Disorder-Specific Patterns of Emotion Coregulation in Couples: Comparing Obsessive Compulsive Disorder and Anorexia Nervosa

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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 interpersonally oriented emotion regulation may vary by disorder. This study examined coregulation as a form of interpersonal emotion regulation in OCD and AN. We hypothesized that OCD is associated with exaggerated and AN with diminished coregulation, and that OCD patients have greater overall levels of emotional arousal than AN patients. Greater symptom severity was expected to exacerbate these opposing tendencies. Vocally encoded emotional arousal was measured during couple conversations in 34 AN patients, 18 OCD patients, and their partners. Two indicators of coregulation (covariation and coupling) were analyzed using cross-lagged actor–partner interdependence and coupled linear oscillator models. As hypothesized, OCD was associated with greater overall emotional arousal than AN. Symptom severity was not associated with emotional arousal or coregulation. Covariation differed in the opposite direction of the hypothesis; 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' arousal over time, while partners were affected by the patients' emotional arousal; thus, symptom accommodation may in part be partners' attempts at managing their own distress along with the patients'. A better understanding of interpersonal emotion regulation in OCD and AN can inform treatment by targeting interaction patterns that may maintain symptoms.

Keywords: emotion regulation, coregulation, fundamental frequency, obsessive-compulsive disorder, anorexia nervosa

Effective emotion regulation, or the ability to influence the occurrence, duration, and intensity of emotions is central to well-being and psychological functioning (Butler & Randall, 2013; Diamond & Aspinwall, 2003). Impaired emotion regulation and reliance on maladaptive strategies to manage distress are central features of many types of psychopathology (e.g., Werner & Gross, 2010), including anxiety and obsessive-compulsive disorder (OCD) as well as eating disorders (e.g., Abramowitz & Jacoby, 2015; Haynos & Fruzzetti, 2011). Importantly, emotion regulation is not solely an individual process but can be fostered or thwarted by interactions with close others, including romantic partners (Butler, 2011; Sbarra & Hazan, 2008). More specifically, some individuals learn to rely primarily on themselves to lower their level of distress, whereas some individuals turn to others to help

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them regulate emotions. These differential tendencies might vary by disorder; either heavy reliance on primarily interpersonal or primarily individual emotion regulation may be maladaptive depending on the disorder. Thus, examining patterns in interpersonal emotion regulation across disorders can enhance our understanding of how interpersonal processes contribute to the maintenance of psychopathology.

Coregulation of emotional arousal is a form of interpersonal emotion regulation that plays an important role in attachment, health, and emotional well-being across the life span (Sbarra & Hazan, 2008). Particularly in the clinical literature, emotion regulation is often studied as a set of strategies, behaviors, or self-reported abilities (e.g., Werner & Gross, 2010). Another approach, however, is to measure emotions (e.g., via self-report, psychophysiological measures) intensively over time and assess how effectively individuals are able to regulate their emotions to stay within or return to an adaptive level. Methods for intensive measurements and appropriate statistical models for the pattern of changes, and interdependence between two partners' changes in arousal over time are now widely available (Butler, 2011); a number of studies have been concerned with coregulation on this level. Within this latter context, coregulation refers to a bidirectional linkage between the ways that two individuals' emotions fluctuate together and influence each other over time, ideally allowing both individuals to regulate emotions efficiently to stay within an adaptive level (Butler & Randall, 2013). In healthy couples, coregulation of emotional arousal contributes to emotional stability because both individuals benefit from coordinated emotional responses (Butler, 2011; Butler & Randall, 2013). However, when one individual experiences psychopathology, emotion coregulation between partners might operate differently due to maladaptive strategies that they have developed in the context of their disorder. Whereas no direct empirical findings are available to identify the characteristics of coregulation specific to any disorder, differences in emotion coregulation would be expected to relate to observable tendencies to "bring in" (i.e., include) or "shut out" (i.e., exclude) the partner from the emotional experience of the disorder.

Even though both OCD and AN involve anxiety and share other features (Kaye, Bulik, Thornton, Barbarich, & Masters, 2004), research suggests that individuals with these two disorders differ in how they include or exclude their partners in attempts to regulate negative emotions. That is, individuals with OCD often "draw in" partners to help with managing anxiety through symptom accommodation (Boeding et al., 2013). Accommodation refers to anything partners might (knowingly or unknowingly) do to reduce or prevent the patients' obsessional fears, such as providing excessive reassurance (e.g., answering repeated questions), participating in rituals, or helping the patient avoid anxiety-provoking stimuli. 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) seeking accommodation is fairly consistent with their individual ways of managing obsessive fears (i.e., seeking fast, short-term relief). Taken together, these considerations suggest that patients with OCD engage in extensive interpersonal emotion regulation processes to address their distress.

On the contrary, patients with AN appear to employ interpersonal avoidance and rely on individual emotion regulation. Patients with AN often have a history of high anxiety that predates AN (Dellava et al., 2010), experience less emotion dysregulation at more severe starvation, and experience dietary restraint as anxiety reducing (e.g., Kaye et al., 2003). Thus, these individually focused strategies are experienced as down-regulating of negative emotions in the short term in the absence of more effective strategies (Haynos & Fruzzetti, 2011; Wildes, Ringham, & Marcus, 2010). Turning to a partner about AN-related distress may have the opposite result, including the partner's attempts to convince the patient to eat or to seek treatment. Such interactions with others may actually be a source of negative emotions for patients with AN (Lattimore, Gowers, & Wagner, 2000), contributing to avoidance of discussing disordered eating with their partners (Bulik, Baucom, & Kirby, 2012). Therefore, extensive reliance on individual AN-related strategies for emotion regulation, along with an overall pattern of withdrawing from others, suggests that patients with AN de-emphasize emotion coregulation.

