 2008), differences in anxious compared to avoidant attachment are of particular interest here. Anxious attachment may facilitate greater interpersonal emotion regulation because of a general "hyperactivation" of interpersonally oriented processes – such as hypersensitivity to emotional information from partners, excessive efforts to maintain closeness, and reliance on others to manage distress. On the contrary, avoidant attachment is characterized by the opposite tendencies, including excessive reliance on individual emotion regulation, minimization of the experience and expression of negative affect, and decreased attention towards expressions of distress by others (Butner et al., 2007; Mikulincer et al., 2003). Thus, these attachment styles may influence interpersonal emotion regulation both by the degree to which an individual seeks interpersonal regulation, as well as the degree to which others are able to identify emotional states in the individual.

Consistent with this notion of attachment styles and emotion regulation strategies, Butner et al. (2007) found empirical evidence for greater coregulation of daily affect in couples associated with more anxious attachment styles, and less coregulation in couples associated with more avoidant attachment styles. Although somewhat dependent on the measure and experimental task, Helm et al. (2012) generally found similar patterns of effects of attachment anxiety and avoidance on coupling of oscillations in respiration and heart rate in couples. These differences in coregulation as a function of attachment style might lead to anticipated increased coregulation in OCD and decreased coregulation in AN. Both groups have been found to show high rates of insecure attachment styles, but a recent review of the literature suggests that individuals with AN are most likely to show avoidant/dismissive attachment patterns (O'Shaughnessy & Dallos, 2009), while some initial evidence suggests that individuals with OCD are more likely to show an anxious attachment style (Doron, Moulding, Kyrios, Nedeljkovic, & Mikulincer, 2009).

Consistent with the correlates of avoidant attachment mentioned above, individuals with AN have been found to be less facially expressive (Davies, Schmidt, Stahl, & Tchanturia, 2011) and more likely to suppress negative emotions and self-silence (Geller, Cockell, & Goldner, 2000) than normal controls. Potentially related to attachment styles are findings that individuals with AN have difficulty identifying emotions in themselves (Bourke, Taylor, Parker, & Bagby, 1992; Schmidt, Jiwany, & Treasure, 1993; Speranza, Loas, Wallier, & Corcos, 2007) and others (Oldershaw et al., 2011). Combined with decreased facial and verbal expressions of emotions, this may be related to impaired empathic responding by both partners, and thereby a decrease in emotion coregulation.

In conclusion, currently there are no studies examining coregulation of emotions in couples in which one partner suffers from OCD or AN. However, integrating relevant research regarding behavioral patterns of how individuals manage distress in each of these disorders, as well as research on other factors that can contribute or detract from interpersonal emotion regulation, suggests that there are marked differences in how emotions become interpersonally processed. In order to examine these differences in emotion regulation empirically, it is also important to consider which measure of emotional arousal is most suitable for the purposes of the current study.

Vocally Encoded Emotional Arousal

Previous studies have primarily used daily diary paradigms or interactions tasks with self-report measures of emotion, related psychological variables such as intimacy and self-disclosure, or psychophysiological measures to assess interpersonal regulatory processes (Boker & Laurenceau, 2006; Butner et al., 2007; Helm et al., 2012). However, measures of vocally encoded emotional information have recently found more applications in psychological research on dyads (B. R. Baucom, 2010) and provide some unique advantages for the study of interpersonal emotion regulation in couples.

In humans, vocalization of distress is a process that is in part learned and under voluntary control, but partially it is mediated by more basal neurological structures that cannot be controlled (Eisenberger & Lieberman, 2004; Juslin & Laukka, 2003; Newman, 2003). For example, a husband might try to speak in a calm voice when delivering bad news to his wife, but the wife might still be alarmed because she picks up on “an unsettling tone.” These involuntary vocalizations of distress have evolved to communicate both physical and social/emotional pain (Eisenberger & Lieberman, 2004; Newman, 2003), and this has been quite extensively studied in infant cries (Protopapas & Eimas, 1997; Soltis, 2004; Zeskind & Marshall, 1988). Thus, changes in the voice are in part a direct response to emotional distress, but at the same time the expression of the distress is a way in which this private information is transmitted to another person. This communicative function makes vocally encoded emotional arousal particularly interesting for the study of interpersonal emotion regulation because it is not an internally subjective state that only the individual experiences; other people often receive a message that the individual is emotionally aroused.

While a large number of features of human speech can be described (Juslin & Scherer, 2005), the mean and range of fundamental frequency of the voice are generally recommended as measures of emotional arousal (B. R. Baucom, 2010; Juslin & Scherer, 2005). Fundamental frequency (f_0) refers to the lowest frequency harmonic of the speech sound wave, which is created by the opening and closing of the vocal folds while air flows outward from the lungs through the larynx during speech production (Atkinson, 1978). Whereas f_0 is a physical property of speech and not subject to perceptual errors, it is closely associated with perceived pitch (Juslin & Scherer, 2005; Owren & Bachorowski, 2007; Weusthoff, Baucom, & Hahlweg, 2013b).

Conceptualized in a dynamic systems perspective of emotions, psychophysiology, self-report, and vocally encoded emotional arousal all represent unique but overlapping components of emotions (Scherer, 2009). As one would expect, fundamental frequency has been shown to be associated with self-report measures of negative emotions and psychophysiological variables such as cortisol and blood pressure (B. R. Baucom, Saxbe, et al., 2012; Weusthoff, Baucom, & Hahlweg, 2013a; Weusthoff et al., 2013b), but it also carries unique information predictive of relationship variables and observed communication behaviors. For example, higher emotional arousal assessed using f_0 has been shown to be associated with higher levels of demand/withdraw behaviors in couples (B. R. Baucom et al., 2011), better recall of communication skills in couples 11 years after a relationship education program (B. R. Baucom, Weusthoff, Atkins, & Hahlweg, 2012), more adaptive, in-depth engagement in women with breast cancer while receiving social support from their partners (Fischer, Baucom, et al., in press), and poorer treatment outcome assessed two years after couple therapy completion (B. R. Baucom, Atkins, Simpson, & Christensen, 2009). Currently, no published articles have examined coregulation in couples using f_0 and coupled oscillator models. However, B. R. Baucom, Saxbe, et al. (2012) used single oscillator models and f_0 range to examine regulation of emotional arousal in adolescents during conversations with their parents, and B. R. Baucom, Iturralde, et al. (2012) report the application of coupled oscillator models in the same family interactions and demonstrated that they can be used with f_0 data in a meaningful way; in this case, demonstrating different degrees of coupling depending on the gender of the child and parent, and domestic violence history.

Generally speaking, vocally encoded emotional arousal is a good candidate for the use in time series analyses because it represents a component of the emotion system that fluctuates rapidly with emotional changes, and these rapid changes can be measured on a fine-grained time scale (Juslin & Scherer, 2005; Scherer, 2009). Furthermore, technological advances in speech signal processing allow for the measurement of f_0 that is not only sensitive to small, rapid changes, but also in a manner that is noninvasive, unobtrusive, and does not interfere with the conversation of a couple. Technical advances in speech signal processing allow one to measure f_0 using audio recordings, and thereby allow investigators to examine data that were not originally collected for the purpose of measuring emotional arousal. Given that both partners' f_0 can be intensively measured during a conversation, this provides an opportunity to explore how each partner's arousal changes over time, how the two partners' emotional arousal change relative to each other, and whether emotional arousal of the two partners seems to be coregulated.

Current Study

The goal of the current study was to examine coregulation as a form of interpersonal emotion regulation in couples who participated in one of two couple-based treatment investigations, either for one partner's OCD or AN. Coregulation was examined based on vocally encoded emotional arousal during videotaped couple conversations that were completed before and after treatment in a similar fashion across studies. The extent of coregulation was compared between the two groups, as well as associations with symptom severity within each group and changes over the course of treatment. Although the main focus lies on regulatory processes that are modeled from the time series of f_0 measurements throughout the conversations, an aggregate measure of the level of emotional arousal across the conversations was also analyzed. This aggregate measure provides additional context to the analyses of regulatory processes.

No healthy control group was included in this investigation. Whereas coregulation is generally thought to be an adaptive process, it is unclear whether this is the case under all circumstances, and whether there is an adaptive "degree" of coregulation for any given couple. Here, high or low degrees of coregulation are not conceptualized as maladaptive per se; rather, the ways in which emotions are interpersonally processed are not functioning well in the context of OCD and AN because they may contribute to the maintenance of the disorders under these specific circumstances.

Data analyses are broadly consistent with Butler and Randall's suggestions for examining emotion coregulation in couples, which includes a set of different analytic approaches in a dynamic systems framework as further discussed below (Butler, 2011; Butler & Randall, 2013). This comprehensive approach was particularly important due to the novelty of this research area, which means that it cannot be determined at this time which aspect of interpersonal emotion regulation will be most relevant in these couples.

While the dynamic systems perspective of emotions in an interpersonal context generally is consistent with the investigation of emotional distress in psychopathology, it is important to reiterate some subtle changes in how certain key features of the dynamic systems framework need to be interpreted in this context. In particular, the assumed equilibrium or stable level of emotional arousal around which oscillations occur is typically described as an optimal or comfortable level. In the presence of OCD or AN, this is likely not the case. However, the equilibrium can still be conceptualized as a typical level *given the demands and constraints that OCD or AN impose on the system.* That is, the interpersonal emotion system may evolve towards a homeostasis that may contribute to the maintenance of a disorder (Shoham V., Butler, Rohrbaugh, & Trost, 2007), but there is nevertheless a stable state (even if elevated) around which emotional arousal should fluctuate for the patients and partners. Note that in the hypotheses below, coregulation was assessed with a set of statistical models that analyze how emotional arousal of the two partners' unfold over time, while aggregate emotional arousal refers to one measure of overall arousal for each partner across a conversation.

Hypotheses

Hypotheses 1a-2b: Rationale. Patients with OCD and AN are expected to exhibit opposing patterns of interpersonal emotion regulation, with higher levels of coregulation in OCD compared to AN. Consistent with this pattern, within each diagnostic group, the severity of symptoms is expected to be associated with the degree of coregulation. Thus, the degree of coregulation is hypothesized to vary between diagnostic groups and within diagnostic group as a function of symptom severity (hypotheses 1a-b).

The first two hypotheses address the ways in which *changes* in level and other dynamics of the system over time are specific to the disorders, but those hypotheses do not focus on the overall level of emotional arousal of individuals with OCD and AN. Thus, additional analyses examined the overall, aggregate level of emotional arousal in order to provide more context to the regulatory processes that occur in the conversations (hypotheses 2a-b). There are no empirical studies directly comparing overall levels of emotional arousal in individuals with OCD and AN. However, drawing on other relevant findings and given the specific setting in which emotional arousal was assessed (couples talking about a problem related to the disorder), it is expected that over the course of the conversation, patients with OCD show higher aggregate emotional arousal than patients with AN. Patients with OCD are expected to become anxious when discussing OCD with their partner, whereas patients with AN are expected to withdraw and avoid discussing upsetting content. More specifically, the hypotheses are:

Hypothesis 1a. At baseline, patients with OCD will show stronger coregulation of emotional arousal than patients with AN.

Hypothesis 1b. At baseline, symptom severity will be positively associated with greater coregulation of emotional arousal in OCD and negatively associated with coregulation emotional arousal in AN for the patients. That is, the more severe the disorder, the more patients will employ their hypothesized strategies to regulate emotion. Thus, OCD patients are expected to show more interpersonal regulation if their overall symptom severity is higher. AN patients are expected to show less interpersonal regulation if their overall psychological symptom severity is higher.

Hypothesis 2a. At baseline, patients with OCD will show greater aggregate emotional arousal across the interaction compared to patients with AN.

Hypothesis 2b. At baseline, patients with more severe OCD are expected to show greater aggregate emotional arousal than patients with less severe OCD. Patients with more severe AN are expected to show lower aggregate emotional arousal than patients with less severe AN.

Hypotheses 3a-b: Rationale. Finally, changes in coregulation over the course of treatment are also expected. If interpersonal emotion regulation styles are indeed disorder-specific and potentially a maintaining factor in OCD and AN, effective (couple-based) treatments should be associated with a decrease in extreme emotion regulation styles. Beyond possible changes due to symptom improvement, both treatments also intervened directly to alter how patients process emotions relative to their partners. For example, an important component of the OCD treatment was to reduce accommodation and reassurance seeking (Abramowitz, Baucom, Wheaton, et al., 2013), while the AN intervention sought to decrease secrecy and withdrawal around AN and help the couple address the disorder in a more shared way (Bulik, Baucom, & Kirby, 2012; Fischer, Kirby, et al., in press). That is, the therapists worked with the couples to reverse the tendency of the partners to be "brought into" or "shut out" from the patients' experience of the disorder, in OCD and AN, respectively.

Consistent with the overall reduction of anxiety in OCD over the course of treatment, a reduction of the aggregate levels of emotional arousal in the couple conversations is predicted as well. For AN, there are reasons to support both directions of the effects of treatment, and two competing, exploratory hypotheses are tested. As previously discussed, many individuals with AN experience high levels of anxiety as part of their disorder, which may recede with recovery (Pollice, Kaye, Greeno, & Weltzin, 1997). Therefore, a decrease in overall levels of emotional arousal during the conversations may be found. However, previously discussed tendencies to suppress negative emotions and avoid difficult topics may lead to relatively low levels of arousal in the conversations at baseline. Given that therapists worked with the couples to help them talk more effectively about AN and guide the patients towards sharing their feelings more openly with partners, emotional arousal while talking about AN could potentially increase from baseline to post treatment in patients with AN as well. More specifically, the hypotheses are:

Hypothesis 3a. For patients with OCD, coregulation of emotional arousal is expected to decrease from baseline to post, whereas coregulation of emotional arousal is expected to increase for patients with AN.

Hypothesis 3b. For patients with OCD, the aggregate level of emotional arousal is expected to be lower during conversations at post compared to conversations at pre. For patients with AN, competing hypotheses about the direction of effects were tested given empirical findings that suggest (a) lower aggregate emotional arousal at post compared to baseline and (b) higher aggregate emotional arousal at post compared to baseline in patients with AN.

CHAPTER 2: METHODS

Participants

Participants included couples in which one partner suffered from OCD or AN and who took part in one of three treatment-outcome studies. The first group of couples ($N = 18$ at baseline) participated in an open trial of a couple-based intervention for the treatment of one partner's OCD (Abramowitz, Baucom, Boeding, et al., 2013); the second group of couples ($N = 34$ at baseline) participated in one of two trials of a couple-based intervention for the treatment of one partner's AN (Bulik, Baucom, & Kirby, 2012; Bulik et al., 2011). Both treatments draw on cognitive-behavioral couple therapy procedures integrated with principles of individual cognitive-behavioral interventions for each disorder; i.e., the interventions do not represent couple therapy focused on relationship distress (D. H. Baucom, Kirby, & Kelly, 2009). Demographic information and other sample characteristics are provided in Table 1. For a number of reasons, not all couples could be included for all analyses for the purpose of the current study; Figure 1 shows the sample composition and any exclusions for each time point.

In the OCD study, all couples received a couple-based intervention. Eligibility criteria were assessed in a screening phone call and in-person baseline assessment including the Mini International Neuropsychiatric Interview to confirm the diagnosis (Sheehan et al., 1998). Participants had to be between 18-75 years old, fluent in English, married or living together in a committed relationship for at least one year, willing to participate in all sessions together, and could be of any gender and sexual orientation. The partner with a principal

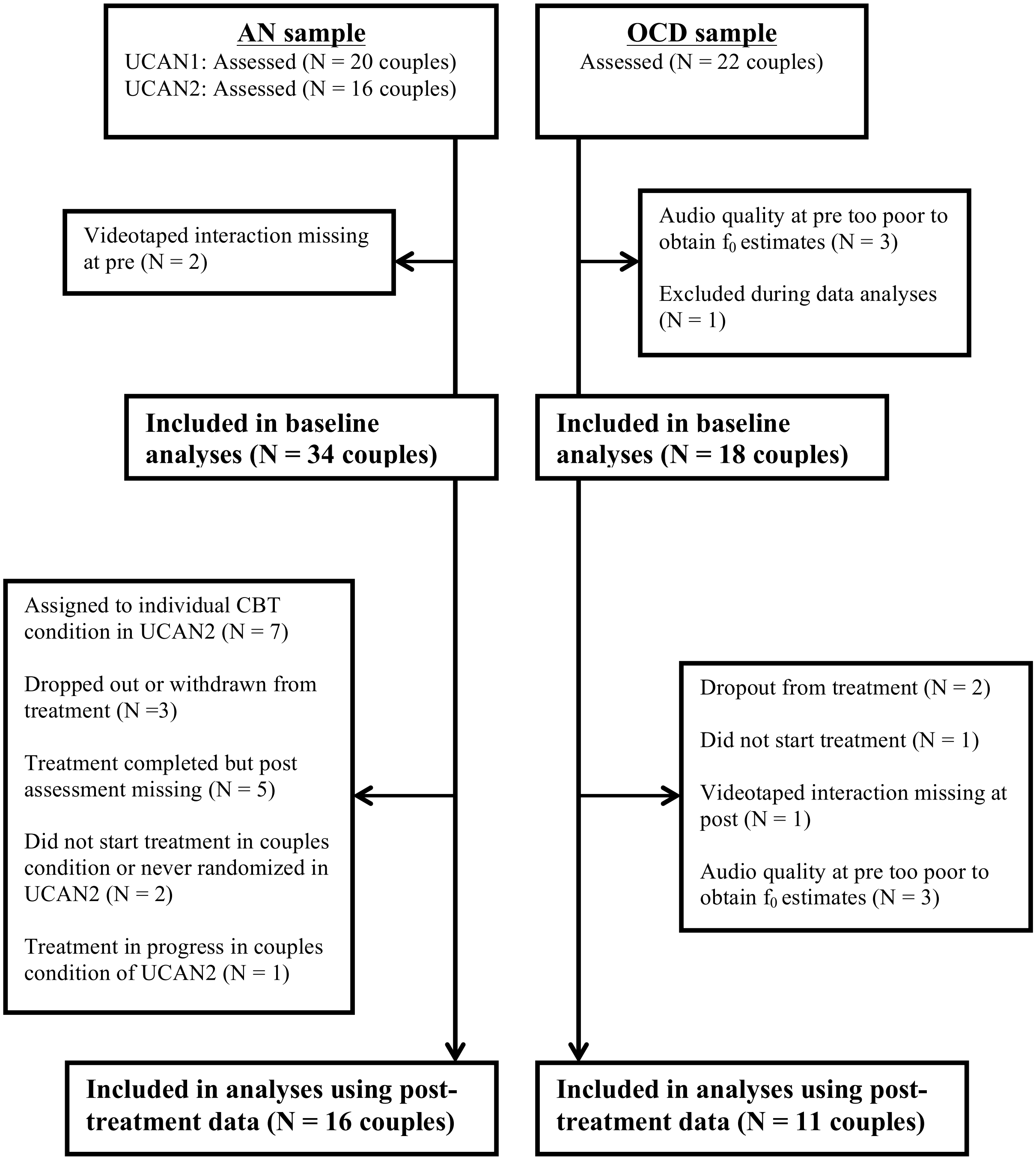


Figure 1. Flow chart of couples included in analyses for each time point for the OCD and AN samples. One additional couple (UCAN) excluded from time-series analyses at baseline.

