Affective Patterns in Triadic Family Interactions: Associations with Adolescent Depression

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Abstract

Affective family processes are associated with the development of depression during adolescence. However, empirical description of these processes is generally based on examining affect at the individual or dyadic level. The purpose of this study was to examine triadic patterns of affect during parent-adolescent interactions in families with or without a depressed adolescent. We used state space grid analysis to characterize the state of all three actors simultaneously. Compared to healthy controls, triads with depressed adolescents displayed a wider range of affect, demonstrated less predictability of triadic affective sequences, spent more time and returned more quickly to discrepant affective states, and spent less time and returned more slowly to matched affective states, particularly while engaged in a problem-solving interaction. Furthermore, we identified seven unique triadic states in which triads with depressed adolescents spent significantly more time than triads with healthy controls. The present study enhances understanding of family affective processes related to depression by taking a more systemic approach and revealing triadic patterns that go beyond individual and dyadic analyses.

Keywords: triadic interactions; affect; depression; adolescence; state space grids

Affective Patterns in Family Triadic Interactions Associated with Adolescent Depression

The connection between family affect and the development of depressive symptoms has been established through two primary lines of research (e.g., Allen & Sheeber, 2008; Cole & Rehm, 1986; Restifo & Bogels, 2009; Sheeber, Hops, & Davis, 2001). One is the affective *quantity* approach, wherein the amount (frequency or duration) of negative or positive affect expressed during family interactions differentiates depressed from non-depressed offspring. For example, parent negativity in the form of angry or hostile affect (Sheeber, Davis, Leve, Hops, & Tildesley, 2007) as well as sad or dysphoric affect (Sheeber & Sorensen 1998) has been tied to depressive disorder. Moreover, depressed adolescents sustain negative affective states for longer durations during family interactions than do their non-depressed counterparts (Sheeber, Allen, Davis, & Sorenson, 2000). Hence, the affective quantity approach attends to individual behavior considering the rest of the family as background context, rather than examining each as active participants that elicit and respond to each other. The second line of inquiry, the affective *process* approach, examines the contingent reactions among family members while they are engaged in an emotionally challenging interaction. Here the focus is on parental responses to children's affect and behavior that foster the development of depressive symptomatology (Lindsey, MacKinnon-Lewis, Campbell, Frabutt, & Lamb, 2002; Oldehinkel, Veenstra, Ormel, de Winter, & Verhulst, 2006; Yap, Schwartz, Byrne, Simmons, & Allen, 2010) as well as on adolescent responses to parental affect and behavior (Davis, Sheeber, Hops, & Tildesley, 2000). For example, maternal facilitative responses (e.g., approval) to adolescent depressive behavior has predicted the duration of adolescent depressive affect (Sheeber et al., 2000). This process approach, therefore, is more directly focused on affective socialization behaviors that facilitate adolescent depression.

Although these two research areas have revealed a number of important affective components of family processes, there are some issues yet to be fully addressed. One set of issues concerns the family context. With few exceptions (e.g., Davis et al., 2000), observational research has focused on the parent-child dyad as the unit of analysis. This may be a methodological convenience – it is challenging to get both parents to participate and bivariate relations dominate the analytical toolbox – but it nonetheless places an upper limit on ecological validity in several ways. First, the majority of family interactions occur with three or more individuals present (Fivaz-Depeursinge, & Corboz-Warnery, 1999; Larson, Richards, Moneta, Holmbeck, & Duckett, 1996). Thus, the assumption that the isolated dyad represents the entirety of a family's affective processes may be questioned. The parent, most often the mother, involved in such studies implicitly functions as a proxy for the family as a whole. Dyadic studies that have separated father effects from mother effects show differential results (e.g., Lunkenheimer, Olsen, Hollenstein, Sameroff, & Winter, 2011; Sheeber et al., 2007), indicating that each family member can provide a unique contribution to the family affective climate. Moreover, families comprised of a single-parent with a single child notwithstanding, a family unit in its most rudimentary form is typically triadic; thus both individual and dyadic foci cannot fully capture all of the affective processes that may shape a child's development.

Second, families have long been acknowledged, formally or implicitly, as integrated systems formed by the pattern of behavior during day-to-day interactions (Cox & Paley, 2003; Granic, 2000; Minuchin, 1974; Restifo & Bogels, 2009; Sameroff, 1983). Unfortunately, despite this general acceptance of families as systems, there has been a relative paucity of research on families *as* systems. Thus, empirical focus on the individual or dyad does not fully map on to ecological or systems theory. To address these issues, rather than making a sudden leap to

research involving four or more family members, the logical next research step is to add just one more individual into the mix. As we delineate below, the shift from dyad to triad is not trivial and may require novel analytical approaches.

Triadic Family Affective Processes

The family affective process approach has made inroads toward a more systemic understanding of developmental mechanisms of depression. Studies of dyadic parent-child interactions have revealed that adolescent depression is associated with elevated levels of parental criticism (Asarnow, Goldstein, Thompson, & Gothrie, 1993; McCleary & Sanford, 2002), overall negative affect (Schwartz, Dudgeon, Sheeber, Yap, Simmons, & Allen, 2011), and more specifically, anger (Sheeber et al., 2007) and dysphoria (Schwartz et al., 2012; Sheeber & Sorenson, 1998), as well as lower levels of parental positivity (Yap, Allen, & Ladouceur, 2008; Sheeber, Hops, Alpert, Davis, & Andrews, 1997). However, only relatively few studies have examined triadic processes – most commonly mother-father-child triads – and associations with depression.