Although the available evidence about differences in interpersonal emotion regulation in OCD and AN stems from clinical and behavioral research, there are no empirical investigations of whether these differences translate to the level of coregulation of emotional arousal when patients and partners interact. Measures of vocally encoded emotional arousal in couples provide unique advantages beyond standard self-report and psychophysiological measures to examine interpersonal regulatory processes in couples (B. R. Baucom, 2010). Changes in the voice that represent vocalizations of distress are partially mediated by basal neurological structures that do not fall under voluntary control (Eisenberger & Lieberman, 2004; Newman, 2003). Involuntary vocalizations of distress have evolved to communicate both physical and social/emotional pain (Eisenberger & Lieberman, 2004; Zeskind & Marshall, 1988). Thus, changes in the voice are in part a direct response to emotional distress, but this private information is also transmitted to another person. This communicative function makes vocally encoded emotional arousal particularly appropriate for the study of coregulation in couples 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 (B. R. Baucom, 2010).

Detailed discussions of vocal measures of arousal, including fundamental frequency (f_0), and its empirical status (Bachorowski & Owren, 1995; Juslin & Scherer, 2005) as well as the utility of f_0 in couples research (Weusthoff, Baucom, & Hahlweg, 2013) are available elsewhere. Broadly, several studies demonstrated that overall levels of f_0 (B. R. Baucom et al., 2011; B. R. Baucom, Weusthoff, Atkins, & Hahlweg, 2012; Fischer, Baucom et al., 2015) as well as within-conversation changes (B. R. Baucom, Dickenson et al., 2015; Baucom, Sheng et al., 2015) are associated with cross-sectional and longitudinal relationship outcomes. Similarly, Weeks and colleagues (Weeks, Heimberg, & Heuer, 2011; Weeks et al., 2012) demonstrated meaningful associations between f_0 during social threat tasks and symptom severity/diagnosis of social anxiety disorder.

Coregulation can only be identified by examining a series of measurements of emotional arousal over time. Two primary forms of interdependence between partners' emotions have been proposed as central to coregulation, again with the definition of *regulating* as maintaining or returning to a typical level (in healthy couples assumed to be adaptive) (Butler & Randall, 2013). First, covariation describes the degree to which two partners' levels of emotion move in tandem. Second, coupling of emotional responses

focuses on the influence of one partner's emotions on the regulation of emotions in the other partner. That is, if an individual's emotional arousal cycles through ups and downs over time, their partner's emotional arousal may divert the patient's emotional arousal from its trajectory. For example, if a patient were to start calming down after being upset, would a partner's low arousal exert a "pull" on the patient's trajectory such that he or she would calm down more quickly? To date, coregulation in couples conceptualized as covariation (e.g., Levenson & Gottman, 1983; Randall, Post, Reed, & Butler, 2013; Saxbe & Repetti, 2010) and coupling (Boker & Laurenceau, 2006; Gottman, Swanson, & Murray, 1999; Helm, Sbarra, & Ferrer, 2012) has only been examined in couples without psychopathology. In their investigation of healthy couples, Butner, Diamond, and Hicks (2007) found that attachment anxiety and attachment avoidance moderated covariation and coupling, which demonstrates that coregulation indeed varies meaningfully depending on psychological characteristics. However, how these processes differ in couples with psychopathology is unknown and is the focus of the current investigation.

Accordingly, the current study is the first to use vocally encoded emotional arousal to examine coregulation as an indicator of how individuals with OCD and AN engage with their partners to regulate emotions. The identification of such strategies can help to elucidate the interpersonal context of the two disorders. Whereas coregulation is generally thought to be an adaptive process, no empirical research has established under which circumstances this is the case, and whether there is an adaptive "degree" of coregulation for any group of couples. Thus, no healthy control group was included in this investigation. Here, the primary focus was on identifying the ways in which emotions are interpersonally regulated in the context of OCD and AN, which provides a launching point for future research on how these patterns may contribute to the maintenance of the disorders. Thus, high or low degrees of coregulation are not conceptualized as maladaptive per se, but as part of the interpersonal context that evolves specific to each disorder.

The above evidence suggests that individuals with OCD and AN differentially rely on individual versus interpersonal emotion regulation strategies to address their distress. More specifically, patients with OCD were expected to show greater coregulation (covariation and coupling) compared to patients with AN. Within each diagnostic group, these patterns were expected to be more pronounced with greater symptom severity. That is, OCD patients were expected to display greater coregulation if their symptoms were more severe, and AN patients were expected to display weaker coregulation if their symptoms were more severe. Including symptom severity as a possible moderator can help determine whether any differences in coregulation are primarily reflective of a qualitative difference between disorders regardless of symptom severity, or whether quantitative differences play a role depending on how severe the respective disorders are. In order to interpret differences in regulatory processes, it also is important to understand the overall level of emotional arousal that individuals generally experience while these processes occur. Although patients in both groups likely experience fairly high levels of distress, it was nevertheless expected that those with a primary anxiety disorder should display greater emotional arousal. Thus, patients with OCD were expected to show greater overall levels of emotional arousal compared to patients with AN. In addition, greater symptom severity was expected to be associated with greater overall emotional arousal in OCD patients and lower emotional arousal in AN patients. Partners' overall emotional arousal and coregulation were included for exploratory purposes. Because coregulation can differ for two partners within one couple and this was the first investigation of coregulation in couples with psychopathology, there were no bases to predict patterns among the partners without a disorder.

Method

Participants

Participants included 52 adult couples in which one partner suffered from OCD or AN who took part in one of three treatment outcome studies. The first group ($N = 18$ couples) participated in an open trial of a couple-based intervention for OCD (Abramowitz et al., 2013); the second group ($N = 34$ couples)[1] participated in one of two trials of a couple-based intervention for AN (Bulik, Baucom, Kirby, & Pisetsky, 2011; D. H. Baucom et al., in press). Inclusion and exclusion criteria are provided elsewhere for the OCD trial (Abramowitz et al., 2013) and AN trials (D. H. Baucom et al., in press; University of North Carolina, Chapel Hill, 2012 November). Four patients in the AN group also had a current comorbid diagnosis of OCD. Kaye et al. (2004) found about 35% of individuals with AN to have a lifetime diagnosis of OCD; however, fewer studies have examined current comorbidity and comorbidity in treatment-seeking samples. The rate of comorbidity in the current sample (11.76%) appears to be generally in the range found in other AN treatments studies; for example, 5% of AN patients with current comorbid OCD (Herzog, Keller, Sacks, Yeh, & Lavori, 1992) and about 24% of AN patients with any current anxiety disorder in the largest treatment study of adult AN to date (Zipfel et al., 2014). Patients with comorbid OCD were retained in the AN sample given that the AN was still considered the primary condition warranting treatment. Demographic information and descriptive statistics are provided in Table 1.