Table 1

Demographic Information at Baseline. Mean (SD), Unless Otherwise Indicated

	OCD sample (n = 18 at baseline)[1]	AN sample (n = 34 at baseline)[2]
Sex (patients)	94.4% female	97.1% female
Sex (partners)	94.4% male	94.4% male
Age (patients)	32.44 (8.10)	33.97 (9.50)
Age (partners)	34.59 (9.79)	36.69 (10.22)
Race/Ethnicity (patients)	94.4% Caucasian, 5.6% Hispanic	85.3% Caucasian, 8.8% African American, 2.9% Asian American, 8.8% Hispanic
Race/Ethnicity (partners)	83.3% Caucasian, 5.6% Asian American, 5.6% Other	91.7% Caucasian, 2.8% African American, 2.8% Other, 2.8% Hispanic

Note: [1]demographic data except gender missing for 1 partner and 2 patients, percentages based on total number of participants; [2]demographic data except gender missing for 1 couple, percentages based on total number of participants. In the AN sample, participants indicated Hispanic ethnicity in a separate question.

diagnosis of OCD (secondary diagnoses of other anxiety or mood disorders permitted) had to have a score of at least 16 on the Yale-Brown Obsessive Compulsive Scale (Goodman, Price, Rasmussen, Mazure, Delgado, et al., 1989; Goodman, Price, Rasmussen, Mazure, Fleischmann, et al., 1989) and could not have previously received CBT for OCD. Exclusion criteria were current suicidal ideation, substance abuse or dependence, mania, psychosis, borderline or schizotypal personality disorder for either partner, and current domestic violence or physical abuse. Patients were permitted to remain on a stable dose of psychotropic medication if they had been on a stable dose for at least three months.

Couples in which one partner suffered from AN participated either in the pilot study of UCAN (Bulik, Baucom, & Kirby, 2012; Bulik et al., 2011; referred to as UCAN1 in the following), or the subsequent, ongoing randomized controlled trial (referred to as UCAN2 in the following). In UCAN1, all couples received a couple-based intervention. In UCAN2, couples were randomized to two conditions of either (a) individual CBT or (b) individual CBT plus the couple-based intervention. Data of couples in the individual condition were used for analyses on baseline data only and excluded from any analyses including post treatment data. Given the equivalence of the eligibility criteria, couple-based intervention and assessment procedures, couples from UCAN1 and 2 are referred to as one sample in the following descriptions; differences in procedures between the subgroups are noted.

Eligibility criteria for UCAN were assessed in a screening interview and confirmed during the baseline assessment, including the administration of the Structured Clinical Interview for DSM-IV Axis I Disorders (SCID-I) to establish a diagnosis (First, Spitzer, Miriam, & Williams, 2002). Adults of any gender and sexual orientation were eligible. Participants had to speak English, be at least 18 years old, and be in a committed relationship with a partner willing to participate. In UCAN2, the minimum length of the relationship was 6 months. In UCAN1, couples had to be cohabiting for at least one year. Patients had to meet DSM-IV criteria for AN at the time of assessment (except for criterion D – amenorrhea), with a BMI between 16.0-19.0. Individuals with a BMI below 16.0 were excluded because of the indication for inpatient treatment. In UCAN2, patients needed insurance coverage to support a higher level of care should the need arise over the course of the study. Exclusion criteria were alcohol or drug dependence in the past year, current significant suicidal ideation reported at the assessment, developmental disability or severe depression that would indicate an impaired ability to benefit from the treatment, psychosis including schizophrenia, and bipolar I disorder. Additional exclusion criteria were moderate to high levels of physical violence between partners, an unwillingness to forgo non-protocol treatment for AN for the duration of the study, previous participation in the pilot study, and current AN diagnosis of the partner (i.e., couples in which both partners meet criteria for AN). In both studies, participants were accepted on stable doses of psychotropic medication. Medications were adjusted if needed by the study physician. Given the fairly common need for a higher level of care in the treatment of AN, participants were allowed to continue in the studies following a maximum of two periods of higher level of care.

Measures

Vocally encoded emotional arousal. Fundamental frequency (f_0) was assessed during videotaped couple interactions in which the couples were instructed to discuss a topic of concern related to the respective disorder, lasting 7-10 minutes (described in more detail under procedures). F_0 is measured in Hertz (Hz), and higher values result from more rapid pattern opening and closing of the vocal folds. While f_0 is a physical property of speech and not subject to perceptual errors, it is closely associated with perceived pitch (Juslin & Scherer, 2005; Owren & Bachorowski, 2007; Weusthoff et al., 2013b). The range of f_0 has been found to contain the most information about emotional arousal compared to related speech indices and is recommended to measure vocally encoded emotional arousal (Busso, Lee, & Narayanan, 2009; Juslin & Scherer, 2005). However, this measure is also particularly sensitive to outliers. In the current study, an initial inspection of the f_0 data raised concerns about undue influence of extreme values, which only represented a small amount of data (e.g., one observation based on 250ms during a talk turn lasting several of seconds) but resulted in likely biased estimates of f_0 range for a number of couples (maximum possible range permitted by the band pass filter). A number of steps were taken to ensure validity of the f_0 estimates (see below); however, given the very large amount of the data and the technical nature of measurement, it is not possible to further ascertain the source of outliers. Therefore, f_0 mean was used instead of range. F_0 mean is another measure of vocally encoded emotional arousal with strong empirical support that is commonly used in psychological and couples research, is typically highly correlated with f_0 range, and is less sensitive to a small number of extreme or biased estimates of f_0 (B. R. Baucom, 2010; B. R. Baucom et al., 2011; Juslin & Scherer, 2005; Zeskind & Marshall, 1988). Greater f_0 mean indicates greater emotional arousal.

Three undergraduate and recent college graduate research assistants were trained in the procedures to prepare the videotaped couple interactions for the extraction of f_0 estimates. The extraction of f_0 requires separate audio files for each partner, as the origin of the voice signals cannot be automatically distinguished. The available recordings included only one audio track per couple. Therefore, the recordings were manually segmented into separate tracks for patient and partner by the research assistants. The audio editing software Audacity 2.0.5 (http://audacity.sourceforge.net) was used to convert video recordings into audio files and to segment tracks for patient and partner. In addition, any background noises and vocalizations that are not speech (e.g., laughter, crying), or overlaps in speech would result in distorted f_0 estimates and were silenced from the tracks of both speakers. The original length of conversations for each sample was used (7 minutes in the OCD sample and 10 minutes in the AN sample). Because the couples were aware of the time they had available for the discussion, it was deemed important to preserve the natural flow of the conversation (e.g., couples may try to bring the conversation to a close and down-regulate emotional arousal towards the end).

Initial estimates of f_0 were obtained using Praat, version 5.3.56 (Boersma & Weenink, 2013). A band pass filter of 75 to 300 Hz was applied to restrict extraction to the frequency range of natural speech of adults, as recommended by Owren and Bachorowski (2007). Plots of f_0 mean values across the conversation for each couple were visually inspected for potential problems with the data (e.g., outliers for each person, unusually high/low values for males/females, extremely high number of talk turns, potential overlaps in speech). Concerns were clarified by referring back to the original recordings and revising segmenting or silencing of any background noises that were missed. Given the number of files with problematic static background noise or relatively poor audio quality, Dr. Panayiotis Georgiou and Sandeep Chakravarthula who are experts in speech signal processing at the University of Southern California assisted with the extraction of final f_0 estimates using robust pitch extraction algorithms in Kaldi (http://kaldi.sourceforge.net/) with a band pass filter of 75 to 300 Hz applied to the previously segmented, cleaned, and de-identified audio files.

Once final estimates of f_0 at each 250ms were obtained, mean f_0 was calculated for each talk turn for use in all time series analyses, and as an aggregate measure of emotional arousal averaged across all talk turns (weighed by length of talk turn) for each conversation and person.

OCD symptom severity. The Yale-Brown Obsessive Compulsive Scale (Y-BOCS; Goodman, Price, Rasmussen, Mazure, Delgado, et al., 1989; Goodman, Price, Rasmussen, Mazure, Fleischmann, et al., 1989) is a semi-structured interview that was used to assess global OCD symptom severity and is considered the gold standard measure of OCD symptoms. The Y-BOCS was administered by trained interviewers at baseline and post treatment. The interview consists of two parts; first, a symptom checklist is used to identify the main obsessions and compulsions. Second, the total severity score is based on the parameters of time spent, interference, distress, resistance, and degree of control, rated by the interviewer separately for the main obsessions and compulsions. The total severity score has a range of 0 – 40. There are no established cutoff scores to indicate clinical levels of OCD symptom severity. For general reference, Steketee, Frost, and Bogart (1996) report a mean total score of 7.2 (*SD* = 4.5) for a non-clinical sample.

AN symptom severity. The Eating Disorders Examination (EDE; Fairburn, Cooper, & O'Connor, 2008) is a standardized interview that was used to assess eating disorder symptoms and confirm the diagnosis of AN. The EDE was administered by trained clinicians at baseline and post treatment. Along with several diagnostic items, questions included in scaled scores cover a wide array of eating disorder symptomology related to the four main areas of dietary restraint (e.g., restricting intake, avoiding certain food groups), concerns and behaviors related to eating (e.g., preoccupation with food or calories, fear of losing control over eating), concerns and behaviors related to body shape (e.g., feeling fat, overvalued importance of shape), and concerns and behaviors related to weight (e.g., preoccupation with weight, desire to lose weight). Only the global score of the EDE was used in the current study, which reflects symptom severity in the four areas described above and is considered the gold standard for assessing eating disorder pathology in treatment outcome studies, along with body mass index (BMI). The possible range of the EDE global score is 0-6. There are no established cutoff scores to indicate clinical levels of eating disorder pathology, and individuals without an eating disorder are not expected to score 0. In a community-based sample of young women, a mean global EDE score of .93 (*SD* = .81) was found (Fairburn & Bèglin, 1994; Fairburn et al., 2008).

The EDE was chosen over BMI as the primary symptom severity measure for greater comparability between symptom severity measures across the OCD and AN groups, and for a greater focus on psychological symptom severity which is captured by the EDE subscales.

While greater overall symptom severity should lead to both higher EDE global scores and lower BMI, BMI primarily captures weight status and consequences of starvation at very low weight. Given the inclusion criteria, no patients had extremely low BMIs that would warrant hospitalization, and some entered the study following discharge from higher levels of care. This can, in some cases, lead to a less severe BMI but patients may still experience very high levels of symptoms captured by the EDE. Thus, the EDE global score was deemed more appropriate for the purpose of the current study. However, BMI was included for exploratory purposes as well. BMI is a measure of weight status that takes both weight and height into account; it is calculated as $[weight\ (kg)]/[height\ (m)]^2$. Weight was assessed at each time point using a digital scale that is regularly calibrated. Height was assessed using a fixed stadiometer at baseline.

Procedure

OCD sample. Data used for the current study consist of a subset of measures from the pre- and post-treatment assessment of couples participating in an open trial of a couple-based intervention combining CBT for OCD (exposure and response prevention, ERP; Abramowitz, 2006) and cognitive-behavioral couple therapy (CBCT) procedures (Epstein & Baucom, 2002). Initial eligibility criteria were determined during a phone screening, and the patient and partner completed a 2-hour in person assessment following informed consent at baseline. Baseline and post-treatment assessment included self-report measures, interview-based measures, and the recording of a videotaped interaction, conducted by trained doctoral students. For the videotaped interaction used in the current study, the patient was instructed to select a topic of concern related to OCD and to share his/her thoughts and feelings about this topic. Partners were instructed to respond as they normally would. The remaining two interactions (not used here) were a similar conversation with the partner picking the topic, and a problem-solving conversation. The research assistant remained in the room to help the couple select a topic but left the room for the duration of the couples' conversation (7 minutes). The first interaction was selected for the purpose of this study because the interaction task most closely resembles the one used in the UCAN studies (sharing thoughts and feelings on a topic the couple chooses together).

The treatment was a manualized, 16-session (90 to 120 minutes each) treatment conducted over the course of 12 weeks. The intervention included psychoeducation about OCD and ERP, communication training (emotional expressiveness and decision-making), partner-assisted exposure exercises, and interventions to reduce symptom accommodation and OCD-unrelated relationship stressors. All sessions were recorded and regularly supervised. A more detailed description of the treatment is provided in Abramowitz, Baucom, Wheaton, et al. (2013). All study procedures for the OCD study were approved by the University of North Carolina at Chapel Hill Institutional Review Board.

AN sample. Data used for the current study consist of a subset of measures from the pre- and post-treatment assessments of couples participating in a pilot study (UCAN1) and RCT (UCAN2) of a couples-based intervention combining CBT for AN and cognitive-behavioral couple therapy (CBCT) procedures, along with nutritional counseling and medication management. Initial eligibility criteria were assessed during a phone screening, and the patient and partner attended in-person assessments following informed consent at baseline. Baseline and post-treatment assessments included self-report measures, interview-based measures, a videotaped interaction, measurement of weight and height as well as a physical exam and labs for the patients. Assessments were conducted by trained clinicians blind to treatment condition. Only one videotaped interaction task was conducted in the UCAN studies for each time point; couples were instructed to select a topic related to AN that was an issue in their relationship (medium intensity) and to share their thoughts and feeling about the topic. Remaining procedures for the videotaped interactions were as described above for the OCD study.

In UCAN1, all patients received 20 weekly sessions of the couple-based intervention along with treatment as usual (TAU) delivered by clinicians of the research team or within the UNC Eating Disorders Outpatient Program. TAU typically involved weekly individual CBT sessions, biweekly psychiatry visits for medication management, and nutritional counseling sessions (beginning with weekly sessions and tapered over the course of treatment). In UCAN2, patients were randomly assigned to either receive 22 weekly sessions of the couple-based intervention plus 22 weekly sessions of individual CBT, or to receive 44 sessions of twice-weekly individual CBT. In both conditions, patients also received nutritional counseling sessions and psychiatry visits for medication management.

All sessions were audio- and video-recorded and regularly supervised. The couple-based intervention included psychoeducation about AN, communication training (emotional expressiveness and decision-making), working with the couple to address specific AN symptoms and challenges as a team, addressing challenges in areas of relationship functioning often affected by AN (e.g., eating together, physical intimacy and affection), and relapse prevention. A more detailed description of the couple-based intervention can be found in Bulik, Baucom, and Kirby (2012). All study procedures for UCAN1 and 2 were approved by the Biomedical Institutional Review Board of the University of North Carolina at Chapel Hill.

CHAPTER 3: RESULTS

To assist with ease of reading across the different sets of data analytic approaches, the results below are reported organized by data analytic approach rather than by order of the hypotheses. First, the overall data analytic strategy is briefly outlined. This is followed by general preliminary analyses and by separate sections for each analytic approach (aggregate analyses, models testing the covariation aspect of coregulation, and models testing the coupling aspect of coregulation). Finally, an integrative summary that will assist with the integration of the results across modeling approaches for conceptually related processes is provided.

General Data Analytic Strategy

All analyses were conducted in SAS 9.4 (SAS Institute Inc, 2013). A multilevel modeling (MLM) approach was applied for all analyses in order to account for non-independence in the data, introduced by the nesting of repeated observations within individuals (for the time series models), and nesting of individuals within couples. MLM is also advantageous because unequal numbers of observations (i.e., talk turns) across couples can be accommodated. All models used to analyze the time series data (repeated measurement of emotional arousal across a conversation) used data at the talk turn level.