By far the most prevalent triadic research is on interpersonal conflict, with most focusing on the child's response to marital conflict (e.g., Cummings, El-Sheikh, Kouros, & Keller, 2007; Davis et al., 1998). In general, greater amounts of conflict among family members predict youth depression (Kane & Garber, 2004; Marmorstein & Iacono, 2004). Even triadic family interaction patterns at very young ages can predict depression. For example, enmeshed, controlling, and disengaged triadic family patterns with 2-year-old children have been shown to predict depressive symptoms in children five years later (Jacobvitz, Hazen, Curran, & Hitchens, 2004). In one of the few studies to examine contingent responding across triad members, the sequence of mothers' aggression towards fathers followed by adolescents' dysphoric behavior to

mother was found to predict an increase in adolescent depression over the course of one year

(Davis et al., 1998). Thus, both global assessments of family functioning and more specific three

person sequences have predicted depression in youth.

In addition to the limitations of a dyadic focus presented earlier, there are further issues

not yet fully addressed in triadic research. First, there are several ways that direct person-to-

person interactions in dyads are qualitatively different than interactions that include three (or

more) individuals: (1) functional roles emerge in triads, like the "peacekeeper" who helps to

resolve the conflict between the other two triad members, the aggressive child as "co-combatant"

with parents, or the "withdrawn witness" who passively ceases to participate in the interaction

(Davis et al., 1998; Emery, 1982; Pincus, 2001; Vuchinich, Emery, & Cassidy, 1988), that

cannot exist in a dyadic contexts; (2) the primary mechanisms of intimate communication such

as eye gaze are necessarily compromised and divided – it is more complex to look at or direct

behavior towards two people at once; (3) when triads have been considered, they typically have

been conceptualized as a set of three dyadic relationships, each of which may be affected by the

presence of the third person (e.g., Davis et al., 1998). However, it may be problematic to "infer

the property of the triad from its dyadic components rather than taking a leap to the triadic

gestalt" (Fivaz-Depeursinge & Corboz-Warnery, 1999, p. xxiv) ; (4) a unique set of relational

processes are available with triads that are not available with dyads such as the exclusion of one

triad member by the other two (Tremblay-Leveau & Nadel, 1996), triangulation as when one

parent complains to the child about the other parent (Fivaz-Depeursinge & Corboz-Warnery,

1999) or coalitions of two triad members in an alliance against the third (Minuchin, 1974); and

(5) in relating parent-child interactions to the development of psychopathology in children, the

parent present in dyadic research may not be the most influential to the etiology; hence, with both parents present, unique problematic processes may be revealed.

Second, a primary barrier to triadic research is analytic complexity (Davis et al., 1998). Most measurement or analytical tools in observational research rely on binary pairings (e.g., conditional probabilities, correlations) or statistical interactions. For example, mom's average valence and dad's average valence plus the interaction between those two variables might be used to predict child's average valence. This purely content-driven approach is not altogether "wrong" but neglects the temporal dynamics or structural patterns unique to triadic interactions. What are needed are techniques that bridge the gap between the rich, systems-based theoretical accounts of developmental psychopathology and the empirical means to test these claims (Granic & Hollenstein, 2003; Richters, 1997). Recent advances with a 2-dimensional technique based on dynamic systems principles, state space grids (Lewis, Lamey & Douglas, 1999; Hollenstein, 2007, 2012, 2013), has opened a window into understanding the dynamics of three interacting individuals (Lavictoire, Snyder, Stoolmiller, Hollenstein, 2012).

The Present Study

The purpose of the present study was to explore differences in triadic family affective dynamics between triads with or without a depressed adolescent. Specifically, we sought to examine differences in the structure (i.e., variability), content (i.e., specific affective states), and the degree of affective matching across triad members. Because this was the first attempt to examine patterns of triadic interaction using state space grids, a technique that provides a wide range of indices of structure and content (described below) for analysis, our approach was primarily descriptive and exploratory.

Families were observed while engaging in three interaction tasks in a set order: an event-planning task, a problem-solving task, and a family consensus task. Rather than just focusing on the problem solving task, as is typical in family interaction research, we included all three tasks to be able to distinguish both context-independent effects across all tasks as well as comparisons of affective dynamics that depended on the interaction context. Each triad member was coded separately and continuously to capture their moment-to-moment affective states. Consistent with previous applications of the LIFE code (Allen, Kuppens, & Sheeber, 2012; Ehrmantrout, Allen, Leve, Davis, & Sheeber, 2011; Kuppens, Allen, & Sheeber, 2010; Sheeber, Allen, Leve, Davis, Shortt, & Katz, 2009), each triad member's behaviour was categorized as angry, dysphoric, happy, or NA. These synchronized categorical time series were analyzed with state space grids (SSGs), an analytical technique based on dynamic systems principles that provides visualizations of real-time trajectories and various measures capturing the structure and content of these trajectories (Hollenstein, 2013). This technique is well suited to research on families as systems with each cell of the grid representing a simultaneous triadic state. Each triadic trajectory (sequence of triadic states) was plotted on the SSG and measures were derived based on frequency and duration. Figure 1 shows two triadic SSGs from this study. The y-axis has the four categories for the child while the x-axis has each of the 16 mother-father category combinations. The plotted trajectories track the changes in triadic affect.