Measures

Vocally encoded emotional arousal. Emotional arousal was measured using fundamental frequency (f_0) during videotaped couple interactions. Couples were instructed to discuss a topic of concern related to the respective disorder, lasting 7–10 min. F_0 refers to the lowest frequency harmonic of the speech sound wave and is closely associated with perceived pitch (Atkinson, 1978). F_0 is measured in hertz (Hz), and higher values result from more rapid opening and closing of the vocal folds (Juslin & Scherer, 2005). F_0 is well suited as a measure of emotional arousal for the study of interpersonal processes because humans are able to detect differences in pitch of just a few Hz (e.g., Tervaniemi, Just, Koelsch, Widmann, & Schroger, 2005). In the current investigation, f_0 mean (for each talk turn) was used as the index of emotional arousal. F_0

[1] Inspecting plots and model fit of the growth curve models (see preliminary analyses for covariation) indicated that one couple with a very high number of talk turns (146) compared to the next group (about 100 talk turns) unduly influenced model estimates and fit. This couple (AN sample) was excluded from all time series analyses.

Table 1
Demographics and Means (Standard Deviations) for All Study Variables

Variable	OCD Sample ($N = 18$)[1]	AN Sample ($N = 34$)[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[3]	85.3% Caucasian, 8.8% African American 2.9% Asian American 8.8% Hispanic[3]
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[3]
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[4]	41.17 (19.34)	53.91 (26.35)
Y-BOCS	26.33 (5.40)	n/a
EDE	n/a	2.71 (1.40)

[1] Demographic data except gender missing for one partner and two patients, percentages based on total number of participants. [2] Demographic data except gender missing for one couple, percentages based on total number of participants. [3] In the OCD study, race and ethnicity were assessed in the same question. In the AN sample, Hispanic ethnicity was assessed with a separate question. [4] Thirty three couples in the AN sample for these calculations (1 additional couple excluded from time-series analyses). Y-BOCS = Yale-Brown Obsessive-Compulsive Scale; EDE = Eating Disorders Examination.

mean has strong empirical support as a measure of arousal, is typically highly correlated with f_0 range (within a given unit of time) as another index of vocal emotional arousal, and is less sensitive to extreme or biased estimates of f_0 that influence range scores in noisy recordings (B. R. Baucom, 2010; B. R. Baucom et al., 2011; Juslin & Scherer, 2005). For example, a single measurement of an extreme f_0 score (based on .25 s out of 10 min) due to noise in the recordings would lead to an artificially inflated range estimate, while the risk of erroneous outliers would only have minimal impact on f_0 mean estimates. The limited quality of some recordings in the current investigation precluded the use of f_0 range due to resulting extreme scores. Greater f_0 mean indicates greater emotional arousal.

Recordings were manually segmented into separate tracks for patient and partner using Audacity 2.0.5 (http://audacity.sourceforge.net), and background noises and nonverbal vocalizations (e.g., laughter, crying) were removed. Because the couples were aware of the time allotted for their conversation, the original length of conversations for each sample was used (7 min in the OCD sample and 10 min in the AN sample) 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 toward the end). Estimates of f_0 were obtained every .25 second using robust pitch extraction algorithms in Kaldi (http://kaldi.sourceforge.net/) with a bandpass filter of 75 to 300 Hz to restrict extraction to the range of natural speech of adults (Owren & Bachorowski, 2007). For all time series analyses, mean f_0 was calculated by averaging the estimates within each talk turn, resulting in alternating observations between patients and partners within each conversations and an average of approximately 41 observations per couple in the OCD group and 53 in the AN group (see Table 1). Mean f_0 was also calculated as an aggregate measure of emotional arousal averaged across all talk turns (weighed by length of talk turn) for each person.

Symptom severity. The Yale-Brown Obsessive Compulsive Scale (Y-BOCS; Goodman et al., 1989) is a semistructured interview that was used to assess global OCD symptom severity. The total severity score takes into account obsessions and compulsions, and reflects time spent, interference, distress, resistance, and degree of control. The Eating Disorders Examination (EDE; Fairburn, Cooper, & O'Connor, 2008) is a standardized interview that was used to assess eating disorder symptoms. In the current study, the EDE global score was used, which reflects a wide array of eating disorder symptomology across the areas of restrictive eating and concerns/behaviors related to eating, body shape, and weight.

Procedure

All study procedures were approved by the (University of North Carolina, Chapel Hill, 2012 November) Institutional Review Board. Data used for the current study consist of a subset of measures from the pretreatment assessments of a pilot study of the OCD treatment (Abramowitz et al., 2013) and a pilot study and randomized-controlled trial of the couple-based treatment for AN (Bulik, et al., 2011; D. H. Baucom, et al., in press). For the videotaped interactions used in the current study, either the patient (OCD) or the couple (AN) was instructed to select a topic of concern related to the disorder (medium intensity of the concern) and to share his or her thoughts and feelings about this topic with his or her partner. The research assistant remained in the room until the couple had selected a topic and then left while the couple had their conversation.

Results

Analyses were conducted using a series of multilevel models (MLMs) estimated in SAS 9.4 (SAS Institute, 2013). MLMs were used because of nonindependence of observations created by the

nesting of talk-turns within individuals (for the time series models) and individuals within couples. Diagnostic group was dummy coded using AN as the reference group in all models. Coregulation of emotional arousal within the conversations was modeled in two ways consistent with recent recommendations (Butler & Randall, 2013). Cross-lagged actor-partner interdependence models (APIMs) were used to examine how partner's mean f_0 changed together over time (covariation), and coupled linear oscillator (CLO) models (Boker & Laurenceau, 2006) were used to examine the influence of partners' f_0 on the oscillatory trajectory (cycling through ups and downs) of f_0 in the other partner (coupling).