Coregulation of emotional arousal within the conversations was modeled in two ways as recommended in the literature (Butler & Randall, 2013) in order to assess two core aspects of coregulation. Cross-lagged actor-partner interdependence models (APIMs) were used to examine the covariation aspect of coregulation, and coupled linear oscillator (CLO) models were used to examine coupling of the dynamics of the patients' and partners' oscillations of emotional arousal across the conversation. These two approaches examine different aspects of coregulation. First, the covariation models focus on how variations in the *level* of emotional arousal over time are linked between partners. Second, the coupled oscillator models addresses the dynamic characteristics (such as displacement from equilibrium, rate of change and increases/decreases in rate of change) of the oscillations in emotional arousal as further explained within each section below. Both model types were analyzed in MLM using the PROC MIXED procedure in SAS.

Sample size and power. To date, there are no established ways to determine power in cross-lagged APIMs and coupled linear oscillator models prior to data analyses. For APIMs, power cannot reasonably be determined without information that is unavailable prior to the current study, in particular the degree of nonindependence in the data which has an impact on the effect sizes (Kenny, Kashy, & Cook, 2006). Comparison with previous studies is difficult given different combinations of sample size, lengths of time series, and predictors included in the models; however, it appears that the magnitude of these parameters is generally comparable to published models. For example, Butner et al. (2007) used both a two-intercept multilevel model assessing covariation using a similar number of predictors as well as a differential equation model assessing coupling with 48 couples and 21 daily assessments. Relevant to the estimation of derivatives from time series data, Boker and Nesselroade (2002) demonstrated that as little as three occasions of measurement can be used to recover the dynamics of a linear oscillator using local linear approximation, although under somewhat restrictive assumptions and with 100 subjects. In the current study, the number of couples is notably lower, but the average number of talk turns was well beyond three per individual, with average numbers of talk turns per person of approximately 20 in the OCD sample and 27 in the AN sample.

Preliminary Data Inspection, Analyses, and Descriptive Statistics

Demographic information for the final sample is shown in Table 1, and descriptive statistics for all study variables are reported in Table 2. Preliminary data analyses and checks for violation of important model assumptions and to examine the suitability of the data for the time-series analyses did not raise substantial concerns (additional model-specific analyses reported further below).[1] Visual inspection of individual Lowess smoothed plots of f_0 mean for each couple revealed clear variability in emotional arousal between individuals in these plots as well as over time in each conversation (i.e., oscillations), suggesting that the use of cross-lagged APIMs and linear oscillator models in MLM to model coregulation is appropriate. Figure 4 in Appendix A shows Lowess smoothed plots for typical couples in the OCD and AN samples. Further, intraclass correlation coefficients (ICCs) based on a two-intercept unconditional multilevel model, modeling patients' and partners' f_0 mean at the talk turn level as a function of the intercepts only, indicated that there was both considerable within- and between person variability in f_0 mean. For patients, ICC = .64 indicated that approximately 64% of the variability in f_0 mean is due to between-person differences, and this finding implies that repeatedly measured f_0 across talk turns are correlated .64 within individuals. Similarly, the partners' ICC of .68 indicated substantial within- and between person variance in f_0 mean as well. Thus, using a multilevel modeling approach to account for the dependence in the data was deemed appropriate. Further preliminary analyses were performed based on the specific models used for hypothesis testing and are described below.[2]

Hypothesis Testing

Aggregate models. All hypotheses were tested using two-intercept multilevel models following procedures and specifications outlined by Campbell and Kashy (2002). Following

Table 2

Means (Standard Deviations) for all Study Variables

	Baseline - full sample	
	OCD Sample (N = 18)	AN Sample (N = 34)
F_0 mean (patients)	179.71 (32.24)	158.37 (37.74)
F_0 mean (partners)	143.56 (27.91)	115.73 (23.14)
Talk turns per couple[1]	41.17 (19.34)	53.91 (26.35)
Y-BOCs (patients)	26.33 (5.40)	-
EDE (patients)	-	2.71 (1.40)
BMI (patients)	-	18.31 (1.59)

	Baseline and post - subsample with complete data at both time points			
	OCD Sample (N = 11)		AN Sample (N = 16)	
	Baseline	Post	Baseline	Post
F_0 mean (patients)	174.89 (34.38)	182.35 (34.72)	154.47 (39.32)	138.26 (28.74)
F_0 mean (partners)	134.22 (25.56)	132.36 (16.76)	110.24 (18.99)	109.56 (14.53)
Talk turns per couple	39.64 (19.48)	44.82 (23.48)	56.00 (24.62)	53.13 (33.35)

Note: [1]33 couples in the AN sample at baseline for these calculations (1 additional couple excluded from time-series analyses). OCD = obsessive-compulsive disorder. AN = anorexia nervosa.

their recommendations, the nonindependence in the data was accounted for by treating the scores for patients and partners within each couple as repeated measures (compound symmetry specification). Thus, separate intercepts were estimated for patients and partners, and interaction terms with the intercepts were added for hypothesis-specific variables of interest. This approach facilitated simultaneously testing the differences in f0 mean for patients, which were the focus of the hypotheses, along with differences for partners for exploratory purposes.

Hypothesis 2a. Patients with OCD were expected to show greater aggregate emotional arousal compared to patients with AN at baseline. The hypothesis was tested by including an interaction term for each intercept with diagnosis (dummy coded using AN as the reference group). The results of the analyses supported this hypothesis; OCD patients' aggregate f_0 mean was significantly greater compared to AN patients' aggregate f_0 mean (β = 21.34, t(48) = 2.37, p <.05). Similarly, OCD partners' aggregate f_0 mean was also significantly greater compared to AN partners' aggregate f_0 mean (β = 27.83, t(48) = 3.09, p <.01). Differences between patients and partners were not estimated and should not be interpreted due to the expected sex differences in f_0 mean.

Hypothesis 2b. At baseline, patients with more severe OCD were expected to show greater aggregate emotional arousal than patients with less severe OCD. Patients with more severe AN were expected to show lower aggregate emotional arousal than patients with less severe AN. Separate models were analyzed for AN and OCD because symptom severity was assessed with different measures for each group. The hypothesis was tested by including an interaction term for each intercept with the grand-mean centered variable for symptom severity.

There was no support for this hypothesis in either group. The model for OCD indicated that the aggregate f_0 mean values did not vary depending on the patients' Y-BOCs score for patients ($\beta = 1.20$, $t(14) = .88$, $p = .39$) or partners ($\beta = 1.34$, $t(14) = .98$, $p = .34$). The model for AN indicated that the aggregate f_0 mean values did not vary depending on the patients' EDE global score for patients (β = 1.25, $t(29)$ = .31, p = .76) or partners (β = -1.07, $t(29)$ = -.26, p = .80).[3]

Hypothesis 3b. This hypothesis focused on changes in aggregate emotional arousal over treatment. For patients with OCD, the aggregate level of emotional arousal was predicted to be lower during conversations at post compared to conversations at baseline. For patients with AN, competing hypotheses about the direction of effects were tested given empirical findings that suggest (a) lower aggregate emotional arousal at post compared to baseline and (b) higher aggregate emotional arousal at post compared to baseline in patients with AN. The hypothesis was tested by including an interaction term for each intercept with a variable for time point (dummy coded using baseline as the reference point). Separate models were analyzed for OCD and AN.

There was no support for this hypothesis in the OCD group. The model for OCD indicated that the aggregate f_0 mean values at post did not differ from baseline for patients (β = 7.46, $t(29)$ = .59, p =.56) or partners (β = -1.86, $t(29)$ = -.15, p = .89). A marginally significant effect for time point in the AN group provided some support for the hypothesis in the direction of a decrease in aggregate emotional arousal for AN patients. Patients' aggregate f_0 mean was 16.21hz lower at post compared to baseline, although this difference was just below significance (β = -16.21, $t(44)$ = -2.01, p = .05). There was no difference in aggregate f_0 mean for AN partners at post compared to baseline (β = -0.68, $t(44)$ = -.08, p = .93).

Covariance: Cross-Lagged Actor-Partner Interdependence Models. Covariation refers to the bidirectional linkage of levels in emotional arousal between patient and partner over the course of the conversation. As outlined above, covariation around a stable level of emotional arousal is of particular relevance for coregulation. Cross-lagged actor-partner interdependence models were used to examine coregulation indicated by covariance (APIM; Kenny et al., 2006). This approach allows one to simultaneously estimate actor effects (e.g., the effect of patients' emotional arousal during one talk turn on their own emotional arousal during the next talk turn) and partner effects (e.g., the effect of partners' emotional arousal during one talk turn on the patients' arousal during the next talk turn) for both members of the couple. Most central to the hypotheses, the patients' covariation of emotional arousal with their partners' emotional arousal at the previous time talk turn are indicated by the partner effect for patients, while controlling for the patients' actor effect of their own previous emotional arousal. Thus, these analyses answer the question whether the patients' emotional arousal at a given talk turn are, in part, a function of their partners' emotional arousal at the previous talk turn, or whether the patients' emotional arousal is independent from the partners' experience and primarily determined by the patients' own previous level of emotional arousal.

Preliminary analyses. First, the presence of linear or quadratic trends was assessed. No overall increasing or decreasing trajectories of emotional arousal within the conversations were expected; however, given the assumption that coregulation should occur around a stable level, it is important to assess their presence (Butler, 2011; Butler & Randall, 2013). Given the complexity of the models used to test the hypotheses, these analyses were conducted as a preliminary step to determine whether any temporal trends in the data were present and, therefore, time (i.e., talk turns) should be included as a predictor in the final models. Linear and quadratic growth curve models predicting f_0 mean were fit as multilevel models for patients and partners separately, first with talk turns as the only predictor and then with an added interaction term for diagnosis. There was no evidence of any linear or quadratic trends over time in any of the models at baseline in this series of models (all $p > .58$). The procedures to test for linear and quadratic growth were repeated for the subsample used in the analyses that involve post treatment data. With the exception of a weak quadratic trend for AN partners at post ($\beta = -.01$, $t(392) = 2.29$, $p < .05$), no linear and quadratic effects were significant. Given the consistent absence of trends over time in the great majority of the models and in order to maintain parsimony in the subsequent models, time (i.e., talk turns) was no longer included as a predictor in the models used for hypothesis testing.

As a next step, a basic cross-lagged APIM was analyzed, using only actor and partner effects as predictors. This served as the basis for model diagnostics and for subsequent models used for hypothesis testing, where additional predictors were entered at level two. Lagged variables of f_0 mean were created such that f_0 mean at each talk turn was used as the dependent variable, predicted by the person-centered f_0 mean of the same and the other member of the couple at their respective previous talk turns. Thus, the general model used here was as follows (with adaptations for each hypothesis as described below), using two dummy codes to distinguish patient and partner predictors and outcome, so that the effects could be modeled for both members of the couple simultaneously. The level 1 equation for the model used as a basis for hypothesis testing was:

$$\begin{aligned} f0mean_{ij} = {} & \beta_{1j}(patient) + \beta_{2j}(partner) + \beta_{3j}\left(actor\_f0mean_{\,(i-1)j} * patient\right) \\ & + \beta_{4j}\left(actor\_f0mean_{\,(i-1)j} * partner\right) \\ & + \beta_{5j}\left(partner\_f0mean_{\,(i-1)j} * patient\right) \\ & + \beta_{6j}\left(partner\_f0mean_{\,(i-1)j} * partner\right) + r_{ij} \end{aligned}$$

where the first two coefficients represent the intercepts specific to patients and partners, and the remaining terms specify the actor and partner effects of emotional arousal at the previous talk turn for patients and partners. The dummy codes for patient and partner lead to half of the terms falling out (multiplied by 0) of the model depending on which outcome is modeled.

In the final model serving as a basis for the hypothesis tests, random effects at level 2 were included for the intercepts only, using an unconstrained covariance structure and heterogeneous residual variances across patients and partners (i.e., 5 variance/covariance parameters were estimated in each model). These specifications were maintained for all subsequent APIMs.[4] Results indicated significant positive actor and partner effects for both members of the couples. To test the hypotheses, level 2 predictors specific to each hypothesis were added as outlined below. For all models, f_o mean at the talk turn level (when used as a predictor) was person-mean centered and symptom severity as a continuous level 2 predictors was grand-mean centered to ease interpretation (Enders & Tofighi, 2007).

Below, the data analytic approach for each hypothesis is briefly explained, and results for the full model are reported, followed by a more detailed description of the effects that are pertinent to the hypothesis being tested. The partner effect for patients (effect of partners' emotional arousal on patients' emotional arousal at the following talk turn) was the focus for the tests of the hypotheses, as this effect indicates the degree to which the patients' emotional arousal covaries with the partners' emotional arousal at the previous talk turn. Of note, no predictions were made about the sign of the coefficient; both positive and negative coefficients could indicate coregulation operationalized as covariance. Whereas the positive association is relatively intuitive, a negative association could indicate a process in which one person tries to be calmer if the other person appears upset.

Hypothesis 1a. This hypothesis predicted greater coregulation for patients with OCD compared to patients with AN at baseline. In order to test differences in the covariation aspect of coregulation, the basic cross-lagged APIM described above was extended by including a dummy code for diagnosis (using AN as the reference group) as a level 2 predictor. Cross-level interactions between diagnostic group and all level 1 predictors (intercepts, actor and partner effects for both members of the couple) were included in the model; however, the fixed effect for the interaction of diagnostic group by partner effect for the patients is the focus of the hypothesis.

Results for the fixed effects including simple intercept and slope estimates are shown in Table 3. The significant main effects indicate positive actor and partner effects for both members of the couple in the AN group. The interaction terms indicate that the actor effects for both members of the couple and the partner effect for patients in the OCD group were significantly less positive than the effects found for the AN group. Figure 2A illustrates significant simple slopes for the actor and partner effects separately for OCD and AN. As hypothesized, the interaction effect of the partner effect by diagnostic group for the patients (β = -.29, t(2355) = -3.38, p < .001) indicated a significant difference between OCD and AN in the effect of partners' f_0 mean on the patients' f_0 mean at the subsequent talk turn; however, the effect was in the *opposite* direction from what was predicted. That is, AN patients' f_0 mean was significantly associated with their partners' f_0 mean at the previous talk turn (β = .29, t(2355) = 5.43, p < .001), but there was no association for OCD patients (β = .00, t(2355) = .06, p = .95). These results imply that for AN patients with personal average f_0 mean at a given talk turn, their f_0 mean at the subsequent talk turn is predicted to be .29hz higher for each 1hz increase of their partners' f_0 mean (relative to the partners' personal average) at the preceding turn.

Hypothesis 1b. In this hypothesis, symptom severity was predicted to be positively associated with greater coregulation of emotional arousal in OCD and negatively associated with coregulation emotional arousal in AN for the patients. To test for differences in the covariation aspect of coregulation, separate cross-lagged APIMs were analyzed for OCD (see Table 4) and AN (see Table 5) because severity was assessed using different instruments and to avoid overtaxing the models by moving to a three-level structure. Severity (grand-mean

Table 3

Fixed Effects and Simple Intercepts/Slopes for the Cross-Lagged APIM at Baseline: Differences in Actor/Partner Effects by Diagnosis, AN as Reference Group (df = 2355)

	Fixed Effect	Coefficient (*SE*)	*t*	*p*
Patients:	Intercept	161.44 (6.62)	24.37***	<.0001
	Actor effect	0.17 (.03)	5.18***	<.0001
	Partner effect	0.29 (.05)	5.43***	<.0001
	Intercept*OCD	18.89 (11.16)	1.69	0.09
	Simple intercept OCD	*180.33 (8.99)*	*20.07****	*<.0001*
	Actor effect*OCD	-0.16 (.07)	-2.23*	<.05
	Simple slope OCD	*.01 (.06)*	*0.23*	*.82*
	Partner effect*OCD	-0.29 (.08)	-3.38***	<.001
	Simple slope OCD	*.00 (.07)*	*0.06*	*.95*
Partners:	Intercept	117.57 (4.50)	26.11***	<.0001
	Actor effect	0.30 (.04)	8.27***	<.0001
	Partner effect	0.08 (.02)	3.77***	<.001
	Intercept*OCD	29.67 (7.59)	3.91***	<.0001
	Simple intercept OCD	*147.24 (6.11)*	*24.08****	*<.0001*
	Actor effect*OCD	-0.37 (.06)	-6.33***	<.0001
	Simple slope OCD	*-.07 (.05)*	*-1.45*	*.15*
	Partner effect*OCD	0.05 (.05)	1.05	.29
	Simple slope OCD	*.13 (.04)*	*3.25***	*<.01*

Note: ***p < .001, **p < .01, *p < .05. APIM = Actor-Partner Interdependence Model. AN = anorexia nervosa. OCD = obsessive-compulsive disorder.