This study was organized around three primary research questions. First, we wanted to examine the overall variability in the triadic dynamics. In dyadic parent-child interactions, structural indices of variability derived from state space grids have been associated with children's internalizing and externalizing problems (Granic, O'Hara, Pepler, & Lewis, 2007; Hollenstein, Granic, Stoolmiller, & Snyder, 2004; Lunkenheimer et al., 2011; Lunkenheimer,

Hollenstein, Wang, & Shields, 2012) and adolescents' stress (Hollenstein & Lewis, 2006). In general, lower affective variability (i.e., greater rigidity) has been associated with elevated problems; greater variability (i.e., flexibility) has been associated with healthy socioemotional functioning. Consistent with these findings, we predicted that the triads with depressed adolescents would be more rigid by dint of lower overall variability in triadic affective states than triads with typically developing adolescents.

Second, we wanted to explore differences in specific triadic affective states between the depressed and non-depressed groups. From the literature on individual affective states, we know that depressed adolescents as well as their parents tend to express more negative affect (Buist, Dekovic, & Gerris, 2011; Schwartz et al., 2012; Sheeber & Sorenson, 1998). What we do not know from this literature is how these individual states combine in a triadic social context. For example, do mothers and fathers alternate negativity or express it simultaneously? For this research question, we were interested in exploring which of the possible triadic combinations of simultaneous affect were different between groups. We predicted that the parent and adolescent dysphoric and angry states would differentiate the depression groups, but were unable to specify which specific triadic combinations would be most important.

Third, to complement and further narrow our focus on group differences, we took our content analyses a step further to examine whether the discrepancy or matching of triadic affective states would differentiate groups. One line of research would suggest that mutually aversive states would characterize the depressogenic family interactions (e.g., Yap, Allen, O'Shea, Di Parsi, Simmons, & Sheeber, 2011). Another perspective is that the mismatching of affect creates an emotionally confusing climate that is not predictable and thus facilitates depressive symptoms (Tronick & Cohn, 1989). We tested these competing predictions in two

ways. First, we tested whether the depressed group spent more time in triadic states with each

triad member in a different state than the other two (e.g., child angry, mother dysphoric, father

happy) and if they returned to those states more quickly than the non-depressed group. Second,

we tested whether the depressed group spent more time in mutual states (e.g., child angry,

mother angry, father angry) and returned to these states more quickly than the non-depressed

group.

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Methods

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Participants

Participants were 107 adolescents (42 boys) and their parents, selected from a larger

sample of families participating in a study of adolescent unipolar depressive disorder ($N = 152$;

Sheeber et al., 2009). Of participating parents, 93% of mothers and 74% of fathers were the

child's biological or adoptive parent; the remaining were step-parents (5% mothers; 23% fathers)

or grandparents/permanent guardians. Because we were interested in examining triadic processes

only two-parent families, in which both parents participated, were included (more recruitment

details follow below). Of two-parent families in the larger study, both parents participated in

93% of families. Relative to the larger study, this subsample had higher family income, χ^2 ($n =$

152) $= 21.52$, $p < .001$, more boys χ^2 ($n = 152$) $= 5.74$, $p < .05$, and fewer depressed χ^2 ($n = 152$)

$= 4.24$, $p < .05$ participants.

The adolescents were between the ages of 14 and 18 and met research criteria for

placement in one of two groups (Depressed, $n = 47$ or Healthy, $n = 60$). Depressed adolescents

met DSM-IV (American Psychiatric Association, 1994) diagnostic criteria for current Major

Depressive or Dysthymic disorder ($n = 1$) based on the K-SADS diagnostic interview (Orvaschel

& Puig-Antich, 1994). Healthy adolescents had no current or lifetime history of psychopathology

based on the K-SADS, and no history of mental health treatment. Twenty-three depressed

adolescents were excluded - 19 due to comorbid externalizing or substance dependence

disorders, and four who were taking either Serotonin Norepinephrine Reuptake Inhibitors

(SNRIs) or Tricyclic antidepressants - because of their potential to influence

psychophysiological measures collected as part of the larger investigation. Demographic

information is provided in Table 1.

Screening and Recruitment

Families were recruited using a two-gate procedure consisting of an in-school screening

and an in-home diagnostic interview. In order to facilitate recruitment of a representative sample

of students, we used a combined passive parental consent and active student assent protocol for

the school screening (Biglan & Ary, 1990). Active parent consent and adolescent assent for the

full assessment were obtained prior to the diagnostic interview. The study was conducted with

approval of the appropriate IRB and in accordance with American Psychological Association

ethical standards.

In-School Screening. High school students ($N = 4182$) completed the Center for

Epidemiological Studies-Depression Scale (CES-D; Radloff, 1977) and a demographic data form

during class. Approximately 70% of enrolled students participated in the screening (12%

declined; 18% absent). The CES-D is a widely-used, self-report measure that has a well-

established record as a screener for depressive symptomatology in adolescent samples (e.g.,

Sheeber et al., 2007). The CES-D cut-off scores for selecting potential participants represented

the 93rd percentile in the distribution of scores obtained in an earlier screening of high school

students ($N = 4495$) in the same area (Sheeber et al., 2007). Relatively high scores ($\geq$ 31 for

males and $\geq$ 38 for females) were selected to maximize the positive predictive power to identify

adolescents experiencing depressive disorder. Approximately 8% of students in the current sample scored above these cut-offs. The pool for the healthy group was defined as students not more than .5 SD above the mean in the earlier sample ($<$ 21 for males and $<$ 24 for females). The mean score in the current sample was 16.04 (SD = 11.4; range = 0-59).