Differences in Aggregate Emotional Arousal

Differences in aggregate levels of emotional arousal over the entire conversation were tested using two-intercept MLMs. The hypotheses were tested by interaction terms of Diagnosis × Intercept (entire sample), or grand-mean centered Symptom Severity × Intercept (in separate models for each diagnostic group because of the different severity measures). As hypothesized, OCD patients' mean f_0 was significantly greater than AN patients' mean f_0 ($\beta = 21.34$, $p < .05$). Similarly, OCD partners' mean f_0 was also significantly greater than AN partners' mean f_0 ($\beta = 27.83$, $p < .01$). Thus, both members of the couple in the OCD group showed greater overall levels of emotional arousal during the conversations compared to AN couples. Differences between patients and partners should not be interpreted due to expected differences in f_0 based on gender.

Contrary to the hypotheses, there were no differences in aggregate emotional arousal based on symptom severity. The aggregate f_0 mean values did not vary depending on the OCD patients' Y-BOCs score for patients ($\beta = 1.20$, $p = .39$) or partners ($\beta = 1.34$, $p = .34$). Similarly, the aggregate f_0 mean values did not vary depending on the AN patients' EDE global score for patients ($\beta = 1.25$, $p = .76$) or partners ($\beta = -1.07$, $p = .80$).

Covariance: Cross-Lagged APIMs

Cross-lagged APIMs (Kenny, Kashy, & Cook, 2006) were used to examine covariance of partners' mean f_0 over time. In these models, each partner's mean f_0 during a given talk turn is predicted by their own mean f_0 during their previous talk turn as well as by the other partner's mean f_0 during that partner's previous talk turn as described by the following series of equations:

Level-1:

$$f0mean_{ij} = Patient * [\beta_{1j}(intercept) + \beta_{3j}(actor_{f0mean_{(i-1)j}}) + \beta_{5j}(partner_{f0mean_{(i-1)j}})] + Partner * [\beta_{2j}(intercept) + \beta_{4j}(actor_{f0mean_{(i-1)j}}) + \beta_{6j}(partner_{f0mean_{(i-1)j}})] + r_{ij}$$

Level-2: for $i = 1$ to 6, $\beta_{ij} = \gamma_{i0}(intercept) + \gamma_{i1}(AN)$ where i indexes talk turns and j indexes couples. Level-2 random effects were included on β_{1j} and β_{2j}. All mean f_0 predictors were person-mean centered prior to analysis.[2] A significant Partner effect for patients (i.e., the degree to which patients' emotional arousal is predicted by the partners' emotional arousal right before) indicates coregulation (covariation) for the patients.

Results of the model testing differences between diagnostic groups are shown in Table 2. The significant Actor and Partner effects indicate that to the extent that either partner expressed higher mean f_0 during a previous talk turn, both members of the couple expressed higher mean f_0 during their next talk turns. Because of the dummy coding of diagnosis, these estimates are specific to the AN group. The significant Actor × OCD effect for partners and patients and the significant Partner × OCD effect for patients indicate the extent to which these effects are different in the OCD couples compared to the AN couples. The negative sign of these significant effects indicates that these 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. Decomposition of the Partner × OCD effect for patients revealed a significant simple slope for AN patients only ($\beta = .29$, $t(2355) = 5.43$, $p < .001$); the simple slope for OCD patients was nonsignificant. Figure 1A illustrates significant simple slopes separately for OCD and AN. That is, there was a difference in covariation for patients as expected; however, the difference was opposite in direction from what was expected. The interaction term and simple slopes show that AN patients' emotional arousal covaried with the partners—if partners' emo-

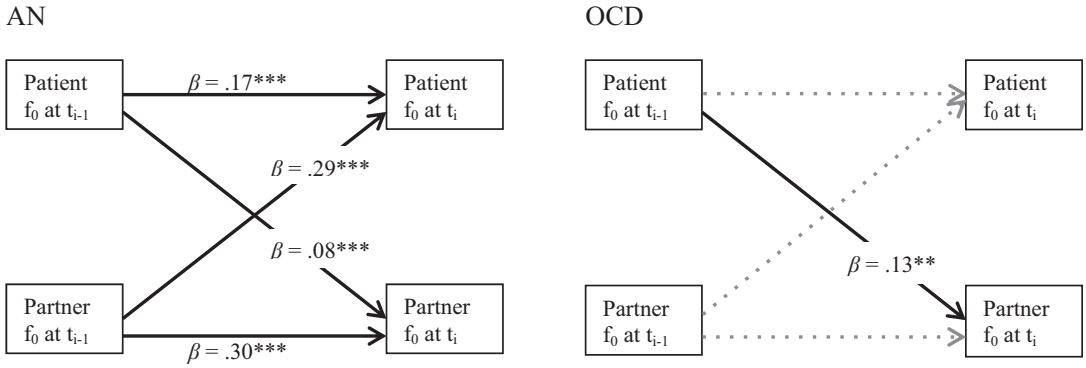
Table 2
Fixed Effects for the Cross-Lagged APIM Predicting Patients' and Partners' f_0 at Talk Turn t from Patients' and Partners' f_0 at Talk Turn t-1 and Diagnosis[a] (df = 2355)