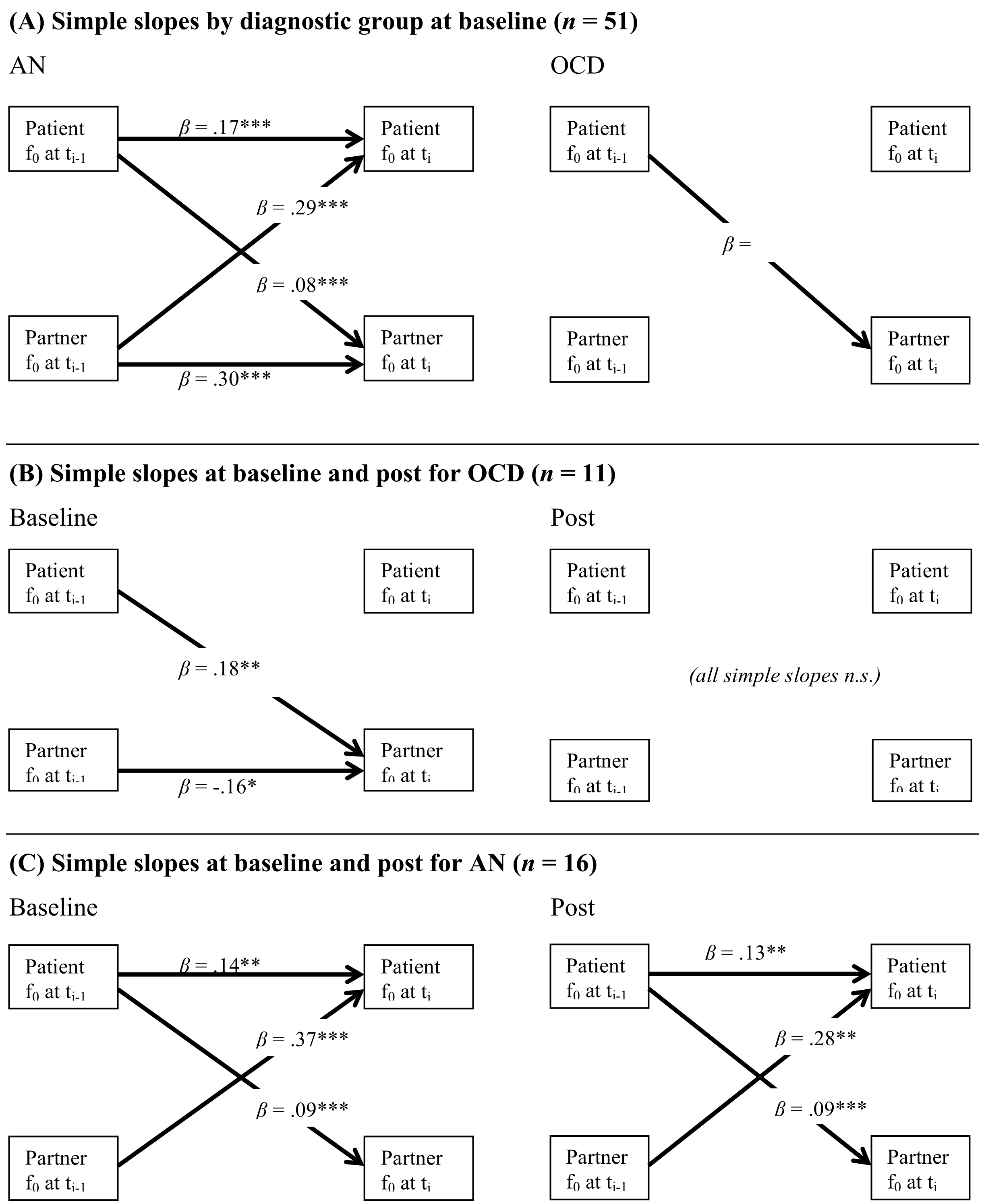


Figure 2. Significant simple slopes for cross-lagged APIMs testing differences based on (A) diagnostic group, (B) time point in the OCD group, and (C) time point in the anorexia group. ***$p < .001$, **$p < .01$, *$p < .05$

centered) was entered as a level 2 predictor.

There was no support for this hypothesis. For both diagnostic groups, no significant interaction effects were found for the partner effects for the patients. That is, the effect of the partners' f_0 mean on patients' f_0 mean at the subsequent talk turn was not dependent on the patients' Y-BOCS (for OCD, $\beta = .00$, $t(675) = .36$, $p = .72$) or EDE (for AN, $\beta = .07$, $t(1668) = 1.55$, $p = .12$) score.[5] Given the lack of significant effects central to the hypothesis in either diagnostic group, interactions were not probed.

Hypothesis 3a. This hypothesis addressed changes in the degree to which emotion coregulation occurs for each diagnostic group over the course of treatment, predicting a decrease in coregulation for patients with OCD and an increase in coregulation for patients with AN from baseline to post. To evaluate changes in the covariation aspect of coregulation from baseline to post, separate cross-lagged APIMs were analyzed for OCD and AN to avoid overtaxing the models by moving to a three-level structure. A dummy code for time point (using baseline as the reference point) was added to the basic models as a level 2 predictor. Only couples for which baseline and post data was available were used for these analyses, reducing the sample size to 11 OCD couples and 16 AN couples.

First, the model testing the hypothesis for the OCD group was analyzed. Results for the fixed effects including simple slopes for post are shown in Table 6. Contrary to the hypothesis, there was no change or decrease in the partner effect for the patients (non-significant interaction effect, $\beta = .03$, $t(862) = .27$, $p =.79$). The partner effects were non-significant at both time points. It is notable, however, that the pattern that was expected for the patients emerged for the partners: As illustrated in Figure 2B, there was a significant positive partner effect of patients' f_0 mean on the partners' f_0 mean at the subsequent talk turn ($\beta = .18$, $t(862) = 2.80$, $p < 01$) at baseline, but this effect disappeared at post

Table 4

Fixed Effects for the Cross-Lagged APIM at Baseline: Differences in Actor/Partner Effects by OCD Symptom Severity (YBOCS, df = 675)

Effect	Estimate (*SE*)	*t*	*p*
Patients			
Intercept	180.40 (7.95)	22.68***	<.0001
Actor effect	.004 (.06)	0.07	0.95
Partner effect	.01 (.07)	0.16	0.87
Intercept*YBOCS	1.24 (1.51)	0.82	0.41
Actor effect*YBOCS	-.01 (.01)	-0.85	0.40
Partner effect*YBOCS	.004 (.01)	0.36	0.72
Partners			
Intercept	147.22 (6.58)	22.37***	<.0001
Actor effect	.02 (.06)	0.25	.80
Partner effect	.11 (.05)	2.28*	<.05
Intercept*YBOCS	1.33 (1.25)	1.06	.29
Actor effect*YBOCS	.03 (.01)	3.00**	< .01
Partner effect*YBOCS	-0.02 (.01)	-1.64	.10

Note: ***p < .001, **p < .01, *p < .05. APIM = Actor-Partner Interdependence Model. AN = OCD = obsessive-compulsive disorder. YBOCS = Yale-Brown Obsessive Compulsive Scale.

(β = .01, t(862) = .09, p =.93). This change was marginally significant, as indicated by the interaction effect with time point (β = -.18, t(862) = -1.94, p =.05).

Second, an equivalent model was used to test the hypothesis for the AN group.

Table 5

Fixed Effects for the Cross-Lagged APIM at Baseline: Differences in Actor/Partner Effects by AN Symptom Severity (EDE Global Score, df = 1668)

Effect	Estimate (*SE*)	*t*	*p*
Patients			
Intercept	161.46	22.68***	<.0001
Actor effect	.13 (.04)	3.60***	<.001
Partner effect	.22 (.06)	3.69***	<.001
Intercept*EDE	1.55 (5.15)	.30	0.76
Actor effect*EDE	.12 (.03)	3.96**	<.0001
Partner effect*EDE	.07 (.04)	1.55	0.12
Partners			
Intercept	117.58 (4.35)	27.01***	<.0001
Actor effect	.19 (.04)	5.37***	<.0001
Partner effect	.07 (.02)	3.16**	<0.01
Intercept*EDE	-1.38 (3.15)	-.44	0.66
Actor effect*EDE	.17 (.03)	6.87***	<.0001
Partner effect*EDE	.02 (.02)	1.18	0.24

Note: ***p < .001, **p < .01. APIM = Actor-Partner Interdependence Model. AN = anorexia nervosa. EDE = Eating Disorders Examination.

Results for the fixed effects including simple slope estimates for post are shown in Table 7. Contrary to the hypothesis, there was no change in the partner effect for the patients (non-significant interaction effect, β = -.09, t(1654) = -.67, p =.51); the effect was positive

Table 6

Fixed Effects and Simple Intercepts/Slopes for the Cross-Lagged APIM for OCD: Differences in Actor/Partner Effects by Time Point (Baseline as Reference Point, df = 862)

Effect			Estimate (SE)	*t*	*p*
Patients:	Intercept		174.05 (10.13)	17.18***	<.0001
	Actor effect		.06 (.08)	0.72	0.47
	Partner effect		-.04 (.07)	-0.54	0.59
	Intercept*post		12.52 (12.00)	1.04	0.30
		Simple intercept post	*186.57 (10.89)*	*17.13****	*<.0001*
	Actor effect*post		.01 (.10)	0.05	0.96
		Simple slope post	*.06 (.07)*	*.93*	*.35*
	Partner effect*post		.03 (.10)	0.27	0.79
		Simple slope post	*-.01 (.07)*	*-.20*	*.84*
Partners:	Intercept		137.34 (7.20)	19.08	<.0001
	Actor effect		-.16 (.07)	-2.40*	<.05
	Partner effect		.18 (.07)	2.80**	<0.01
	Intercept*post		-1.56 (5.09)	-.31	0.76
		Simple intercept post	*135.78 (4.93)*	*27.52****	<.0001
	Actor effect*post		.24 (.10)	2.52*	<0.05
		Simple slope post	*.08 (.07)*	*1.14*	*.26*
	Partner effect*post		-.18 (.09)	-1.94	0.05
		Simple slope post	*.01 (.06)*	*.09*	*.93*

Note: ****p* < .001, ***p* < .01, **p* < .05. APIM = Actor-Partner Interdependence Model. OCD = obsessive-compulsive disorder.

Table 7

Fixed Effects and Simple Intercepts/Slopes for the Cross-Lagged APIM for AN: Differences in Actor/Partner Effects by Time Point (Baseline as Reference Point, df = 1654)

Effect		Estimate (SE)	*t*	*p*
Patients:	Intercept	154.14 (9.80)	15.74***	<.0001
	Actor effect	0.14 (.05)	2.84**	<.01
	Partner effect	0.37 (.09)	3.99***	<.0001
	Intercept*post	-16.61 (11.17)	-1.49	.14
	Simple intercept post	*137.53 (9.80)*	*15.74****	*<.0001*
	Actor effect*post	-.01 (.07)	-0.12	.90
	Simple slope post	*.13 (.05)*	*2.63***	*<.01*
	Partner effect*post	-.09 (.14)	-0.67	.51
	Simple slope post	*.28 (.10)*	*2.83***	*<.01*
Partners:	Intercept	113.41 (5.05)	22.44***	<.0001
	Actor effect	.04 (.05)	0.71	.48
	Partner effect	.09 (.03)	3.64***	<.001
	Intercept*post	-3.89 (4.37)	-0.89	.37
	Simple intercept post	*109.52 (3.97)*	*27.57****	*<.0001*
	Actor effect*post	.04 (.07)	0.51	.61
	Simple slope post	*.07 (.05)*	*1.45*	*.15*
	Partner effect*post	-.00 (.04)	-0.13	.90
	Simple slope post	*.09 (.02)*	*3.60****	*<.001*

Note: ***$p < .001$, **$p < .01$, *$p < .05$. APIM = Actor-Partner Interdependence Model. AN = anorexia nervosa.

and significant at both time points, see Figure 2C. Similarly, there were no changes in the partner effect for the partners; the effect remained positive and significant at both time points.

Summary of covariance model results. Contrary to hypothesis 1a, the results of the APIM analyses indicated that there was greater covariation of emotional arousal with their partners for patients with AN but not for patients with OCD. There was no evidence for any difference in covariation based on symptom severity for either diagnostic group (hypothesis 1b). Finally, there was partial support for hypothesis 3a. As expected, the degree of covariation for patients with OCD decreased from baseline to post. Contrary to the hypothesis, there was no increase in covariation for patients with AN (no change).

Coupling: Coupled Linear Oscillator Models. Coupling refers to the associations of the dynamic characteristics of two self-regulated systems. In other words, each individual's oscillations of emotional arousal over the course of a conversation (fluctuating around an equilibrium level) are regulated as a function of the state of their own emotion system as well as the state of their partner's emotion system. For example, this may include how far an individual's current arousal is removed from their preferred level of arousal (e.g., stronger tendency to move back towards equilibrium if emotional arousal is unusually high rather than just minimally elevated). In addition, the partner's displacement from equilibrium may play a role as well – for example, an individual's emotional arousal may remain high longer than predicted by his or her own self-regulatory dynamics if their partner's arousal is unusually high as well. If such cross-partner influences occur, then the two emotion systems are described as "coupled." Previously, coupling has been metaphorically compared to the characteristics of two pendulums that are connected by a spring. Appendix B provides a discussion of linear oscillator models and self-regulatory processes in this framework that serve as the basis for the models applied here. For the purpose of assessing coregulation in this study, multilevel coupled linear oscillator models were used. The basic level 1 equation for patients is

$$\ddot{x}_{ij} = \eta_{ix} x_{ij} + \varsigma_{ix} \dot{x}_{ij} + \eta_{iy} y_{ij} + \varsigma_{iy} \dot{y}_{ij} + e_{ij}$$

where $\ddot{x}_{ij}$ is the second derivative (rate of change in the slopes, or curvature) of emotional arousal of patient i on talk turn j, x_{ij} and $\dot{x}_{ij}$ are the displacement from equilibrium and first derivatives (rate of change in f_0, or slope) for patient with their respective coefficients. The next two terms are the equivalent terms for the partners, and the coefficients η_{iy} and ς_{iy} indicate the degree to which the partners' displacement from their equilibrium (y_{ij}) and their rate of change in displacement ($\dot{y}_{ij}$) influence the patients' second derivative of emotional arousal, that is, the degree to which coregulation in the form of coupling occurs for the patient. In these models, self-regulation is always assumed to occur (i.e., η_{ix} should be negative and significant), and for the purpose of the current study, the influence of the partners' displacement from equilibrium is the main focus to determine coupling (i.e., η_{iy}).

The dampening parameters ς determine whether an individual's oscillations become smaller in amplitude over time (i.e., fluctuations become closer to the equilibrium) and how this may be influenced by the partner's regulation, given that coregulation should ideally contribute to homeostasis for each member of the couple. However, dampening is most relevant if measurement occurs after a perturbation in the system (Butler & Randall, 2013), for example, after one partner becomes very upset following bad news. In this study, this is not part of the paradigm and dampening is not expected to occur. Thus, the dampening components were included in the models but are not the focus of the hypotheses.

To test the hypotheses, the level 2 equations of the multilevel model were extended in a similar fashion to the APIMs, resulting in cross-level interactions with the coupling parameters to assess for differences by diagnostic group, symptom severity, or time point. To assess coupling for the partners to the patients, separate models were used with equivalent terms. No specific hypotheses were made about the coupling parameter for partners, but they were obtained for exploratory reasons given that this is the first time these models have been employed in couples in which one partner suffers from OCD or AN.

Estimation of derivatives and preliminary analyses. The first step in the application of linear oscillator models is the estimation of the first- and second-order derivatives for each time series. Multiple approaches are described in the literature, all of which are relatively new developments in their application to psychological questions. For the purpose of the current study, local linear approximation (LLA) of the estimates (Boker & Laurenceau, 2006; Boker & Nesselroade, 2002) was used. LLA has been applied successfully in psychological studies using differential equation models (Boker & Laurenceau, 2006) and is a relatively simple approach to obtain observed estimates of derivatives from a time series. One of the main limitations of LLA is that estimates obtained using LLA may be biased if τ, which is the lag used in the embedded matrix of the observations required for the estimates and can be thought of as a smoothing parameter, is chosen incorrectly (Deboeck, 2010). However, given that the data used for the current study consists of talk turns as distinct, and to some degree naturally occurring and alternating units, LLA was chosen as an adequate method to estimate derivatives using a lag of $\tau = 1$ talk turn, consistent with prior studies that used LLA with f_0 data (B. R. Baucom, Iturralde, et al., 2012; B. R. Baucom, Saxbe, et al., 2012). Prior to estimating derivatives, linear trends have to be removed. Detrending was accomplished by fitting a slope and intercept model to each time series (i.e., one per individual and conversation) and saving the residuals for use in the following analyses (Boker & Laurenceau, 2006). The first and second derivatives were then estimated using LLA.

Before testing the models used for the hypotheses, simple coupled linear oscillator models without any level 2 predictors were analyzed for patients and partners, including random effects for each person's own and partners' displacement from equilibrium,[6] estimating variances for each effect but not covariances.[7] Importantly, the fixed effects for the self-regulation effects (effects of each person's displacement from equilibrium on their own second derivative) were negative and significant for patients (η = -2.03, $t(1074)$ = -28.92, $p < .0001$) and partners (η = -1.98, $t(1081)$ = -24.41, $p < .0001$). This is a critical preliminary finding because coupled linear oscillator models can only be meaningfully interpreted and analyzed if self-regulatory processes are present. Thus, these findings confirmed that these models were well suited to proceed with further analysis and hypothesis testing.