In-Home Diagnostic Assessment. Interviewers conducted the Schedule of Affective Disorders and Schizophrenia-Children's Version (K-SADS, Orvaschel & Puig-Antich, 1994) with adolescents who had elevated CES-D scores in order to obtain current and lifetime diagnoses for mood, anxiety, psychotic, externalizing, eating, and substance use disorders. After each adolescent in the depressed group completed the lab assessment, a healthy comparison participant matched, to the extent possible, on sex, race/ethnicity and school was recruited from the pool of students who scored within the normal range on the CES-D. Approximately 9% of families contacted by phone were not eligible to participate as per criteria described above (e.g., not living with parent; treatment history not appropriate for condition). Of families invited to participate (N = 498), approximately 26% declined. Rates of decline did not vary as a function of pre-interview group status (i.e., elevated or healthy CES-D score), age, or race, though more males than females declined (31.6% vs. 23%), χ^2 (1, n = 498) = 4.57, $p <$ .05. Reliability ratings were obtained on approximately 20% of the interviews, chosen at random. Average agreement on an item by item basis was κ = .94, across diagnoses. Agreement at the level of diagnosis for depressive disorder was κ = .80.

Family-Based Lab Assessment. Families who met criteria for the investigation after the diagnostic interview were invited to participate in the lab assessment. Approximately 4% of families declined. The decline rate did not vary as a function of group status, age, race, or sex. The lab assessment included three family interaction tasks designed to elicit varying degrees of

happy, angry, and dysphoric affect. Each interaction lasted 18 minutes, evenly divided across

two discussions. In the first task, families were first instructed to plan a vacation and then to

reminisce about a fun time they had experienced together (Event-Planning Interaction; EPI). The

second task consisted of two consecutive problem-solving interactions in which families were

asked to discuss and resolve two areas of conflict (Problem-Solving Interaction; PSI). In the last

interaction, families were asked to discuss two areas of family life; one focused on identifying

and describing the best and most difficult years the adolescent had experienced, and the other

focused on the most challenging and most rewarding aspects of parenting the adolescent (Family

Consensus Interaction; FCI).

Measures

   Observational Coding. The Living in Family Environments coding system (LIFE; Hops,

Biglan, Tolman, Arthur, & Longoria, 1995) was used to code the triadic interactions. Observers,

blind to diagnostic status, coded each family members' nonverbal affect and verbal content in

real time. Because we were specifically interested in affects that are core to depression, three

constructs, angry, dysphoric, and happy were derived from individual affect, and affect-laden

content codes, in the present investigation. Angry behavior included aggressive or contemptuous

nonverbal behavior and cruel or provoking statements captured by the LIFE codes contempt,

anger, and belligerence. Dysphoric behavior was defined by sad nonverbal behavior or

complaining statements. Happy behavior reflected happy nonverbal behavior or humorous

statements. Other verbal content with neutral affect as well as three other affect codes (caring,

whine, anxious) were combined into the NA category. Approximately 25% of videos were coded

by a second observer for reliability purposes. Kappas for the coding were .73, .70, and .88 for

adolescent angry, dysphoric, and happy, respectively.

Diversity, Flexibility, and Unpredictability. Three measures of variability were derived from the state space grids using GridWare 1.1 (Lamey, Hollenstein, Lewis, & Granic, 2004) to capture the overall structure of the interaction. First, Diversity was measured by dispersion, which reflects the range of triadic affect by effectively summing the number of unique cells occupied controlling for the proportional durations in each cell. The formula for Dispersion is:

$$1 - [[(n\Sigma(d_i/D)^2) - 1]/n - 1]$$

where D is the total duration, d_i is the duration in cell i and n is the total number of cells in the grid (64 for this study). Values for Dispersion range from 0 (all affect is in one cell for the entire interaction) to 1 (affect is equally distributed with the same duration in every cell). The second measure was Flexibility, computed by transitions per minute: a count of the number of times the triad changed affect to occupy a different cell, divided by the total duration of the discussion. Finally, Unpredictability was the third variability measure taken from Shannon's entropy (Shannon & Weaver, 1949), which is an index of the predictability of the *sequence* of triadic states (Dishion, Nelson, Winter, & Bullock, 2004; Lunkenheimer et al., 2011):

$$\sum_i p_i \log p_i$$

where p_i is the probability of a visit to each cell (e.g., # of visits to cell i divided by total visits across all cells). Low entropy values reflect interaction sequences that repeat the same patterns over and over again, whereas high entropy values indicate unpredictability in those sequences.

Triadic Affective States. Using GridWare 1.1. (Lamey et al., 2004), the mean durations of events in each of the 64 cells of the state space grids were obtained for each triad. This measure uses both duration and frequency information (duration in a cell divided by the number

of visits to that cell) to reflect the degree to which triads got "stuck" in these states. High values

reflect that states lasted a long time each time they occurred, on average.