Fixed effect	Coefficient (*SE*)	*t*	*p*
Patients			
Intercept	161.44 (6.62)	24.37^{***}	<.0001
Actor effect	.17 (.03)	5.18^{***}	<.0001
Partner effect	.29 (.05)	5.43^{***}	<.0001
Intercept × Diagnosis	18.89 (11.16)	1.69	.09
Simple intercept OCD	*180.33 (8.99)*	20.07^{***}	*<.0001*
Actor effect × Diagnosis	−.16 (.07)	-2.23^{*}	<.05
Simple slope OCD	*.01 (.06)*	*.23*	*.82*
Partner effect × Diagnosis	−.29 (.08)	-3.38^{***}	<.001
Simple slope OCD	*.00 (.07)*	*.06*	*.95*
Partners			
Intercept	117.57 (4.50)	26.11^{***}	<.0001
Actor effect	.30 (.04)	8.27^{***}	<.0001
Partner effect	.08 (.02)	3.77^{***}	<.001
Intercept × Diagnosis	29.67 (7.59)	3.91^{***}	<.0001
Simple intercept OCD	*147.24 (6.11)*	24.08^{***}	*<.0001*
Actor effect × Diagnosis	−.37 (.06)	-6.33^{***}	<.0001
Simple slope OCD	*−.07 (.05)*	*−1.45*	*.15*
Partner effect × Diagnosis	.05 (.05)	1.05	.29
Simple slope OCD	*.13 (.04)*	3.25^{**}	*<.01*

Note. Main effects shown are for AN, interaction terms test the difference between groups, simple intercepts/slopes show effects for OCD group. APIM = Actor-Partner Interdependence Model.
[a] Diagnosis was dummy coded, AN as the reference group.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

[2] In a series of preliminary analyses, the presence of linear or quadratic trends was assessed given that coregulation should occur around a stable level (Butler, 2011). Linear and quadratic growth curve models predicting f_0 mean were fit for patients and partners separately in MLM, with talk turns and diagnostic group as predictors. There was no evidence of any linear or quadratic trends over time in any of the models (all $p > .58$). In order to maintain parsimony, time (i.e., talk turns) was not included in the model used for hypothesis testing.

(A) Cross-lagged Actor-Partner Interdependence Model predicting patients' and partners' f_0 at talk turn t from patients' and partners' f_0 at talk turn t-1: Simple slopes for each diagnostic group (see Table 2 for interaction terms testing group differences). Partner effects indicate covariation.



(B) Coupled linear oscillator models predicting patients' and partners' acceleration of fluctuations in emotional arousal (tested in separate patient and partner models) from own and partner emotional arousal: Simple slopes for each diagnostic group (see Table 3 for interaction terms testing group differences). Cross-partner effects indicate coupling.

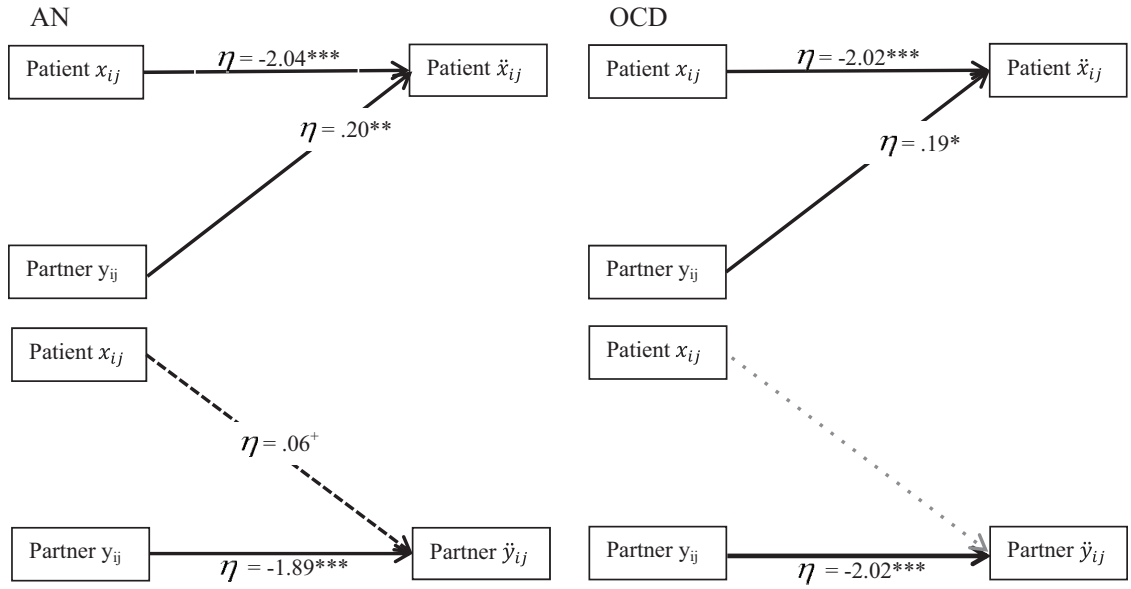


Figure 1. Results of the models examining differences in coregulation between the AN and OCD groups. Dotted lines indicate nonsignificant effects. *** $p < .001$, ** $p < .01$, * $p < .05$, † $p < .1$.

tional arousal was higher than their typical level, patients' emotional arousal at the subsequent talk turn was also higher. There was no such association for OCD patients; that is, OCD patients' emotional arousal was not related to their partners' immediately preceding level of arousal. However, OCD partners' (as well as AN partners') emotional arousal covaried with the patients' emotional arousal at the previous talk turn, meaning that if patients' emotional arousal was higher than their typical level, partners' emotional arousal at the subsequent talk turn was also higher.

Contrary to the hypotheses, there were no differences in covariation based on symptom severity (YBOCS or EDE) tested separately for each diagnostic group. Actor effects for OCD partners and for AN patients and partners were significantly higher for greater symptom severity (i.e., f_0 at a given talk turn was more strongly predicted by their own f_0 at the previous talk turn), although this has no bearing for covariation between patients' and partners' emotional arousal. No other effects were moderated by symptom severity (detailed results available upon request).