Using the multilevel model outlined above, the hypotheses focused on the coupling aspect of coregulation were tested as reported below, adding hypothesis-specific level 2 predictors to the CLO model. In each model, the interaction terms for the added predictor with the effects for patients' and partners' displacement for equilibrium were included as random effects as well (increasing the number of variance parameter estimates to 5 for each model). Of note, the hypotheses are concerned with the presence/degree of coupling, not with the sign of the coefficient. The magnitude of the effect is the focus of the hypotheses. Both positive and negative coefficients can indicate coupling; the sign is related to the phase of the oscillations which is not as central to coupling as a general construct (Story & Butner, 2010). Below, the data analytic approach for each hypothesis is briefly explained, and results for the full model are reported, followed by a more detailed description of the effects that are pertinent to the hypothesis being tested.

Hypothesis 1a. This hypothesis predicted greater coregulation for patients with OCD compared to patients with AN at baseline. To test differences in coupling as an indicator of coregulation for this hypothesis, diagnostic group was added as a level 2 predictor in the coupled oscillator model for patients as described above. Diagnosis was dummy coded, using AN as the reference group in the models. Cross-level interactions between diagnostic group and all level 1 predictors (own and partner's displacement from equilibrium, own and partner's first derivative) were included in the model as fixed effects; however, the interaction of diagnostic group by fixed effect of partner's displacement from equilibrium is the focus of this hypothesis. An equivalent model for partners was tested for exploratory purposes.

Results for the fixed effects including simple slope estimates for both the patient and partner models are provided in Table 8; see Figure 3A for an illustration of significant effects of patients' and partners' own and coupled effects of the displacement from equilibrium. The model for patients is of primary interest for the hypothesis. Consistent with the basic CLO model for patients described above, the significant negative main effect for AN patients' own displacement from equilibrium confirms the presence of the self-regulatory process (η = -2.04, $t(1070) = -23.97$, $p < .0001$). The non-significant interaction effect for diagnosis indicated that the effect for OCD patients was the same, which was confirmed by the significant negative estimate for the simple slope for OCD patients' own displacement from equilibrium (η = -2.02, $t(1070) = -15.48$, $p < .0001$).

As previously described, the coupled effect of partners' displacement from their

Table 8

Fixed Effects and Simple Slope Estimates for 2 CLO Models at Baseline: Displacement from Equilibrium (f_0), Slopes (1^{st} Derivatives of f_0), and Diagnosis Predicting Curvature (2^{nd} Derivatives of f_0) for (A) Patients and (B) Partners. AN as the Reference Group.

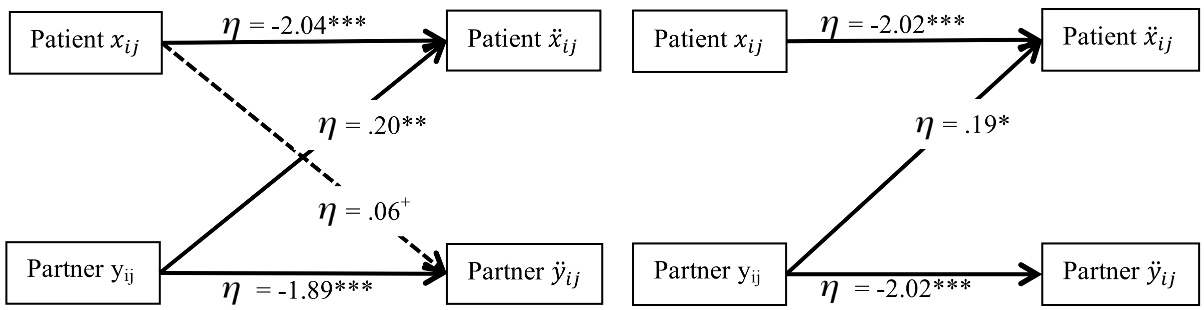
	(A) Patient model (*df* = 1070)			**(B) Partner model (*df* = 1077)**		
Effect	Estimate (SE)	*t*	*p*	Estimate (SE)	*t*	*p*
F_0 displ. (self)	-2.04 (.09)	-23.97***	<.0001	-1.89 (.10)	-18.42***	<.0001
F_0 displ. (other)	.20 (.07)	2.67**	<.01	.06 (.03)	1.85	.07
F_0 slope (self)	.01 (.06)	.17	.87	-.003 (.07)	-.05	.96
F_0 slope (other)	.19 (.10)	1.90	.06	.02 (.04)	.55	.58
F_0 displ. (self)*OCD	.02 (.16)	.14	.89	-.22 (.17)	-1.31	.19
Simple Slope OCD	*-2.02 (.13)*	*-15.48****	*<.0001*	*-2.11 (.13)*	*-16.22****	*<.0001*
F_0 displ. (other)*OCD	-.01 (.12)	-.06	.95	.03 (.09)	.36	.72
Simple Slope OCD	*.19 (.09)*	*2.09**	*<.05*	*.09 (.08)*	*1.09*	*.28*
F_0 slope (self)*OCD	.06 (.13)	.52	.60	.00 (.11)	.04	.97
F_0 slope (other)*OCD	.06 (.17)	.34	.73	.04 (.09)	.44	.66

Note: ****p* < .001, ***p* < .01, **p* < .05. CLO = Coupled Linear Oscillator. AN = anorexia nervosa. OCD = obsessive-compulsive disorder. Displ. = displacement.

equilibrium in the patient models is the focus of the hypothesis. There was a significant positive effect for AN patients (η = .20, $t(1070) = 2.67$, $p < .01$), and the absence of a significant interaction effect with diagnosis indicated a similar effect for OCD patients, which was confirmed by testing the simple slope for the coupled effect of partners'

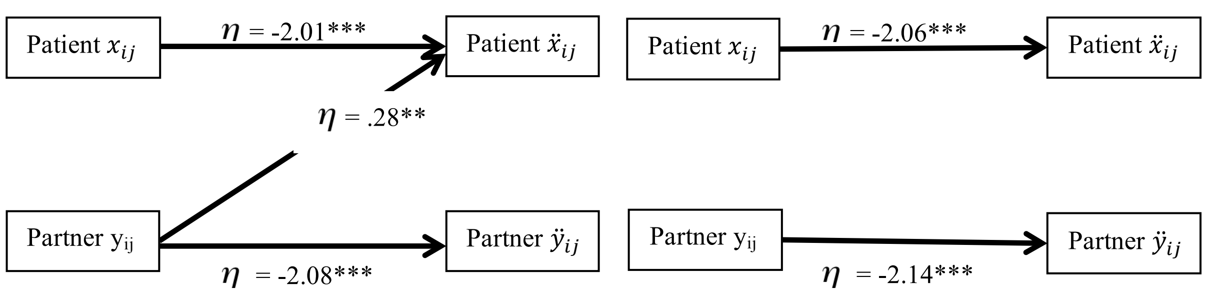
(A) Simple slopes for f_0 mean displacement (self & other) by diagnostic group at baseline, obtained in separate models for patients and partners (*n* = 51)

AN OCD



(B) Simple slopes for f_0 mean displacement (self & other) for OCD at baseline and post, obtained in separate models for patients and partners (*n* = 11)

Baseline Post



(C) Simple slopes for f_0 mean displacement (self & other) for AN at baseline and post, obtained in separate models for patients and partners (*n* = 16)

Baseline Post

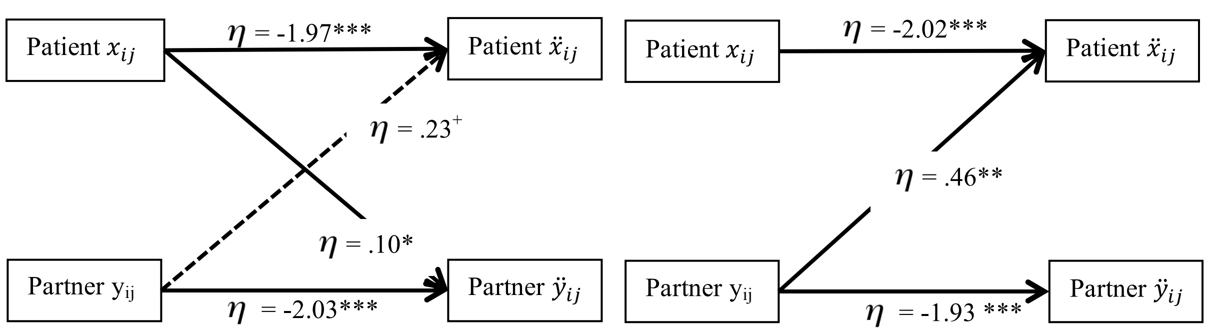


Figure 3. Significant simple slopes for CLOs (displacement from equilibrium) testing differences for (A) diagnostic group, (B) time point in the OCD group, and (C) time point in the AN group. ****p* < .001, ***p* < .01, **p* < .05, ^{+}p < .1

displacement for the OCD group (η = .19, $t(1074) = 2.09$, $p < .05$). Thus, there was no support for the hypothesis of greater coupling in the OCD group as both patient groups were significantly and equally influenced in their regulation of emotional arousal by their partners' displacement from their equilibrium. The positive direction of the effects indicates a "pull" of the partners' emotional arousal on the patients' curvature in the direction of the partners' displacement from equilibrium. For example, if both patients' and partners' emotional arousal lies above their respective equilibriums, the positive effect on patients' curvature is predicted to lead to a slower return to equilibrium for patients than would be expected if they were unaffected by their partners. Similarly, a slower return to equilibrium would also be predicted if patients and partners are matched with emotional arousal below their respective equilibrium points.

The remaining fixed effects for the patient model indicated that there was no intrinsic dampening effect for either group (patients' slope/rate of change in f_0 did not predict their curvature). For patients in both diagnostic groups, there were trend-level effects ($p < .06$) of the partners' slope on patients' curvature, indicating that there may be an "opposite" dampening effect – patients' curvature is predicted to respond positively to change in partners' displacement from equilibrium, resulting in an increase in the magnitude of patients' oscillations over time.

Although the model for partners' curvature were not central to the hypothesis, the results are presented here for exploratory purposes and to contribute to a more complete picture of the regulatory processes that occur in the same conversation for both members of the couple. Fixed effects and estimates for the simple slopes for partners are also shown in Table 8. Similar to the patient models, significant self-regulatory effects for partners' own displacement from equilibrium were found for both groups. However, the pattern for the coupled effect of patients' displacement from their equilibrium in the partner models was slightly different. There was only a trend for AN partners (η = .06, $t(1077) = 1.85$ $p = .07$), and the absence of a significant interaction effect with diagnosis indicated a similar effect for OCD partners, which also was not significant as indicated by the simple slope for the coupled effect of patients' displacement for the OCD group (η = .09, $t(1077) = 1.09$, $p = .28$). However, the difference in patterns between the patient and partner models should be interpreted with caution as the estimates were obtained in separate models and cannot be compared directly. Finally, there were no dampening effects for the partners.

Hypothesis 1b. This hypothesis predicted differences in coregulation based on symptom severity within each diagnostic group, predicting greater coregulation for greater OCD severity and weaker coregulation for greater AN severity. This hypothesis was tested by using separate multilevel models for AN and OCD, because symptom severity was assessed on different measures across diagnostic groups. Within each diagnostic group, this hypothesis was assessed in a similar fashion to hypothesis 1a. Here, symptom severity was added as a level 2 predictor, and the interaction effect between symptom severity and partners' displacement from equilibrium on the patients' second derivative of emotional arousal is the focus of the hypothesis.

Results for the fixed effects for both the patient and partner models are provided in Table 9 for the OCD sample and in Table 10 for the AN sample. There was no support for this hypothesis in either diagnostic group. The fixed interaction effects for partners' displacement from equilibrium and Y-BOCs (b = -.01, $t(295) = -.99$, $p = .33$) in the model for OCD patients and for partners' displacement from equilibrium and EDE global score (b = .03, $t(767) = .51$, $p = .61$) in the model for AN patients were not significant.[8] There were no

Table 9

Fixed Effects for 2 CLOs at Baseline Testing Differences Based on OCD Severity: Displacement from Equilibrium (f_0), Slopes (1st Derivatives), and Y-BOCs Score Predicting Curvature (2nd Derivative) for (A) OCD Patients and (B) OCD Partners

	(A) Patient model (*df* = 295)			**(B) Partner model (*df* = 304)**		
Effect	Estimate (SE)	*t*	*p*	Estimate (SE)	*t*	*p*
F_0 displ. (self)	-1.98 (.12)	-16.19***	<.0001	-2.06 (.13)	-16.16***	<.0001
F_0 displ. (other)	.14 (.10)	1.39	.17	.09 (.08)	1.06	.29
F_0 slope (self)	.07 (.11)	.62	.53	.01 (.12)	.09	.93
F_0 slope (other)	.25 (.13)	1.89	.06	.07 (.09)	.74	.46
F_0 displ. (self)*YBOCS	-.01 (.03)	-.21	.83	.01 (.03)	.28	.78
F_0 displ. (other)*YBOCS	-.01 (.01)	-.99	.33	-.02 (.02)	-1.13	.26
F_0 slope (self)*YBOCS	-.01 (.02)	-.47	.64	.07 (.02)	.37	.71
F_0 slope (other)*YBOCS	.00 (.02)	.00	1.00	.00 (.02)	.14	.89

Note: ****p* < .001, ***p* < .01, **p* < .05. CLO = Coupled Linear Oscillator. OCD = obsessive-compulsive disorder. YBOCS = Yale-Brown Obsessive Compulsive Scale. Displ. = displacement.

significant interaction effects with the severity scores for any of the other predictors in the models for OCD patients and partners or for AN patients and partners.

Hypothesis 3a. This hypothesis addresses changes in the degree to which emotion coregulation occurs for each diagnostic group over the course of treatment, predicting a decrease in coregulation for patients with OCD and an increase in coregulation for patients with AN from baseline to post. As discussed above for the covariation models, this

Table 10

Fixed Effects for 2 CLOs at Baseline Testing Differences Based on AN Severity: Displacement from Equilibrium (f_0), Slopes (1^{st} Derivatives), and EDE Global Score Predicting Curvature (2^{nd} Derivative) for (A) AN Patients and (B) AN Partners

	(A) Patient model (df = 767)			**(B) Partner model (df = 765)**		
Effect	Estimate (SE)	*t*	*p*	Estimate (SE)	*t*	*p*
F_0 displ. (self)	-2.04 (.09)	-24.04***	<.0001	-1.20 (.07)	-28.84***	<.0001
F_0 displ. (other)	.17 (.09)	2.00	.05	.07 (.03)	1.97*	<.05
F_0 slope (self)	.01 (.06)	.09	.93	.00 (.06)	-.04	.97
F_0 slope (other)	.18 (.11)	1.69	.09	.03 (.04)	.65	.52
F_0 displ. (self)*EDE	.05 (.07)	.73	.47	.09 (.09)	1.06	.29
F_0 displ. (other)*EDE	.03 (.07)	.51	.61	.02 (.02)	.93	.35
F_0 slope (self)*EDE	.00 (.06)	.07	.94	.01 (.04)	.17	.86
F_0 slope (other)*EDE	.05 (.08)	.66	.51	-.02 (.03)	-0.65	.52

Note: ***$p < .001$, **$p < .01$, *$p < .05$. CLO = Coupled Linear Oscillator. AN = anorexia nervosa. EDE = Eating Disorders Examination. Displ. = displacement.

hypothesis was tested in separate models for each diagnostic group rather than in a single three-level model, using time point as a level 2 predictor (dummy coded with baseline as the reference condition). Only couples for which baseline and post data was available were used for these analyses.

First, the model for patients testing the hypothesis for the OCD group was analyzed. Results for the fixed effects including simple slope estimates are shown in Table 11; see Figure 3B for an illustration of significant simple slopes. There was partial support for the

Table 11

Fixed Effects and Simple Slope Estimates for 2 CLOs for OCD at Baseline and Posttest: Displacement from Equilibrium (f_0), Slopes (1^{st} Derivatives), and Time Point Predicting Curvature (2^{nd} Derivative) for (A) Patients and (B) Partners, Baseline as the Reference Group.

	(A) Patient model (df = 387)			**(B) Partner model (df = 394)**		
Effect	Estimate (SE)	*t*	*p*	Estimate (SE)	*t*	*p*
F_0 displ. (self)	-2.01 (.16)	-12.71***	<.0001	-2.08 (.19)	-10.72***	<.0001
F_0 displ. (other)	.28 (.10)	2.90**	<.01	.12 (.11)	1.09	.28
F_0 slope (self)	.19 (.14)	1.37	.17	-.01 (.16)	-.06	.95
F_0 slope v(other)	.20 (.15)	1.32	.19	.15 (.14)	1.05	.30
F_0 displ. (self)*post	-.05 (.24)	-0.23	.82	-.06 (.17)	-.34	.73
Simple slope post	*-2.06 (.24)*	*-8.58****	*<.0001*	*-2.14 (.17)*	*-12.32****	*<.0001*
F_0 displ. (other)*post	-.25 (.14)	-1.70	.09	-.03 (.15)	-.18	.85
Simple slope post	*.08 (.11)*	*.36*	*.72*	*.09 (.12)*	*.78*	*.43*
F_0 slope (self)*post	-.11 (.18)	-0.62	.53	-.02 (.20)	-.12	.91
F_0 slope (other)*post	-.07 (.20)	-0.37	.71	-.02 (.19)	-.09	.93

Note: ****p* < .001, ***p* < .01, **p* < .05. CLO = Coupled Linear Oscillator. OCD = obsessive-compulsive disorder. Displ. = displacement.

hypothesis for OCD patients. There was a significant coupled effect for partners' displacement from equilibrium on patients' curvature at baseline ($\eta = .28$, $t(387) = 2.90$, $p < .01$), and, at the trend level, the interaction effect for time point suggested some change in the simple slope for this effect at post ($p = .09$). Probing the simple slope revealed that the coupled effect was no longer significant at post ($\eta = .04$, $t(387) = .36$, $p = .72$). Thus, while OCD patients' curvature was significantly influenced by the partners' displacement from equilibrium (i.e., the patients' regulation of emotional arousal was coupled with the partners' emotional arousal), this association disappeared after treatment. However, given that the difference in the effects was not significant, this should be interpreted with caution. The fixed effects of the model for partners showed that only the self-regulatory effect of partners' own displacement from equilibrium on their own curvature was significant, and there were no significant changes from baseline to post (see Table 11).