Discrepant and Matching States. Two subsets of state space grid cells were identified

based on whether the triad members expressed (a) three different affects simultaneously (e.g.,

child anger, mother dysphoric and father happy) and (b) three identical affects (e.g., child angry,

mother angry, and father angry). Out of the 64 cells, there were 24 unique discrepant states and 4

unique matching states (see Figure 2). Two measures were obtained for these two regions of the

state space grid: the total Duration and the Return Time. Duration was simply the total amount of

time summed across all the cells in the Discrepancy or Matching regions. Return Time was the

average amount of time between visits to the region. For example, a Return Time of 12 seconds

for the Matching region would mean that on average the triad returned to a matched triadic state

after being in non-matched states for 12 seconds. Thus, shorter Return Times reflect a more

habitual repetition of either Discrepant or Matching states.

Results

Diversity, Flexibility, and Unpredictability. Our first set of analyses was conducted to

test for group differences in the overall structure or variability of the interactions. Each of the

three measures was analyzed in separate 2x2x3 between-within repeated measures ANOVAs

with depression group and sex as between-subjects factors and the three interaction tasks as the

within-subjects factor.

For Diversity, there was a significant quadratic effect of Task, $F (1, 100) = 9.14$, $p =$

$.003$, $\eta_p^2 = .08$, as well as a significant Task by Group interaction, $F (1, 100) = 5.06$, $p = .03$, $\eta_p^2 =$

$.05$. As shown in Figure 3a, the triads with depressed adolescents had greater range of affective

states in the problem-solving task than did the control triads. Follow up contrasts showed that

this was a significant difference between groups for just the problem-solving task ($p = .02$), and

that Diversity during the problem-solving task for the depressed group was significantly higher

than Diversity in the previous interaction task ($p = .006$) and the subsequent interaction task ($p =$

.002).

For Flexibility, there was a linear decrease across tasks, $F(1, 100) = 10.76$, $p = .001$, η_p^2

$= .10$ (see Figure 3b). Contrary to hypotheses, there were no significant group effects.

For Unpredictability, there was a significant quadratic effect of Task, $F(1, 100) = 52.56$,

$p < .001$, $\eta_p^2 = .35$, a significant Task by Group interaction, $F(1, 100) = 4.83$, $p = .03$, $\eta_p^2 = .05$,

and a between-subjects main effect of group, $F(1, 100) = 4.15$, $p = .04$, $\eta_p^2 = .04$. As shown in

Figure 3c, the triads with depressed adolescents had greater affective Unpredictability in the

problem-solving task than did the control triads. Follow-up contrasts showed that the between

group effect was significant for just the problem-solving task ($p = .008$), and that

Unpredictability during the problem-solving task for the depressed group was significantly

higher than Unpredictability in the previous interaction task ($p < .001$) and the subsequent task

($p < .001$). This difference was also found for the control group with significantly less

unpredictability (i.e., more predictability) in the first task ($p < .001$) and the last task ($p = .005$) in

comparison to the middle problem-solving task.

Triadic Affective States. In order to detect group differences in simultaneous triadic

affective states, we ran a stepwise discriminant function analysis on the 64 mean durations in the

cells for each interaction task separately. The dependent variable was depression group. In the

first step of the analysis, all 64 cell values were included and variables that contributed the least

to the group discrimination were eliminated one-by-one in each step until only the variables that

contributed to that discrimination remained. Thus, following previous triadic analyses

(Lavictoire et al., 2012), the analysis detected which triadic states maximally discriminated groups. Results are summarized in Table 2. Criteria for inclusion were based on Wilks' Λ at p < .05[1]. For all cells identified by the analysis, the depression group had higher mean durations. In the Event Planning task, three triadic states were identified, whereas for each of the other two tasks only two triadic states were identified. All seven states were different from one another. The pattern of results revealed that none of the states included matched affect with the child and mother but three of the seven states included matched affect with the father, who shared dysphoric affect in Event-Planning task and angry affect during the Problem-Solving and Family-Consensus tasks.

Discrepant and Matching States. As a final exploration into triadic state differences between groups, we examined regions of cells, rather than individual cells. First, we combined the 24 triadic states in which each triad member was in a different affective state than the other two to create a discrepancy region (see Figure 2). The two measures of total duration and latency to return to this region were analyzed with a repeated-measures (Task) ANOVA, as described for the variability analyses. For duration in the discrepancy region, there was a significant quadratic effect of Task, $F (1, 100) = 42.74, p < .001, \eta_p^2 = .30$, as well as a significant Task by Group interaction, $F (1, 100) = 9.41, p = .003, \eta_p^2 = .09$. As shown in Figure 4a, the triads with depressed adolescents spent more time in mutually discrepant states in the problem-solving task than did the control triads. Follow-up contrasts revealed that this was a significant difference between groups for just the problem-solving task ($p = .006$). Furthermore, the duration in the discrepancy region during the problem-solving task was significantly higher than in the previous task for both the depressed ($p < .001$) and control ($p = .005$) groups but greater in the subsequent task for the depressed group only ($p < .001$).