Coupling: CLO Models

CLO models were used to assess coupling as a more complex aspect of coregulation, focused on how one individual's emotional arousal affects the ability of the other person to maintain or return to their typical level of arousal (i.e., the degree to which patients' emotion regulation is "coupled" to the partners' emotional arousal). Detailed descriptions of CLO models are available elsewhere (Boker & Laurenceau, 2006; Butner & Story, 2010), although several basic points are important here. The basis of CLO models are single linear oscillator models, which describe the trajectory of each individual's emotional arousal as they cycle through ups and downs around a midpoint or baseline level (i.e., an oscillatory pattern similar to a sinusoid curve). These models reflect self-regulation, in that someone's emotional arousal fluctuates around a baseline or typical level specific to that individual, and the tendency to begin returning to that level becomes stronger the further emotional arousal is displaced (rather than escalating indefinitely). This self-regulatory pattern can be quantified by a linear negative association between the rate of change in slope of the curve (second derivative, or acceleration) and the "displacement" of f_0 from its baseline. Acceleration is of particular interest and used as the dependent variable because it contains information about the shape (frequency, how slowly or quickly arousal returns to baseline) of an individual's trajectory over time. In addition, if the amplitude of the ups and downs decreases over time, this dampening effect can be quantified by the association of the rate of change in slope (acceleration) and the slope at a given time (first derivative, or velocity). In the current study, visual inspection of plots for each individual as well as linear oscillator models for patients and partners confirmed the presence of lawful oscillations.

The coupled linear oscillator model includes the partners' mean f_0 (displacement from partners' own baseline) and velocity of f_0. A significant effect of partners' mean f_0 for patients would indicate coupling (i.e., partners' emotional arousal influences the shape of the patients' trajectories and how quickly patients return to their baseline) and is the focus of the hypothesis. The basic Level 1 equation for patients is

$$\ddot{x}_{ij} = Patient * [x_{ij} + \dot{x}_{ij}] + Partner * [y_{ij} + \dot{y}_{ij}]$$

Where $\ddot{x}_{ij}$ is the second derivative[3] (acceleration) of patient i's mean f_0 during talk turn j, $\dot{x}_{ij}$ is the rate of change (velocity) of patient's mean f_0 during talk turn j, and x_{ij} is the value of patient's mean f_0 during the talk turn j. The y terms are the equivalent terms for the partners at the talk turn immediately preceding the patients' talk turn j. For the purpose of the current study, the influence of the effect of partner's mean f_0 during the previous talk turn ($\dot{y}$) is the main focus as an indicator of coregulation. To test differences in coregulation based on diagnostic group, the Level 2 equations included diagnosis on all Level 1 effects, and the cross-level interaction of diagnosis with partner's mean f_0 during the previous talk turn was used to test the hypothesis. Random effects were included for patients' and partners' mean f_0 and the interaction terms with mean f_0. Similarly, differences in coregulation based on symptom severity were tested in separate models for OCD and AN, including symptom severity instead of diagnosis as a Level 2 predictor.

Finally, equivalent models were estimated to examine differences in coupling based on diagnostic group and symptom severity for partners. There were no specific hypotheses for partners, but CLOs were analyzed 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.

Results for the fixed effects for patient and partner models examining differences by diagnostic group are provided in Table 3; see Figure 1B for an illustration of significant effects of patients' and partners' own and coupled effects of mean f_0. The significant negative effect for AN patients' mean f_0 confirms the self-regulatory component of the oscillator models, that is, AN patients' mean f_0 has a greater tendency to begin returning to baseline the further it was displaced from baseline ($x = -2.04$, $p < .001$); the nonsignificant OCD $\times$ mean f_0 interaction effect indicates that the effect for OCD patients was not meaningfully different (simple slope for OCD patients $= -2.02$, $p < .001$). Thus, the coupled effects can be interpreted as the influence of the partners' arousal on these fluctuations beyond the form they would take for the patients alone.

For patients, significant positive effects emerged for partners' mean f_0 for AN ($y = .20$, $p < .01$) and OCD ($y = .19$, $p < .05$), indicating that coregulation took place in the sense that the patients' regulation of their emotional arousal back to baseline level was coupled to the partners' emotional arousal. The positive direction of the effects indicates that when partners' mean f_0 is farther from their baseline during the previous talk turn (that is, more or less emotionally aroused than is typical), patients return to their own baseline more slowly. Thus, whenever patients' and partners' levels of emotional arousal are either both higher (or both lower) than their respective baselines, it takes the patient longer to return to baseline. The nonsignificant mean partner f_0 $\times$ OCD interaction terms indicates these coupled effects were the same across diagnostic groups, which is inconsistent with the hypothesis of greater coregulation in the OCD group.

Equivalent models for partners (see Table 3) were estimated for exploratory purposes and contribute to a more complete picture of the regulatory processes that occur in the same conversation for both members of the couple. Similar to the patient models, significant effects emerged for the effect of partners' mean f_0 during the previous talk turn for both groups (AN: $y = -1.89$, $p < .001$; OCD: $y = -2.11$, $p < .001$) indicating self-regulation for partners. However, there were no effects of patients' mean f_0 during the previous talk turn (AN: $y = .06$, $p = .07$; OCD: $y = .03$, $p = .28$; see Table 3). Thus, the patients' mean f_0 did not influence how quickly partners returned to baseline in either diagnostic group.

No models testing differences in coregulation based on symptom severity (patient and partner models each for OCD and AN separately) indicated differences based on YBOCS or EDE scores in any of the self- or coregulatory effects (detailed results available upon request).

In summary, as hypothesized, OCD patients displayed higher aggregate levels of emotional arousal compared to AN patients.

[3] The first- and second-order derivatives for each time series were estimated using local linear approximation (LLA; Boker & Laurenceau, 2006; Boker & Nesselroade, 2002), using a lag of $\tau = 1$ talk turn, consistent with prior studies with f_0 data (B. R. Baucom, Iturralde, et al., 2012; B. R. Baucom, Saxbe, et al., 2012). Prior to estimating derivatives, each time series was detrended by fitting a slope and intercept model and using the residuals in the following analyses (Boker & Laurenceau, 2006).