Next, the model for patients testing the hypothesis for the AN group was analyzed. Results for the fixed effects including simple slope estimates for post are shown in Table 12; see Figure 3C for an illustration of significant simple slopes. There was partial support for the hypothesis for AN patients. There was a trend for a positive effect for partners' displacement from equilibrium on patients' curvature at baseline ($\eta = .24$, $t(770) = 1.85$, $p = .06$). Even though the interaction effect for time point was not significant ($p = .26$), the estimate for the simple slope at post was almost twice as large ($\eta = .46$, $t(770) = 2.81$, $p < .01$). This should be interpreted with caution, but points towards an increase in the coupling of patients' regulation of emotional arousal (patients' curvature) with partners' displacement from equilibrium. The fixed effects of the model for AN partners showed a significant effect for patients' displacement from equilibrium on partners' curvature at baseline ($\eta = .10$, $t(768) = 2.57$, $p < .05$), and there were no significant changes in any of the effects from baseline to post (see Table 12).

Table 12

Fixed Effects for 2 CLOs for AN at Baseline and Posttest: Displacement from Equilibrium (f_0), Slopes (1^{st} Derivatives), and Time Point Predicting Curvature (2^{nd} Derivative) for (A) Patients and (B) Partners, Baseline as the Reference Group.

	(A) Patient model (df = 770)			**(B) Partner model (df = 768)**		
Effect	Estimate (SE)	*t*	*p*	Estimate (SE)	*t*	*p*
F_0 displ. (self)	-1.97 (.12)	-15.82***	<.0001	-2.03 (.09)	-21.72***	<.0001
F_0 displ. (other)	.24 (.13)	1.85	.06	.10 (.04)	2.57**	.01
F_0 slope (self)	.05 (.09)	.52	.60	.05 (.08)	.60	.55
F_0 slope (other)	.19 (.15)	1.23	.22	.02 (.05)	.47	.64
F_0 displ. (self)*post	-.05 (.14)	-.39	.70	.10 (.15)	.66	.51
Simple slope post	*-2.02 (.15)*	*-13.41****	*<.0001*	*-1.93 (.14)*	*-13.55****	*<.0001*
F_0 displ. (other)*post	.22 (.19)	1.12	.26	-.05 (.05)	-.82	.41
Simple slope post	*.46 (.16)*	*2.81***	*<.01*	*.06 (.04)*	*1.31*	*.19*
F_0 slope (self)*post	-.09 (.14)	-.67	.50	-.06 (.14)	-.43	.67
F_0 slope (other)*post	-.19 (.26)	-.70	.48	-.03 (.07)	-.43	.67

Note: ****p* < .001, ***p* < .01, **p* < .05. CLO = Coupled Linear Oscillator. AN = anorexia nervosa. Displ. = displacement.

Summary of the CLO results. There was no support for hypothesis 1a; patients in both diagnostic groups were found to exhibit significant and equal levels of coupling (patients' curvature predicted by partners' displacement from equilibrium). Further, there was no support for hypothesis 1b, as the strengths of the coupling parameter did not differ based on symptom severity in either group. Finally, there was partial support for hypothesis 3b. As expected for the OCD group, there was a coupled effect for partners' displacement from equilibrium on patients' curvature at baseline, and this effect disappeared at post. However, the decrease in the strengths of the effect was only a trend (p = .09). Similarly, the strengths of the coupled effect within the AN group increased from baseline to post as expected, but this change was not significant.

Integration of Results by Hypothesis

The first four hypotheses (1a-2b) were concerned with baseline differences between the two diagnostic groups and based on symptom severity within each group. Contrary to expectations, AN patients displayed greater covariation of emotional arousal (rather than weaker covariation) compared to OCD patients, and the two patient groups did not differ in the coupling effect of their regulation of emotional arousal (both groups displayed significant coupling). As hypothesized, OCD patients displayed higher aggregate levels of emotional arousal at baseline compared to AN patients. Symptom severity was not significantly associated with covariance, coupling, or aggregate levels of emotional arousal in either diagnostic group at baseline.

The remaining two hypotheses (3a-3b) were focused on changes in coregulation and aggregate emotional arousal from baseline to post within each diagnostic group. In the OCD group, the hypothesis about a decrease in coregulation was partially supported: OCD patients exhibited significant coupling at baseline but not at post; however, the decrease in coupling was only a trend (p = .09). There was no change in covariation for OCD patients. However, it is notable that the expected pattern was observed for OCD partner instead: OCD partners exhibited significant covariance at baseline but not at post, and this decrease was significant. Contrary to the hypothesis, there was no change from baseline to post in aggregate levels of emotional arousal in the OCD group.

The hypothesis about an increase in coregulation was largely unsupported for the AN group: There was no change in covariation from baseline to post for AN patients (significant covariation at both time points), and, although there was a notable increase in the coupling estimate for AN patients, this increase was not significant. Competing hypotheses for the direction of change in aggregate levels of emotional arousal for AN patients from baseline to post were tested; the results indicated a marginally significant decrease in aggregate arousal for AN patients (p = .05).

CHAPTER 4: DISCUSSION

The current investigation is the first study to examine emotion coregulation in couples in the context of psychopathology, and one of the first to examine both covariation and coupling as different indicators of coregulation in the same sample. Coregulation was conceptualized from a dynamic systems perspective and examined based on vocally encoded emotional arousal during videotaped couple conversations that were completed before and after couple-based treatments for OCD or AN.

Interpretation of Findings

Broadly, it was expected that patients with OCD would exhibit higher levels of emotional arousal as well as stronger coregulation compared to patients with AN, that these indicators would vary by symptom severity, and that the two groups would change in opposite directions with treatment. That is, emotional coregulation was expected to decrease for patients with OCD and increase for patients with AN, consistent with a reduction of patterns in interpersonal emotional regulation that may be maladaptive within the context of the respective disorders. Further, levels of emotional arousal were expected to decrease for patients with OCD and either increase or decrease for patients with AN. Thus, the findings can be grouped into two separate sets, the first being focused on differences prior to treatment and the second focused on changes from baseline to post treatment.

At baseline, only the hypothesis concerning differences in aggregate emotional arousal was supported. However, the analyses suggested distinct patterns in the regulatory processes for each diagnostic group. A more complete picture emerges when integrating the findings across analytic approaches and when considering the coregulation effects for patients in the context of the full models. The covariation models indicated that there was stronger covariation of emotional arousal for AN patients compared to OCD patients (opposite to what was expected), and the coupling models indicated that coupling occurred for both patient groups to the same degree. In other words, AN patients exhibited both covariation and coupling while OCD patients only exhibited coupling. Importantly, these processes occurred in the context of greater aggregate emotional arousal for OCD patients and partners compared to AN patient and partners. Thus, consistent with the notion that OCD patients would easily experience anxiety when talking to their partners about the disorder while AN patients may be more likely to attempt to control their emotional arousal, this group difference in aggregate arousal was indeed reflected in the findings.

In examining the patterns in covariation for OCD couples at baseline more closely, it is notable that the patients' level of emotional arousal at a given talk turn was not associated with either their own or their partners' emotional arousal at the previous talk turn. Typically, one would expect an individual's emotions and behaviors at a given time point to be associated to some degree with the same process at a subsequent time point, especially for closely spaced observations. The absence of any actor effects for OCD couples suggests that there appears to be little predictability within each member of the couple in terms of levels of emotional arousal. However, OCD partners' level of emotional arousal was predicted by the patients' emotional arousal at the preceding talk turn (but not their own). Thus, a picture emerges of the conversations among OCD couples in which both partners are highly emotionally aroused (compared to the AN group), and in which partners are responsive to the patients' emotional arousal at any given talk turn, although there is little to predict the patients' own arousal from one talk turn to the next. Thus, the partners' level of emotional arousal appears to be primarily driven by the patients' emotional arousal, but the patients' emotional arousal may increase, decrease, or stay the same from one talk turn to the next with no predictability. Therefore, the partner is left to respond to a highly aroused patient with little information to anticipate what will happen next. If partners are highly responsive to such unpredictable levels of emotional arousal of the OCD patients, this may have important implications for understanding the partners' experience and how they respond to patients with attempts to help patients manage patients' distress. For example, this may suggest that partners' provision of reassurance and other accommodating behaviors may partially be driven by their own emotional arousal in response to the patients' distress.

To further contextualize this pattern for the OCD group, it is important to consider the results of the coupling models (CLO models) for information about other ways in which patients' and partners' level of emotional arousal may influence the other member of the couple. While the patients' emotional arousal did not covary with the partners' emotional arousal as noted above, the patients' regulation of emotional arousal (i.e., curvature of the oscillations in emotional arousal) was positively coupled to the partners' displacement from equilibrium. There was no coupling for OCD partners. Integrating this set of findings of covariation for OCD partners and coupling for OCD patients has important implications that are based on a more nuanced understanding of the CLO results.

In interpreting this pattern of results, it is essential to understand that the specific predictions based on the CLOs vary, based on the phasing of each person's oscillations and whether each person is above or below their equilibrium at a given time. The following scenario may be particularly important to consider in order to understand the predictions for periods of time when both partners are unusually highly aroused. When partners experience high emotional arousal (positive displacement from their respective equilibriums), the CLO model for the patients indicate that the patients' curvature of their oscillations in emotional arousal is predicted to become "flatter" beyond what is predicted based on the self-regulatory dynamics of the patients' oscillatory pattern. That is, if patients' arousal is also above their equilibrium at the same time the partners' arousal is high, this would result in a slower return to their equilibrium. In other words, if partners and patients are matched in high emotional arousal, regulating back to their equilibrium becomes more difficult for patients.[9]

Therefore, integrating the covariation and coupling findings for OCD couples, a recursive pattern of coregulation between the two partners emerges: Even though patients' level of emotional arousal is not directly predicted by the partners' emotional arousal (no covariation), the partners' emotional arousal still influences how quickly patients are able to return to their equilibrium level of emotional arousal (coupling). This can result in patients being "kept" at an unusually high or low level of emotional arousal for longer periods of time, which in turn has important implications for partners, as their emotional arousal covaries with the patients' arousal. That is, when patients are highly aroused, partners respond with higher arousal. And when both members of the couple are highly aroused, it takes longer for patients to return to their equilibrium level of arousal. Although other interpretations could be drawn from this pattern of findings integrating the turn-by-turn sequence of changes in emotional arousal and coregulation for these couples, this set of findings suggests that there are lawful patterns in interpersonal emotional regulation for these couples when they talk about OCD that warrant further investigation.

A different pattern of covariation and coupling was found for AN patients and their partners. Contrary to the hypotheses, there was no indication of diminished emotion coregulation in AN patients compared to OCD at baseline. Rather, emotion coregulation appeared to be either stronger (covariation) or the same (coupling) in AN patients compared to OCD patients. This coregulation must be understood within the context of a lower overall aggregate level of arousal compared to the OCD group. Overall, the analyses suggested that changes in emotional arousal and the processes of emotion regulation in AN couples over the course of a conversation were more predictable in the AN group. The APIM at baseline indicated that the levels of emotional arousal in both members of the couple were positively predicted by their own previous level of emotional arousal, indicating that individuals who were emotionally aroused above their mean at a given talk turn are predicted also to experience emotional arousal above their mean at the next talk turn. In addition, emotional arousal for AN patients and partners positively covaried with the emotional arousal of the other member of the couple; that is, as one person became more aroused, the other person was likely to respond with a higher than average level of arousal as well. Similarly, the CLO model for patients indicated that there was significant positive coupling of the patients' regulation of emotional arousal (curvature of patients' oscillations) to the partners' displacement from equilibrium. The direction of the coupling effect was the same for AN patients as for OCD patients, suggesting that returning to the equilibrium level of emotional arousal for AN patients would be equally slowed if their emotional arousal is matched at high or low levels with the partners' relative to their respective equilibriums. Thus, for AN patients a consistent pattern of emotion coregulation was found.

The hypotheses regarding diminished emotion coregulation in AN patients were derived from a series of empirical findings that suggest heavy reliance on individually focused emotion regulation strategies and a consistent patterns of "shutting out" close others from emotional experiences. Within this reasoning, a lack of coregulation would have been interpreted as maladaptive, with the hopes that treatment would increase its strength. However, it is important to consider that the clear pattern of emotion coregulation in AN patients prior to treatment found in this investigation may not necessarily imply that it is adaptive (see discussion of the implications of the coupling effect) or comfortable for the patients. That is, these results may alternatively be reflective of a high sensitivity and reactivity of the AN patients to the emotional expression of their partners, which may be an underlying factor in the behaviorally observed tendencies to withdraw from partners, limit emotional sharing, and attempts to revert to individually focused emotion regulation strategies. Related ideas of emotional sensitivity and reactivity in an interpersonal context have been suggested in the literature (Haynos & Fruzzetti, 2011; Schmidt & Treasure, 2006) and may be related to known difficulties in accurately recognizing emotions in others (Harrison, Sullivan, Tchanturia, & Treasure, 2010; Oldershaw et al., 2011). However, the notion of greater emotional reactivity to emotional expression of others has not been directly tested empirically. In the current context, patients with AN do manage to keep their overall level of arousal relatively low (compared to patients with OCD) while responding to their partner's arousal in a systematic, coregulatory fashion. Thus, even though not all hypotheses regarding baseline differences between OCD and AN were found, this series of findings nevertheless suggests that there may be disorder-specific patterns of interpersonal emotion regulation that warrant further investigation. In particular, it will be important to further contextualize the current findings to determine whether covariation and coupling have similar adaptive or maladaptive functions among OCD and AN patients and their partners, and how they may be related to relevant disorder-specific individual and couple behaviors such as restriction, avoidance, reassurance seeking, or symptom accommodation.

The second set of analyses was focused on changes in coregulation and aggregate arousal from baseline to post treatment within each diagnostic group. Emotion coregulation was expected to decrease for OCD patients and increase for AN patients. Aggregate arousal was predicted to decrease for OCD patients, while either an increase or decrease was understandable for AN patients. For the OCD group, changes in covariation and coupling were broadly consistent with the expectation that undergoing a couple-based intervention for OCD should result in a decrease in coregulation. More specifically, the covariation effect for OCD patients and coupling effect for OCD partners that were found at baseline had disappeared post treatment, although the change in coupling was only a trend (p = .09). Although the hypothesis was focused on patients only, the same mechanisms may be at play in driving this change for both members of the couple. An important component of the couple-based treatment was to help the patients engage in response prevention and learn to tolerate obsessional fears, and for partners to be supportive without providing reassurance or accommodating OCD symptoms. It appears that this intervention successfully reduced the entanglement of the couples' interactions on the level of emotional arousal as well – that is, at post the partners' levels of emotional arousal were no longer predicted by the patients' level of emotional arousal (no covariation), and patients' curvature of the oscillations of emotional arousal were no longer coupled to the partners' displacement from their equilibrium (no coupling). This change in coregulation occurred even though there was no change in the aggregate levels of emotional arousal in the OCD group from baseline to post. Previously published findings from the same trial demonstrated that accommodation behaviors were successfully reduced in daily life (Boeding et al., 2013); the reduction in covariation of emotional arousal for OCD partners may suggest that this change occurs alongside with a reduced reactiveness of partners to the patients' emotional arousal, which may facilitate the reduction in accommodation. Similarly, if patients' regulation of emotional arousal is no longer influenced by the partners' arousal while discussing OCD, this may further be reflective of a more individually-based emotion regulation when interacting around the disorder that may be adaptive for this group in the early stages of recovery from OCD. Of course this interpretation of the meaning of changes from baseline to post in coregulation is speculative because the current investigation did seek to relate changes in coregulation empirically to other specific treatment changes (e.g., symptom reduction and accommodation). This possible interpretation points the way for further investigation of how changes across different domains of functioning in response to treatment can clarify how interventions impact functioning at a more nuanced level.

For the AN group, a marginally significant ($p = .05$) decrease in aggregate emotional arousal was found for AN patients, but not for partners. This may indicate either a general reduction in emotional arousal for patients with AN, or a reduction that is specific to the context of having a conversation about their disorder with their partners. Even though AN patients were less emotionally aroused compared to OCD patients at baseline, clinical observations suggest that many AN patients were highly uncomfortable during conversations with their partners at the beginning of treatment (Bulik, Baucom, & Kirby, 2012; Fischer, Kirby, et al., in press). An important component of the UCAN treatment was to help couples have more frequent and more open conversations about AN and each person's emotional experiences of the disorder, and to help patients become more comfortable opening up to their partners (Bulik et al., 2011). Thus, the decrease in aggregate emotional arousal for AN patients may reflect that such changes indeed occurred over the course of treatment; that is, they could have conversations about AN without becoming as emotionally aroused.