For Return Time to the discrepancy region, there was a significant quadratic effect of

Task, $F(1, 100) = 36.64$, $p < .001$, $\eta_p^2 = .27$, as well as a significant Task by Group interaction, F

$(1, 100) = 8.30$, $p = .005$, $\eta_p^2 = .08$. As shown in Figure 4b, the triads with depressed adolescents

returned more rapidly to mutually discrepant states in the problem-solving task than did the

control triads. Follow-up contrasts revealed that the between-group difference was significant

only in the problem-solving task ($p = .004$). Furthermore, Return Time during the problem-

solving task was significantly shorter than in the previous task ($p < .001$) and the subsequent task

($p < .001$). For the control group, Return Time was significantly higher in the first task than both

the problem-solving ($p < .001$) and family consensus ($p = .002$) tasks.

Using the same analysis strategy, we examined Duration and Return Time in the region

defined by the four cells of triadic matched affect (see Figure 2). For Duration in the matched

affect region, there was a significant quadratic effect of Task, $F(1, 100) = 30.24$, $p < .001$, $\eta_p^2 =$

.23, as well as a significant Task by Group interaction, $F(1, 100) = 6.38$, $p = .01$, $\eta_p^2 = .06$. As

shown in Figure 5a, the triads with depressed adolescents less time in matched affective states in

the problem-solving task than the control triads. Follow-up contrasts revealed that this was a

significant difference between groups for just the problem-solving task ($p = .01$). Moreover, for

the depressed group the duration in the matched affect region was significantly different between

tasks 1 and 2 ($p < .001$), 2 and 3 ($p < .001$), and 1 and 3 ($p = .002$). For the control group,

duration of matched affect in the first task was significantly different from both problem-solving

($p = .002$) and family-consensus ($p = .007$) tasks.

For Return Time to the matched affect region, there was a significant quadratic effect of

Task, $F(1, 100) = 24.48$, $p < .001$, $\eta_p^2 = .20$, as well as a significant Task by Group interaction, F

$(1, 100) = 4.51$, $p = .04$, $\eta_p^2 = .04$. As shown in Figure 5b, the triads with depressed adolescents

returned more slowly to matched affect states in the problem-solving task than did the control

triads. Follow-up contrasts revealed that this was a significant difference between groups for just

the problem-solving task ($p = .04$). Moreover, for the depressed group the return time to the

matched affect region was significantly different between tasks 1 and 2 ($p < .001$), 2 and 3 ($p =$

.03), and 1 and 3 ($p = .006$). For the control group, return time to the matched affect region in the

first task was significantly different from both problem-solving ($p < .001$) and family-consensus

($p = .001$) tasks.

Discussion

The purpose of this study was to explore the patterns of triadic affect in families with or

without a depressed adolescent. Compared to families with non-depressed adolescents, triads

with depressed adolescents displayed a wider range of affect with less predictability of triadic

affective sequences, spent more time and returned more quickly to discrepant affective states,

and spent less time and returned more slowly to matched affective states, particularly while

engaged in a problem-solving interaction. Furthermore, we identified seven specific triadic states

in which triads with depressed adolescents spent significantly more time than triads with healthy

controls.

The present study was designed to investigate families as dynamic systems (Granic,

2000). One of the fundamental premises in a dynamic systems approach to development is that

variability or the overall structure of changes in states is an important signal of a system (Granic

& Hollenstein, 2003; Thelen & Ulrich, 1991; van Geert & van Dijk, 2002). Specifically, the

ability to move in and out of states with relative ease is indicative of a system that can more

readily adapt to changing environmental demands. Depressed individuals have been shown to get

stuck in affective states (e.g., inertia; Kuppens, Allen, & Sheeber, 2010). In general in dyadic

parent-child interactions, lower affective variability has been associated with both internalizing and externalizing problems in children (Granic et al., 2007; Hollenstein et al., 2004). However, one study in a preschool sample found that higher mother-child variability but lower father-child variability was associated with children's problem behavior (Lunkenheimer et al., 2011). Though our results showed that variability was indeed a signal that differentiated the affective dynamics of these triads, depression was unexpectedly associated with *greater* dispersion and unpredictability but was unrelated to flexibility. Moreover, this was shown most clearly in the problem-solving task. This means that triads with depressed adolescents expressed affect in a greater number of combinations and the patterns of their state-to-state transitions were less predictable. Interestingly, the number of transitions was not different between groups, indicating that the greater diversity of triadic states did not arise from making more frequent changes in states. Instead, depressed triads differed with respect to range and sequence, but not flexible movement in and out of states.

In previous parent-child dyadic variability studies, measures of diversity and flexibility have consistently been positively correlated (Hollenstein, Lichtwarck-Aschoff, & Potworowski, 2013). There are several possible reasons for the difference in the current study. First, triadic and dyadic variability may be functionally different with respect to psychopathology, although it is simply too soon to evaluate this possibility until further triadic examinations are made. Second, the present study utilized an affective coding scheme that resulted in a higher base rate of non-neutral codes. This resulted in higher values for these three measures than seen in previous studies (e.g., Hollenstein et al., 2004; Hollenstein & Lewis, 2006). As variability detected with state space grids is a nascent analytical approach, in the future it will be necessary to systematically compare the effect of these measurement differences across studies. Nonetheless,

each study that has attempted this structural approach has found modest to strong connections

with psychopathology – there is a signal in variability that is complementary to the effects of

affective content.