Table 3
Fixed Effects for Two CLO Models: Displacement from Baseline (f_0), Velocity (1^{st} Derivatives of f_0), and Diagnosis[a] Predicting Acceleration (2^{nd} Derivatives of f_0) for (A) Patients and (B) Partners

	(A) Patient model (df = 1,070)			(B) Partner model (df = 1,077)		
Effect	Estimate (SE)	t	p	Estimate (SE)	t	p
F_0 (self)	−2.04 (.09)	−23.97***	<.0001	−1.89 (.10)	−18.42***	<.0001
F_0 (other)	.20 (.07)	2.67**	<.01	.06 (.03)	1.85	.07
F_0 velocity (self)	.01 (.06)	.17	.87	−.003 (.07)	−.05	.96
F_0 velocity (other)	.19 (.10)	1.90	.06	.02 (.04)	.55	.58
F_0 (self) × Diagnosis	.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 (other) × Diagnosis	−.01 (.12)	−.06	.95	.03 (.09)	.36	.72
Simple slope OCD	*.19 (.09)*	*2.09**	*<.05*	*.09 (.08)*	*1.09*	*.28*
F_0 velocity (self) × Diagnosis	.06 (.13)	.52	.60	.00 (.11)	.04	.97
F_0 velociy (other) × Diagnosis	.06 (.17)	.34	.73	.04 (.09)	.44	.66

Note. Main effects shown are for AN, interaction terms test the difference between groups, simple intercepts/slopes show effects for the OCD group. CLO = Coupled Linear Oscillator.
[a] Diagnosis was dummy coded, with AN as the reference group.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Contrary to expectations, AN patients displayed greater covariation of emotional arousal (rather than weaker covariation) than OCD patients, meaning that AN patients responded to their partner's previous level of arousal whereas OCD patients did not. Also, both of the patient groups displayed a significant coupling effect of their regulation of emotional arousal, meaning that the partners' emotional arousal influenced how quickly patients were able to return to their typical level of arousal. There were no significant differences between the two patient groups on degree of coupling. In addition, there were no differences based on symptom severity within each diagnostic group in terms of overall levels of aggregate arousal, covariation, or coupling.

Discussion

The current study was the first examination of emotion coregulation as a form of interpersonal emotion regulation in couples in the context of psychopathology. When examining two aspects of coregulation, covariation of two individuals' emotional arousal over time and coupling of emotion regulation to the other partner's emotional arousal, the results suggested distinct patterns in coregulation for AN and OCD, although only the hypothesis concerning differences in overall levels of emotional arousal was supported. As expected, OCD patients (and partners) showed greater emotional arousal during the couple conversations compared to AN patients (and partners), suggesting that discussing the disorder with their partners is more highly arousing for OCD patients.

The patterns in interpersonal emotion regulation are best understood across both aspects of coregulation (covariation and coupling) within each diagnostic group. In examining the patterns in covariation for OCD couples, 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, whereas 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 OCD couples in which both partners are relatively highly emotionally aroused (compared to AN), and in which partners are responsive to the patients' emotional arousal, although there is little to predict the patients' own arousal. Therefore, the partner is left to respond to a highly aroused patient with little information to anticipate how the patient will respond from one moment to the next. Additionally, partners' emotional arousal was not predicted by their own previous arousal, which further indicates that partners are primarily focused on the patient. This may suggest that partners' reassurance and other accommodating behaviors are partially due to their own emotional arousal in response to the patients' distress. In addition, the results of the coupling models indicated that OCD patients' regulation of emotional arousal (i.e., how quickly patients' arousal returned back to their typical level) was positively coupled to the partners' displacement from baseline. There was no coupling for OCD partners. This pattern for patients implies that if a partner and patient are matched in unusually high (or low) emotional arousal, regulating back to a more comfortable or typical level is slower for patients than what would happen if they were uninfluenced by partners. Integrating the covariation and coupling findings for OCD couples, a recursive pattern of coregulation between the two partners emerges. 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 baseline level of arousal. This pattern could be difficult for these couples to confront.

Clinical implications are preliminary and should be treated with great caution. However, the patterns in interpersonal regulation of emotional arousal may suggest that it is important for therapists to monitor how patients and partners respond to each other during treatment for OCD. For example, in our couple-based treatment for OCD, reducing symptom accommodation is central to response prevention. The current study suggests that partners are quite reactive to patients' emotional arousal. If partners' accommodation behaviors (e.g., providing reassurance) are partially an attempt to regulate their own emotional arousal, partners may be ill prepared to abstain from accommodation if they are unable to either tolerate or regulate their own distress in other ways. In our clinical work with these couples, we have found that partner-assisted exposure

exercises are experienced as distressing exposures for many partners as well, given that they are not accustomed to seeing their loved one in distress without attempts to help them in the moment. Thus, clinicians should explore partners' own emotional distress, especially if the couple struggles to decrease symptom accommodation. These suggestions would be further supported by future research regarding the association of symptom accommodation and emotion coregulation for partners.

A different pattern of coregulation was found for AN patients and their partners. Contrary to our hypotheses, there was no indication of diminished emotion coregulation in AN patients compared to OCD. Rather, emotion coregulation appeared to be either stronger (covariation) or the same (coupling) in AN patients than OCD patients, and this occurred in the context of a lower overall level of arousal compared to OCD. The covariation results indicated that the levels of emotional arousal in both members of the couple were positively predicted by their own and their partners' previous level of emotional arousal. Importantly from an interpersonal perspective, these findings indicate that as one person becomes more aroused, the other person is likely to respond with a higher than average level of arousal as well. Similarly, there was significant positive coupling of the patients' regulation of emotional arousal (i.e., how quickly patients' arousal returned to their typical level or baseline after being displaced) to the partners' displacement from baseline. The direction of the coupling effect was the same for AN patients as for OCD patients, suggesting that returning to typical levels of emotional arousal for AN patients would be slowed if their emotional arousal is matched at unusually high or low levels with the partners' arousal. Thus, for AN patients a consistent pattern of emotion coregulation was found.