Limited changes in coregulation from baseline to post were observed for the AN group. There were no effects of time point in the APIM model, indicating that both patients' and partners' levels of emotional arousal continued to covary positively with the emotional arousal of the other member of the couple at post. The CLO model did not reveal significant changes in the coupling effects; however, the coupling coefficient for patients nearly doubled from baseline to post (η = .23 at pre, η = .46 at post). While this finding should be interpreted with great caution, it is important to note that strong coupling effects in CLO models are somewhat unlikely to find, and the direction of the change is consistent with the hypothesis. If this effect is indicative of a true change in coupling for AN patients, a number of interpretations are important to consider.

First, a change in coupling may be indicative of an adaptive increase in coregulation for AN patients, consistent with the reasoning that led to the hypothesis. That is, individuals with AN were thought to engage in interpersonal emotion regulation at a level that is maladaptively low, while primarily engaging in individually focused emotion regulation strategies (including disordered eating). However, as previously discussed, the results of the baseline models also gave rise to the question whether the positive covariance and coupling effects for AN patients could be reflective of a heightened sensitivity or reactiveness to the partners' emotional expression, which may contribute to patients' discomfort during vulnerable conversations and play into the tendency of AN patients to withdraw interpersonally on a behavioral level. Thus, it is also possible that this sensitivity and reactiveness has increased with treatment. This may either be problematic for these couples as they interact around the disorder; alternatively, the increase in coupling (and maintenance of covariation) could also have coincided with a change of how such interpersonal emotion regulation is experienced by the patients and the function it serves. That is, strong covariation and coupling could be indicative of heightened sensitivity at baseline, experienced as uncomfortable, and contribute to patients' withdrawn interpersonal style; similar levels of covariation and coupling at post might be occurring with patients who are now more comfortable discussing emotional content related to their disorder. The latter interpretation seems to be consistent with the decrease in overall levels of aggregate emotional arousal for AN patients from baseline to post; however, this possible interpretations and implications clearly need further investigation. In this context, it will also be important to consider whether the “equilibrium” around which coregulation occurs can be thought of as an adaptive level, and whether a return to equilibrium is useful. On the contrary, for example, it could be adaptive for coregulation to result in a slower return to the equilibrium range if the equilibrium level is either too high or too low.

The changes in emotion coregulation from baseline to post in the two diagnostic groups are also important to consider in the context of the effectiveness of the treatment. That is, more consistent and larger changes in emotion coregulation were found in the OCD group compared to the AN group. This is in some ways unsurprising, as treatment effects were larger and more consistent within the OCD group compared to the AN group; by and large, most OCD patients saw substantial improvement in their OCD symptoms, and the changes in coregulation observed in the current investigation may represent typical changes that occur with successful treatment (Abramowitz, Baucom, Boeding, et al., 2013). On the other hand, effective treatment of AN in adult is often more challenging, and improvement rates varied more widely among AN couples (Bulik, Baucom, Kirby, et al., 2012). Thus, further examination would be warranted to determine whether changes in emotion coregulation are associated with treatment effectiveness in these two groups; in particular, in a couple-based intervention, it will be important to consider changes in interpersonal emotion regulation as a potential moderator of treatment outcome.

Finally, a number of effects that were expected but not found are important to consider. The absence of covariation for OCD patients (i.e., partner effects for patients in the baseline APIM) was unexpected. While this findings merits further investigation, it is possible that talking about OCD before undergoing treatment was so anxiety provoking for patients that no additional impact of the partners' emotional arousal on the patients' experience occurred. That is, patients may be so highly emotionally aroused or anxious that their anxiety dominates their experience and what their partner does has little impact on them. Importantly, this interpretation also implies that further clarification may be needed to explore whether the difference in covariation for patients with AN and OCD is a function of the respective disorders per se, or whether this is a function of differences in overall emotional arousal. In other words, would OCD patients display covariation if they were less emotionally aroused during the conversation, and would AN patients' emotional arousal cease to covary with their partners if their emotional arousal reached a higher level?

Further, none of the hypotheses regarding differences based on symptom severity were supported. The lack of association of symptom severity with aggregate levels of emotional arousal, covariation, and coupling for patients or partners may be due to a variety of factors. First, the patterns of emotion coregulation and overall emotional arousal found in this investigation may be indicative of fairly ingrained patterns for these two patient groups, which may change as a result of a fairly intensive intervention, but is not based on severity alone prior to treatment. Second, the measures used to assess symptom severity in OCD and AN are a combination of a variety of facets of the disorders that combine emotional, behavioral, and cognitive components. It is possible that differences in emotion regulatory processes are a function of the severity of symptoms that are either more closely tied to patients' emotional experiences and emotion regulation (e.g., levels of distress, symptoms that are associated with emotion dyregulation such as binge eating) or more directly relevant to how they may interact with close others. For example, previous research on couples with OCD based on the same sample have suggested that rates of symptom accommodation vary by the type of compulsion that the patient displays, with partners of patients engaging in overt compulsions providing accommodations at higher rates (Boeding et al., 2013). On the contrary, patients with obsessions that are sexual or religious in nature and who primarily engage in mental rituals may be less likely to turn to partners to disclose and manage their distress. Similarly, different components of AN severity captured in the EDE may also map onto interpersonal emotion regulation processes in different ways. For example, greater dietary restraint has previously been found to be associated with more distanced communication in a subset of the AN couples included in the current investigation (Hudepohl, 2011), and bingeing and purging have been discussed relative to impulsivity and emotion regulation in eating disorders (Engel et al., 2013; Haedt-Matt & Keel, 2011; Pryor, Wiederman, & McGilley, 1996). Thus, differences in coregulation may exist between diagnostic subtypes of AN or based on the change in severity of restricting versus binge/purge symptoms.

In conclusion, the set of findings described here provide rich insights into the emotion regulation processes that occur during couple conversations about OCD and AN before and after treatment. The combination of novel methods to assess expressed emotional arousal and model complex interpersonal regulatory processes greatly aided an initial understanding of emotion coregulation in this context, suggesting that there may indeed be disorder-specific patterns. Broadly speaking, it appears that consistent emotion coregulation occurs for patients with AN, which is maintained or potentially even strengthened after treatment. Patients with OCD were generally more emotionally aroused than patients with AN, and their regulation of emotional arousal was coupled to partners' arousal as well but generally less predictable, which may pose a challenge for partners who appeared to be quite reactive to the patients' emotional arousal. Following treatment, emotion coregulation no longer occurred in couples with OCD.

The main aim of continued research in this area will be to develop a better understanding regarding the implications of these disorder-specific patterns and changes with treatment. It is important to recognize that the findings here are primarily descriptive of the emotion regulation patterns that occur in each group, but there are several questions left to answer with regards to the circumstances under which covariation and coupling are adaptive or problematic within each group. The current investigation primarily served to isolate what the patterns of emotion regulation are, which can now serve as a basis for future research.

Ultimately, this line of research has the potential to inform clinical interventions, for example, by providing clarification for how interpersonal emotion regulation contributes to the maintenance of symptoms and how shifts in the regulatory processes may facilitate treatment success. However, at this stage, it would be premature and highly speculative to draw conclusions about specific clinical implications from the current investigation. While the application of novel methods to this area is promising, this investigation primarily provides evidence that the constructs explored here warrant further examination and will likely continue to be important to consider to develop a better understanding of emotion regulation in an interpersonal context related to eating and anxiety disorders.

Methodological Contributions

In addition to the substantive contributions to the understanding of interpersonal emotion regulation in couples related to OCD and AN, a number of theoretical and methodological contributions are an important aspect of the current investigation as well. The present study was the first to examine interpersonal emotion regulation processes in couples in which one partner suffers from a psychological disorder, and, more broadly, only the second study to examine more than one aspect of emotion coregulation in couples in a single investigation. Furthermore, the findings presented here add to a growing body of literature demonstrating that the analysis of vocally encoded emotional arousal in couple interactions is a useful method to learn about couple relationships in a variety of ways.

In their reviews of interpersonal emotion systems (Butler, 2011), and coregulation more specifically, Butler and Randall (2013) emphasize the importance of a more comprehensive analysis of different aspects of coregulation, including the assessment of average levels, linear trends, covariation and coupling, and dampening after a perturbation (Butler & Randall, 2013). However, with the exception of one study (Butner et al., 2007), published empirical studies to date have primarily utilized methods that assess either covariation or coregulation, or focus on processes that are not considered coregulation within the current definition (Butler, 2011). Thus, the current study represents one of the first investigations to assess both covariation and coupling in the analysis of emotion coregulation, along with other recommendations put forth in the literature. The unique insights provided by this comprehensive approach confirm its importance for a more nuanced understanding of coregulation. Furthermore, this study also represents the first study of emotion coregulation in couples with more than one assessment time point, and the findings highlight that it was possible to model coregulation in a way that is sensitive to change.

This study also is the first empirical investigation of interpersonal emotion regulation from a dynamic systems perspective applied to individuals with psychopathology. While this research heavily draws from basic emotion research and conceptualizations of emotion coregulation as a normative, adaptive process in couples (Butler, 2011; Sbarra & Ferrer, 2006), this work raises important questions with regards to the role of coregulation in the context of psychopathology. As previously discussed, future research will be needed to determine the circumstances under which emotion coregulation may be adaptive or maladaptive in OCD and AN, and whether the function of the same processes may change during recovery. Within a dynamic systems perspective, further consideration is also needed, particularly around the notion of emotion regulation serving to help both individuals regulate emotional arousal to stay close to an adaptive equilibrium. While coregulation in couples in the presence of psychopathology may contribute to stability of the system, it reasonable to assume that this may not necessarily be an adaptive or ideal state. Thus, the current investigation only represents an important first step, providing a descriptive overview of the processes that occur in couples in the presence of OCD and AN before and after treatment.

Finally, this study adds to a growing body of research on vocally encoded emotional arousal in couples (B. R. Baucom, 2010; B. R. Baucom et al., 2015; B. R. Baucom, Weusthoff, et al., 2012; Fischer, Baucom, et al., in press; Weusthoff et al., 2013a, 2013b) and provides further confirmation that this is an important construct to consider for the understanding of couple interactions. From a methodological perspective, this is also one of the first studies to utilize fundamental frequency in dyadic intensive time-series analyses and dynamical systems analyses, suggesting that this is a feasible and worthwhile pursuit.

Limitations and Future Directions

The current study has a number of limitations that are important to consider for the interpretation of the findings and that point towards next steps for future research. First, all participants included in the current study were treatment-seeking patients and their committed romantic partners. All analyses that included post treatment data were based on couples who participated in a couple-based intervention. Thus, it is unclear whether the results are specific to treatment-seeking patients, and whether the changes observed after treatment would have occurred with individual treatment as well. Additionally, almost all patients were female and almost all partners were male. This introduces the possibility that differences in emotion coregulation between patients and partners found in this investigation may be due to gender rather than patient status. Moreover, the sample size for the analyses focused on changes from baseline to post was notably smaller compared to the sample included in the baseline analyses due to dropout from treatment, couples lost to follow up, interactions lost for analyses due to poor audio quality, and couples in the AN sample who were assigned to the individual treatment condition and therefore not included in the post analyses.

The use of an existing data set and particularly the use of recordings that were not obtained for the purpose of speech signal processing introduced unique challenges. A number of couples had to be excluded from the sample due to insufficient recording quality. Even though sufficient amounts of data could be salvaged with good confidence, this required extensive preliminary data processing and cleaning. Typically, the range of fundamental frequency is recommended as the best measure of emotional arousal (Juslin & Scherer, 2005). However, given that (a) this measure is particularly sensitive to outliers and (b) the limited quality of some of the audio recordings could have created a number of extreme observations that could not be removed but might not have been speech, the mean fundamental frequency was used instead. Typically, the range and mean of fundamental frequency are closely related and are both commonly used as a measure of emotional arousal (B. R. Baucom, 2010; Juslin & Scherer, 2005), but it cannot be determined for the current study whether results would have differed if it had been possible to obtain estimates of the range of fundamental frequency with good confidence in their validity.

The statistical procedures employed in the current study have possible limitations as well. Talk turns were used as units of observations in the time series analyses, and the length and spacing of talk turns were not included in the statistical analyses. While this would be feasible and should be explored in future research, this would greatly increase the complexity of the models, which introduces additional challenges from a statistical modeling standpoint. Alternatively, other ways of coding time instead of counts of talk turns could be explored, such as the start time of each talk turn. Moreover, local linear approximation is commonly used to obtain estimates of the derivatives for differential equation models similar to the models used in the current study (Boker & Laurenceau, 2006; Boker & Nesselroade, 2002). However, estimates obtained using LLA may be biased if τ, which is the lag used in the embedded matrix of the observations required for the estimates and can be thought of as a smoothing parameter, is chosen incorrectly (Deboeck, 2010). Thus, future research may examine further whether using a lag of one talk turn is ideal; different approaches to aid the selection of τ have been suggested (Boker & Laurenceau, 2006; Deboeck et al., 2008; Steele, Ferrer, & Nesselroade, 2013). In addition, alternative approaches to obtain estimates of derivatives could be explored as well, such as Generalized Orthogonal Local Derivative (GOLD) estimates (Deboeck, 2010, 2012).

These limitations are important to consider when interpreting the findings of the current investigation and should be addressed in future studies. In addition, there are a number of further substantive considerations that should guide future research in order to continue building a more nuanced understanding of interpersonal emotion regulation in AN and OCD and the function that emotion coregulation may serve in these two populations.

First, emotional arousal and emotion coregulation were examined during couple conversations in which couples were specifically instructed to discuss a topic related to OCD or AN. Thus, it is important to keep in mind that it is unclear if and how these findings would generalize to other contexts. For example, it will be important to determine whether the same patterns would emerge if couples with OCD or AN interact around a topic unrelated to the respective disorder; that is, whether these findings are representative of pervasive emotion regulation processes in couples in which one partner suffers from OCD or AN, or whether these findings are specific to conversations about disorder-related content. Additionally, it is unclear how unusual it was for the couples included in the current study to discuss the disorder, and whether there were systematic differences across the two samples in this regard. Considering the secrecy and reluctance to discuss their disorder commonly reported for patients with AN (Bulik, Baucom, & Kirby, 2012; Schmidt & Treasure, 2006) along with reports of frequent symptom accommodation in patients with OCD that likely requires some discussion of OCD related content (Boeding et al., 2013; Calvocoressi et al., 1995), it is possible that OCD patients had more frequently discussed the disorder with their partner prior to participation in the study. Thus, even though the study procedures were comparable across samples, the couples' prior experience with these types of conversations may have differed based on their willingness to discuss their disorders during every day life.

Moreover, the intensity of the topic discussed was not systematically varied beyond the instruction to the couples to select a topic they believed would be of "medium intensity." It will also be important to explore in the future whether the disorder-specific patterns in covariation and coupling in the current study would hold across different levels of overall emotional arousal within each diagnostic group. This would allow one to disentangle whether differences in regulatory processes are stable regardless of how highly emotionally aroused patients are. Alternatively, a certain amount of "unpredictability" of emotional arousal over the course of the conversation (as the APIM suggested for the OCD group) might occur across diagnostic groups once emotional arousal reaches a high level and potentially overrides regulatory processes that could otherwise be observed. For example, this could be achieved by recording a series of interactions during which couples are instructed to select topics of varying intensity. Topics that are either related or unrelated to the disorder could be selected in order to explore the question of how specific observed regulatory processes are to interactions focused on the disorder.

The assessment of emotional arousal and emotion coregulation at two distinct time points is an important strength of the current investigation. However, this was only a first step towards an understanding of how interpersonal emotion regulation processes may change with treatment, and the analyses were limited to couples participating in the couple-based interventions. Thus, it is currently not possible to determine whether any changes found in the analyses comparing the two time points were due to symptom improvement, passage of time, or changes in the couples' relationships based on their shared participation in treatment. An important next step would be to further examine whether changes in aggregate emotional arousal, covariation, and coupling are associated with overall symptom improvement, changes in more specific cognitive or behavioral features of each disorder, or changes in relationship variables such as relationship satisfaction.

Furthermore, there may be other couple-level variables that are specific to each disorder and that have relevance for interpersonal emotion processes. Of note, the two couple-based interventions that couples in the current study participated in targeted specific behavioral interaction patterns that are thought to contribute inadvertently to the maintenance of symptoms for that specific disorder, and these behaviors may also play a role in mediating emotion coregulation. For example, symptom accommodation in OCD was reduced in the current sample as a function of treatment and has been shown to predict symptom improvement (Abramowitz, Baucom, Boeding, et al., 2013; Boeding et al., 2013). Symptom accommodation, for example by providing reassurance to the patient, is an important way in which patients and partners respond to OCD-related distress. Given that both symptom accommodation and emotion coregulation (covariation for OCD partners and coupling for OCD patient) decreased with treatment, future research should examine how changes on the emotional and behavioral level are associated in these couples.