As expected, there were consistencies with previous research on the emotional states of

individual family members and reciprocal affective dynamics within dyads (Sheeber et al., 2007;

Schwartz et al., 2011). Families with depressed adolescents expressed more negative affect

(dysphoria and anger) and less positive affect relative to controls. However, the results revealed

combinations that went beyond a simple more-negative and less-positive interpretation. First,

only one of the seven significant combinations was formed by one triad member in a neutral state

and the other two in a non-neutral state – a combination that would support the conclusion that

dyadic states are sufficient for understanding family processes. Second, two of the seven

significant triadic states included dysphoric or angry states for the adolescent but neutral for both

the parents. This is consistent with research that has focused on the depressed individual's

affective expression during interpersonal interactions (e.g., Sheeber et al., 2009). Parents were

affectively unperturbed by their depressed child's anger during event-planning and dysphoria

during family-consensus tasks. This could have resulted from the parents' habituation to their

child's mood states or disruptions in contingent affective reactions that have been shown to be

etiologically relevant to adolescent depression (Sheeber, Hops, Andrews, Alpert, & Davis,

1998). Third, and most importantly, the majority of differentiated states were uniquely triadic

with each person expressing an affect that was different from the other two - patterns that would

be obscured by a dyadic approach. In the problem solving interaction (the task which exposed

most of the group differences), there was dyadic mutual anger but not triadic mutual anger,

showing that dyadic findings do not extend to triads. With the adolescent in a dysphoric affect or

the mother in NA, the mutual anger involving the father may be evidence of the withdrawn or passive witness role emerging in the depressed group (e.g., Davis et al., 1998). Furthermore, across interaction tasks, none of these triadic states were significant more than once, suggesting that the interactional context is an additional factor that can significantly moderate family processes associated with psychopathology.

Exploring these triadic states further, we found that depression was associated with greater mismatching and, conversely, less matching. This means that triads with depressed adolescents were less likely to share their anger, dysphoria, and happiness than were those without depressed adolescents. On the surface this may be somewhat surprising as it might be expected that getting locked into three-way mutual anger or dysphoria would be indicative of dysfunctional family processes. However, these results may better reflect the functional roles that may be fixed in the distressed families. For example, when anger is expressed by two triad members, the third may be a peacekeeper using humor to try to regulate their anger or a withdrawn witness who becomes dysphoric or neutral (Davis et al., 1998; Emery, 1982; Pincus, 2001; Vuchinich, et al., 1988). As highlighted above, the mutual adolescent-father anger with mother NA or the mutual mother-father anger with adolescent dysphoric implicate a withdrawn witness role. Alternatively, because of the ipsative nature of mutually-exclusive and exhaustive affect codes, these results may reflect differences between groups in the amount of NA observed. Triads with depressed adolescents expressed more non-NA states, which may be reflected in their lower triadic mutual NA (NA/NA/NA) durations. Thus, matching and mismatching differences could have been driven by differences in the most common triadic state. However, if the triadic mutual NA was a significant difference above and beyond other states, it would have been one of the states found

in the discriminant function analyses. Thus, our interpretation is that the NA explanation cannot fully account for the present results.

Theoretical Implications

The present results can be interpreted through several theoretical models. First, interpersonal theories of depression are predicated on the primacy of intimate relationships in the formation and maintenance of depression (Joiner & Coyne, 1999). Typically, this approach emphasizes the importance of each dyadic relationship. It is now possible to expand this understanding beyond dyadic relationships in the presence of others to more directly incorporate larger relationship systems. Second, family systems theory has provided rich accounts of family processes in the therapeutic context (Minuchin, 1974; Restifo & Bogels, 2009). Incorporation of dynamic systems methodologies such as state space grids that can quantify the hypotheses derived from family-systems theory is an important contribution to reduce the theory-method gap in developmental psychopathology (Granic & Hollenstein, 2006; Richters, 1997). Finally, several emerging models of adolescent psychopathology focus on the regulation of emotional arousal as a critical developmental process (Allen & Sheeber, 2008; Steinberg, 2007). In an interpersonal context such as the family system, both self- and co-regulation modulate the rise and fall of affective states (Butler & Randall, 2013). The present study integrated these interpersonal, systemic, and regulatory frameworks to move beyond a simple quantitative approach and to enhance the process approach to understanding depression.

Clinical Implications

In the treatment of depression in youth, individual therapies are far more common (68%) than family-based interventions (Sander & McCarty, 2005). The evidence from previous research indicates quite clearly that affective processes within the family system are associated

with the onset and continuation of depressive symptoms in youth (Davis et al., 1998; Schwartz et al., 2011; Sheeber et al., 2007; Sheeber & Sorenson, 1998). Moreover, research on Attachment-based Family Therapy (ABFT) indicates that the amelioration of caustic family processes and the emergence of warmer and more nurturing ones, reflective of improved relationship quality, results in the reduction of symptoms (Diamond, Siqueland, & Diamond, 2003). This evidence suggests that adverse family processes are a prospective, modifiable risk factor that represent a target for preventative interventions. The present study adds to this growing body of evidence by identifying simultaneous affective states that distinguish the families of depressed teenagers. Family-based prevention and intervention strategies, like ABFT, could focus on resistance to matched affect across all family members as a marker of distressed relationships or inability to co-regulate affect that warrants attention in the intervention context. Furthermore, the present results indicate that a decontextualized therapeutic approach to regulating specific affective states (e.g., angry or dysphoric affect) neglects the functions of emotions in specific interpersonal contexts. Rather than a simple reduction of anger or dysphoria, informed interventions would focus on how, when, and with whom these affective states are expressed.