The hypothesis of diminished interpersonal emotion regulation in AN patients was based on empirical findings that suggest AN patients rely heavily on individually focused emotion regulation and a consistent pattern of "shutting out" others from emotional experiences. However, those findings are based on contexts where the patient can choose whether to engage with a partner about AN. In the current study, patients were asked to discuss AN with their partner in a restricted laboratory setting. These findings could reflect that when they do interact with their partners around AN, patients are highly reactive to partners' emotional arousal. While responsiveness to a partner's emotions facilitates emotion coregulation, this could still be aversive to AN patients. This could be one reason they often do not engage with partners in such discussions in the real world, contributing to observed tendencies to withdraw, limit emotional sharing, and use individually focused emotion regulation strategies. Emotional reactivity in an interpersonal context has also been suggested in the literature but rarely empirically tested (Haynos & Fruzzetti, 2011; Schmidt & Treasure, 2006). Should this hypothesis be supported in future research, a clinical implication would be that going through AN treatment with a partner involves repeated in-session exposure not only because treatment requires facing AN-related fears (e.g., weight gain) but also because of the interpersonal process in session. This is consistent with our clinical observations during our couple-based treatment and statements from patients about how extremely difficult it was in the beginning to share AN-related experiences with their partners (Fischer, Kirby, Raney, Baucom, & Bulik, 2015). Many of these couples have later commented on the importance of these conversations to their treatment success. However, more research is needed on the association between patients' subjective experience and emotion coregulation, as well as changes in treatment for both.

Overall emotional arousal, covariation, and coupling did not vary depending on symptom severity for either AN or OCD. On the one hand, the presence (rather than severity) of the disorder may be the driving factor in the configuration of emotion coregulation between partners. On the other hand, instead of global measures of symptom severity, more nuanced aspects of the disorder might be of greater importance in emotion coregulation. For example, in our OCD couples research, partners were more likely to accommodate to behavioral compulsions such as checking instead of mental rituals which partners might be unaware of (Boeding et al., 2013). Thus, specific symptoms might differentially engage a partner and patient rather than global severity per se. Two prior studies demonstrated differences in aggregate f_0 indices during social threat situations between individuals with and without social anxiety disorder (Weeks et al., 2011, 2012); distressing situations specific to the disorder may be better suited to detect differences based on symptom severity. Finally, these analyses were conducted separately for AN and OCD; power was lower with symptom severity as a Level 2-predictor, particularly for the smaller OCD sample.

From a methodological perspective, this study adds to a growing literature on vocally encoded emotional arousal in couples, although prior studies were not focused on couples in which one partner has a psychological disorder (B. R. Baucom, Dickenson et al., 2015; B. R. Baucom, Weusthoff et al., 2012; Fischer, Baucom et al., 2015; Weusthoff et al., 2013). However, these studies collectively suggest that vocally encoded emotional arousal plays an important role for our understanding of couple interactions in a variety of contexts. Very little prior research is available related to f_0 in psychopathology, with two notable exceptions. Weeks et al. (2011) found differences in mean f_0 between individuals with and without social anxiety disorder (SAD) of 30–38hz measured during exposure tasks, and a 9hz difference in peak f_0 in a different study with another social threat task (Weeks et al., 2012). Although the differences in overall f_0 mean are smaller in the current study, this was expected given that (a) Weeks et al. compared individuals with SAD to healthy controls rather than individuals with another disorder, and (b) they used a paradigm that directly elicits SAD symptoms, while couples in the current study merely discussed the disorder. For coregulation, the covariation and coupling parameters are the effects controlling for auto-regressive components (i.e., actor or self-regulatory effects), and partner or coupled effects tend to be small yet meaningful in other coregulation studies as well (e.g., Helm, Sbarra, & Ferrer, 2014). Most importantly, these previous investigations indicate the value of exploring vocally encoded emotional arousal in individuals with psychopathology; the current study expands this domain of investigation by exploring coregulation of vocally encoded emotional arousal related to psychopathology in couples, further demonstrating the fruitfulness of the approach. The current findings are particularly promising as they could potentially afford clinicians a window into the objective assessment of emotional arousal and coregulation as they unfold during a therapy session given that humans' pitch perception is sensitive to changes in f_0 comparable to those found in this study.

The current study has a number of limitations. First, all participants were treatment-seeking patients and their committed romantic partners; thus, it is unclear whether the results generalize to non-treatment-seeking patients and partners. Additionally, almost all patients were female and almost all partners were male. Thus, differences in emotion coregulation between patients and partners could be due to gender rather than patient status. Also, the intensity of the topic discussed was not systematically varied beyond the instruction to the couples to select a topic of "medium intensity." It will be important to explore whether the current findings would hold across different levels of overall emotional arousal within each diagnostic group.

Finally, it is important to consider how adaptive or maladaptive different degrees of coregulation of emotional arousal may be in different contexts. Generally, some coregulation is considered an adaptive process in healthy couples (Sbarra & Hazan, 2008), but more research is needed for couples with psychopathology. For example, a partner might respond in a way that helps the patient lower emotional arousal in the short term, but it might not be adaptive in the long run. In fact, this is how accommodation appears to operate, and accommodation from family members is associated with more severe symptoms and poor treatment outcome in OCD (Boeding et al., 2013; Strauss, Hale, & Stobie, 2015). Thus, the current investigation served to identify the patterns of interpersonal emotion regulation in these couples, yet the adaptive/maladaptive nature of those processes requires further study. At the same time, it is important for clinicians to become aware of how patients are trying to regulate emotions, how they rely upon their partner in this process, and to elicit this information as part of functional assessments surrounding a given disorder. Couple-based treatments differ from individual treatments for OCD and AN in that interpersonal dynamics with a partner can be addressed within the context of a therapy session. However, couple therapists may need to account for how difficult this may be for patients and also for partners when psychopathology is present and treatment requires a shift in how patients typically process (or avoid processing) emotional content with their partners.

In conclusion, the current study represents the first investigation of emotion coregulation in couples relative to psychopathology. Appropriately, the current study has led to a set of new questions, hypotheses, and issues to address. In addition to the growing literature on behavioral interaction patterns (e.g., symptom accommodation, criticism/hostility, interpersonal avoidance) related to psychopathology, the investigation of interpersonal emotion regulation adds to a more comprehensive understanding of the interpersonal factors that play a role in the maintenance of disorders. Ultimately, future insights could serve to identify interpersonally oriented targets to optimize treatment outcome.

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