On the other hand, in the AN sample, countering secrecy, withdrawal, and avoidance around the disorder was a major component of the couple-based intervention (Bulik, Baucom, & Kirby, 2012; Bulik et al., 2011). Thus, it may be particularly important to explore further the association of changes in behavioral measures of these behaviors and communication styles with emotion coregulation in AN. Additionally, the results tentatively suggested that there may be an increase in coupling for AN patients, but levels of covariation remained stable across the two time points. As previously discussed, another important future direction would therefore be to examine whether changes in coregulation occur depending on the degree of symptom reduction, along with changes in more specific couple-level behavioral interaction styles.

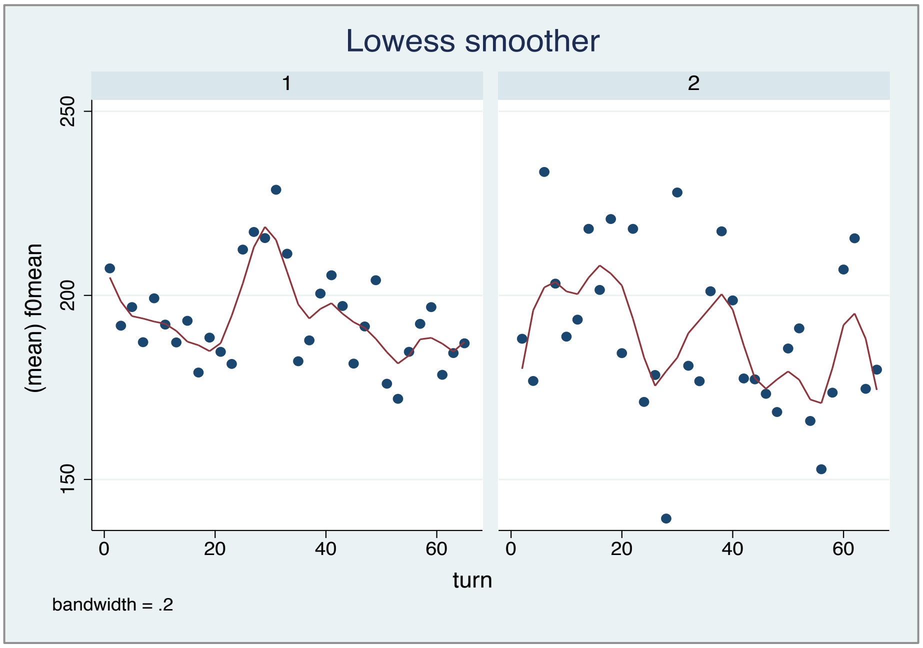
Finally, it is important to consider how adaptive or maladaptive different degrees of coregulation of emotional arousal may be in a context-specific manner. Generally, some degree of emotion coregulation is considered a normative, adaptive process in healthy couples (Butler & Randall, 2013; Sbarra & Hazan, 2008), and the premise of the current study was to consider ways in which adaptive processes may be altered or serve a maladaptive function in the presence of psychopathology. However, as discussed above, it is possible that the patterns of emotion coregulation, particularly in the AN group, may be indicative of either adaptive or maladaptive processes. That is, the somewhat surprising finding of consistent covariation and coupling in the AN group at baseline raises the question of whether this may be indicative of sensitivity of AN patients to their partners' emotional expression, or more broadly, whether conversations in which these processes occur are uncomfortable or distressing to patients. Moreover, it is also possible that the function of covariation or coupling changes over time. The lack of a control group of healthy couples in this study prohibits a direct comparison with normative processes. While this is a clear limitation of the current study, it is also important to consider that a mere comparison with healthy couples is not sufficient to determine the function that covariation and coupling serve for couples with psychopathology. In particular, there is no research to date that would suggest a set "amount" of emotion coregulation for "healthy" couples that should be considered adaptive, as the function of specific processes likely varies within and across couples based on context and relationship variables. Thus, a better understanding of the role of the interpersonal emotion regulation processes relative to psychopathology may primarily be achieved by examining covariation and coregulation in conjunction with other relevant disorder-specific variables and as predictors of treatment outcome.

Concluding Comments

The current study represents the first investigation of interpersonal emotion regulation in couples relative to psychopathology, drawing on advances in the measurement of emotional arousal and statistical modeling approaches in a dynamic systems framework. Meaningful patterns of coregulation of vocally encoded emotional arousal specific to patients with AN and OCD were identified. The integration of the content and the methods was an entirely novel endeavor, which has opened access to a new field of study on interpersonal emotion regulation in couples in the context of psychopathology. Appropriately, the current study has led to a whole set of new questions, hypotheses, and issues to address. Even though the approach presented here was complex and tied into prior theoretical and empirical work, the findings ultimately are best considered descriptive of patterns in vocally encoded emotional arousal and its regulation within the context of OCD and AN. This is a critical first step in this new area of research. In and of itself, it cannot yet determined with certainty which aspects of each pattern are adaptive and how they relate to other domains of functioning; this will be subject to future research. Further investigation in this area – related to OCD and AN and broadened to other disorders – may shed new light on how couples interact around psychopathology, how they function on an emotion process level, and how these insights can serve to identify interpersonally oriented targets for treatment to facilitate optimal outcome.

APPENDIX 1: SUPPLEMENTAL FIGURES

(A)



(B)

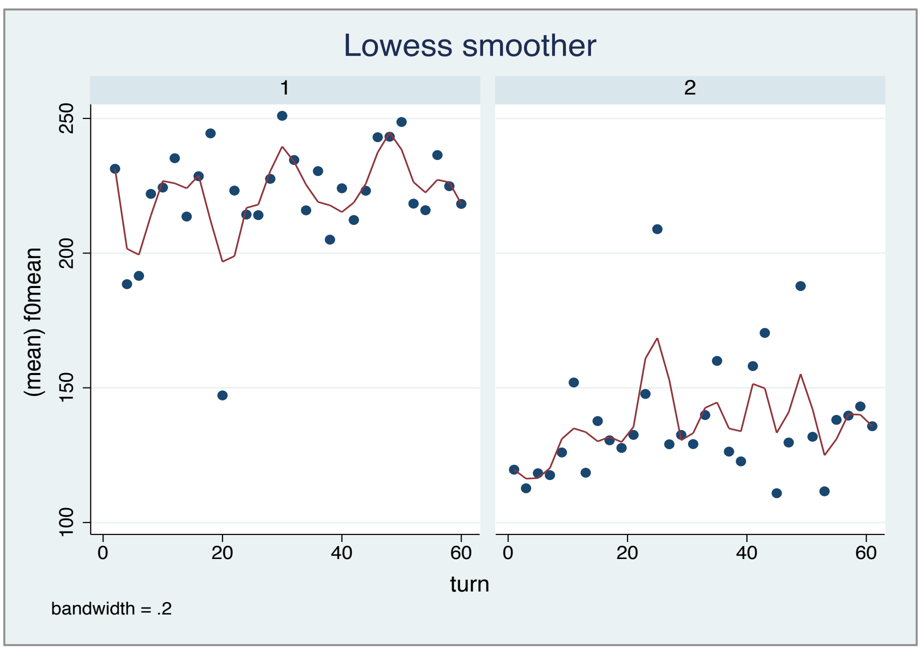
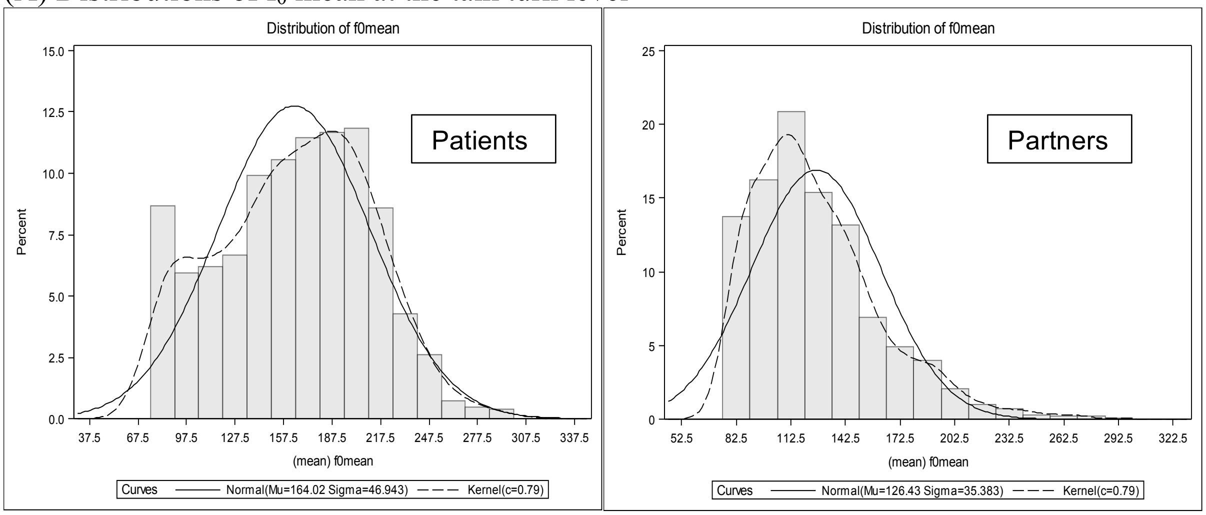


Figure 4. Lowess-smoothed plots of f_0 mean for each talk turn. (A) Patient (panel 1) and partner (panel 2) of the OCD sample at baseline. (B) Patient (panel 1) and partner (panel 2) of the AN sample at baseline.

(A) Distributions of f_0 mean at the talk turn level



(B) Distributions of f_0 mean at the aggregate level

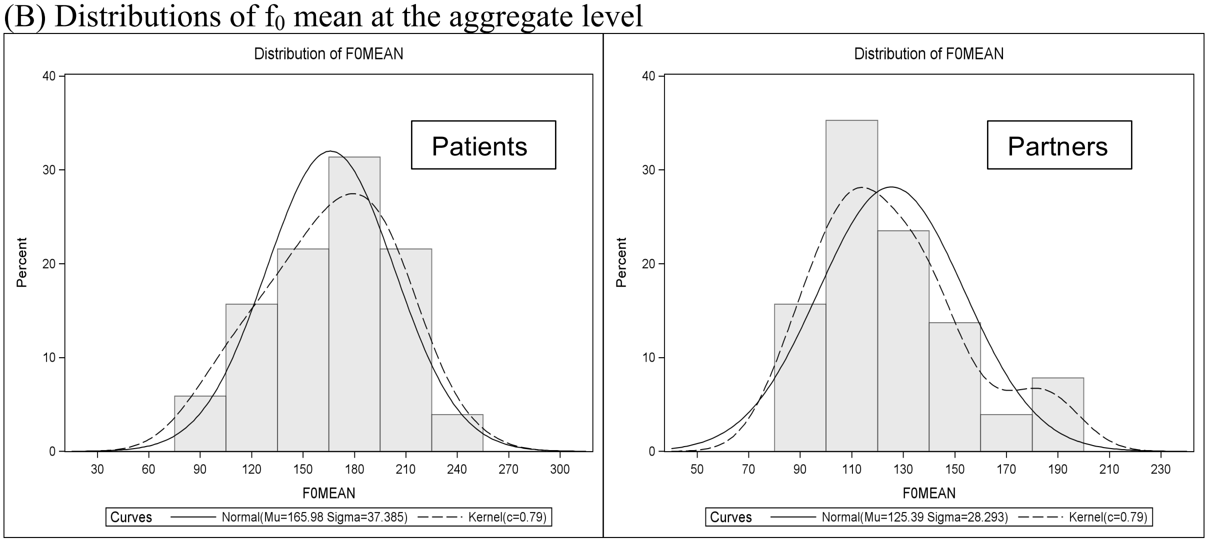


Figure 5. Histograms of f_0 mean at the talk turn and aggregate levels at baseline for patients and partners.

APPENDIX 2: SUPPLEMENTAL INFORMATION ON LINEAR OSCILLATOR MODELS

The basis of coupled linear oscillator models are linear oscillator models for each individual. In order to understand the coupled models better, it is best to first consider the characteristics of the self-regulation of one individual's emotional arousal, as described in more detail by several authors (e.g., Boker & Laurenceau, 2006; Deboeck, 2012). Assuming that no escalation/de-escalation occurs, one would expect the repeated measurement of emotional arousal throughout the conversation to result in a time series of scores that vary within some range. The mid-point of this range represents the equilibrium, and the individual may experience emotional arousal that is higher than his or her equilibrium at some time points, and emotional arousal lower than the equilibrium at other times. If extreme displacement from the equilibrium occurs (e.g., the individual becomes highly emotionally aroused), one would assume that the next observation of emotional arousal more likely yields a score that is closer to the typical level of arousal for this individual. Thus, the individual system of emotional arousal is self-regulated in the sense that the tendency to return to the equilibrium increases the further removed the level of emotional arousal is, which results in the oscillatory pattern. This rather technical notion is consistent with current models of emotion regulation, which posit that individuals regulate emotional arousal to return to or stay within an optimal level (Butler & Gross, 2009; Gross, 2013). Returning to the comparison to a pendulum discussed in the main text, this is equivalent to the characteristics of the swings: If a pendulum is displaced from its equilibrium, it will swing back towards the mid-point and reach its highest velocity at the lowest point of the swing. This leads the pendulum to overshoot its equilibrium, and it decelerates the further it moves away from the equilibrium, until it reverses its direction and accelerates until it passes through the mid-point again. Thus, the rate of change in velocity is greater the further the pendulum is displaced from its equilibrium point.

Such oscillations of a self-regulated system can be described using differential equations, which have been used increasingly in the analysis of time series data in psychological applications. While traditional linear modeling approaches applied to a time series as described here (repeated measures of emotional arousal that result in scores that vary within some range) would be able to describe some sort of trajectory over time (e.g., a linear or quadratic trend), the variance in the scores around this trajectory would be treated as error (Deboeck et al., 2009). Here, we are assuming that the way in which emotional arousal varies (i.e., the characteristics of the pendulum swings) contains important information about the regulation of emotional arousal, and differential equation modeling allows us to describe the characteristics of these oscillations (Boker & Laurenceau, 2006; Boker & Nesselroade, 2002; Deboeck, 2012). A self-regulated system of emotional arousal can be described with the following differential equation (referred to as a linear oscillator):

$$\ddot{x}_t = \eta x_t + \varsigma \dot{x}_t + e_t$$

where $\ddot{x}_t$ is the second derivative of the individual's emotional arousal (i.e., the acceleration or deceleration of the oscillation) at time t. The second derivative is a function of the displacement of emotional arousal x_t from the equilibrium and a negative constant η (i.e., the "forces" to return to equilibrium are negative proportional to the displacement, leading to deceleration while moving away and acceleration while moving towards the equilibrium). In addition, if the oscillations became smaller over time, this would be referred to as "dampening" and would be captured by the negative proportional relationship between the second and first derivatives (i.e., a negative constant ς). Thus, the values of the constants determine how rapidly oscillations occur, as well as the degree to which the oscillations are dampened over time.

ENDNOTES

[1] See Figure 5 in Appendix A for distributions of f_0 mean. Conditional distributions of the residuals were visually inspected for the basic CLO and APIM models (prior to entering hypothesis-specific predictors and with diagnosis as a level 2 predictor) and did not indicate substantial reasons for concern about violations of important model assumptions, such as normal distributions of level 1 and 2 residuals and differences in residual variances across predictors where it could not be accounted for within the model specifications.

[2] Inspecting plots, descriptives, and model fit of the growth curve models (see preliminary analyses for covariation models below) indicated that one couple with a very high number of talk turns (146) compared to the next group of couples with high numbers of talk turns (about 100) unduly influenced model estimates and fit. This couple (AN sample, baseline data only) was excluded from all time series analyses. Given the modest sample size of the two groups and the potential for unstable results (e.g., as evidenced by changes in the effects at baseline when using the full sample compared to the smaller sample in models with post data), additional checks were performed. Based on a combination of regression diagnostics and model comparisons, one couple appeared to substantially bias patterns of findings that were otherwise stable. Therefore, this couple was excluded from all analyses (OCD sample, baseline only). No other couples or extreme observations appeared to unduly influence the findings.

[3] BMI was tested as another important indicator of symptom severity for AN; likewise, there were no significant differences in aggregate f_0 mean based on BMI at baseline.

[4] The inclusion of random effects for the actor and partner effects (even with more constrained variance/covariance structures) led to model convergence and estimation problems and likely increased the complexity of the models beyond a reasonable level given the sample size and structure.

[5] Another model using BMI as a measure of AN severity was tested; the pattern of results was equivalent to the results of the model using the EDE global score.

[6] Models including random effects for patients' and partners' dampening effects (1st derivatives) were initially tested. In both models (for patients and partners), the variance estimates for the dampening parameters ς were zero. Because of the complexity of the models, simpler models were examined. Sequentially omitting these random effects led to no change in the model fit statistics and remaining parameter estimates. Therefore, the dampening parameters were analyzed as fixed effects only in all subsequent models.

[7] Models using an unconstrained covariance structure (estimating different variances and covariances for all random effects) did not converge once additional level 2 predictors were added.

[8] A model using BMI as a measure of severity for the AN group was tested as well; the pattern of results was equivalent to the results of the model using the EDE global score.

[9] The predictions mirror this scenario when both partners' arousal levels are unusually low; low emotional arousal in partners would result in a slower return to the equilibrium if patients are also below their equilibrium at the same time. Partners' displacement from equilibrium at the opposite end compared to the patients' arousal would result in a faster return to equilibrium for patients.

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