Limitations and Future Directions

The present study has extended previous investigations on family processes related to the development of depression. These data were well suited to examine triadic effects, yet there were some limitations. First, this study was cross-sectional. Thus, it is not clear whether these triadic processes would be prospectively associated with the emergence of depression in these adolescents, or are phenomena that only emerge once symptoms are present. A prospective longitudinal design would be ideal to show the importance of triadic affect. Second, though we made the assertion that dyads are different from triads, this has not been shown directly. An ideal

design would be to be able to compare depressed adolescents' dyadic interactions with each

parent to their interactions with both parents simultaneously. Third, though parents are primary

socializers of emotion, siblings are also a significant influence and adolescents are also

developing more intimate peer relationships. Because adolescents tend to socialize in small

groups, peer affective processes related to depressive symptoms may be best understood in a

broader social context. Such approaches would provide a richer understanding of how

interpersonal affect transpires in diverse contexts and across multiple relationship types. Fourth,

we have focused on a coherent subset of the wide range of analytical possibilities afforded by

triadic state space research. Other conceptual regions such as negative affect from one or more of

the interactants (Hollenstein & Lewis, 2006), parenting categories such as harsh or permissive

(Granic & Lamey, 2002; Granic et al., 2007), mutual positivity (Lunkenheimer et al., 2011), and

even several others that are uniquely triadic (e.g., both parents negative while child is neutral or

positive) have yet to be explored. Moreover, the state space grid technique allows for the

analysis of state-to-state transitions and multi-step transition sequences (e.g., mother dysphoric

followed by father anger followed by child dysphoric; Butler, Hollenstein, Shoham, &

Rohrbaugh, 2013). The present analyses only scratch the surface of possibilities. Finally,

analyzing families as systems, we have shown the utility of shifting the focus from dyads to

triads. With this shift, it is also possible to go beyond the triad to examine families as they are

(e.g., more than three members) rather than as we need them to be for our methodological

pragmatics. Siblings, extended families, and complex family configurations (e.g., divorced and

remarried) are all possible with the present approach. In addition to state space analyses, small

group research also may provide tools for understanding family processes beyond the dyad

(Arrow, McGrath, & Berdahl, 2000; Pincus, 2001; Pincus, Ortega, & Metten, 2010).

Conclusions

As a mood disorder, depression is fundamentally a disturbance in the experience, expression, and regulation of affect (Allen & Sheeber, 2008). Emotions and affect are inherently social and, even when experienced without the physical presence of others, these states are fundamentally related to social goals (van Kleef, 2010). Over the course of development, the primary interpersonal contexts in which affects and moods become habitual involve the family system. Thus, to be able to analyze patterns of interaction within a family *as* a system is an important advance for future research. State space grids are one way to realize this analytical need and we look forward to continued advances in the understanding of the development of psychopathology with this and other techniques in the future.

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Footnotes

[1] To make sure that the results of the discriminant function analysis were not due to violations of assumptions of normality or outliers, we reran these analyses using bootstrapping, which can be used to address these concerns (Dagleish, 1994). Furthermore, we ran a stepwise logistic regression with the same variables and criteria as the discriminant function analysis. In both cases, the same variables were significantly different by group.

Table 1. Demographic Data

Demographic Category	Depressed (n = 47)	Healthy (n = 60)	Test Statistic
Sex			
Male	17 (36.2%)	25 (41.7%)	$\chi^2 = 0.33$, ns
Female	30 (63.8%)	35 (58.3%)	
Age			
Mean (SD)	16.38 (1.20)	16.15 (1.07)	$t = 1.01$, ns
Income			
Median	$52,500	$67,500	$\chi^2 = 1.42$, ns
Race			
Caucasian	32 (68.1%)	46 (77.7%)	$\chi^2 = 0.60$, ns
African American	1 (2.1%)	1 (1.7%)	
Asian	0 (0.0%)	1 (1.7%)	
Native American	0 (0.0%)	0 (0.0%)	
More than one race	11 (23.4%)	10 (16.7%)	

Ethnicity			$\chi^2 = 0.20$, ns
Hispanic	4 (8.5%)	7 (11.7%)	
Not Hispanic	40 (85.1%)	52 (86.7%)	
Unknown	3 (6.4%)	1 (1.7%)	

$\chi^2 = 0.20$, ns

Table 2. Mean durations (means and standard deviations) of triadic affect states in which the depressed group had higher mean durations.

Child	Mother	Father	Depressed	Control
Event Planning				
Happy	Dysphoric	Angry	0.81 (1.8)	0.09 (0.3)
Angry	NA	NA	3.09 (1.8)	2.36 (1.7)
Dysphoric	Happy	Dysphoric	1.30 (1.9)	0.76 (1.1)
Problem-solving				
Dysphoric	Angry	Angry	2.47 (3.2)	0.65 (1.5)
Angry	NA	Angry	2.55 (2.3)	1.02 (1.9)
Family Consensus				
Dysphoric	NA	NA	5.34 (2.9)	4.20 (2.0)
Angry	Happy	Angry	0.39 (1.0)	0.02 (0.1)
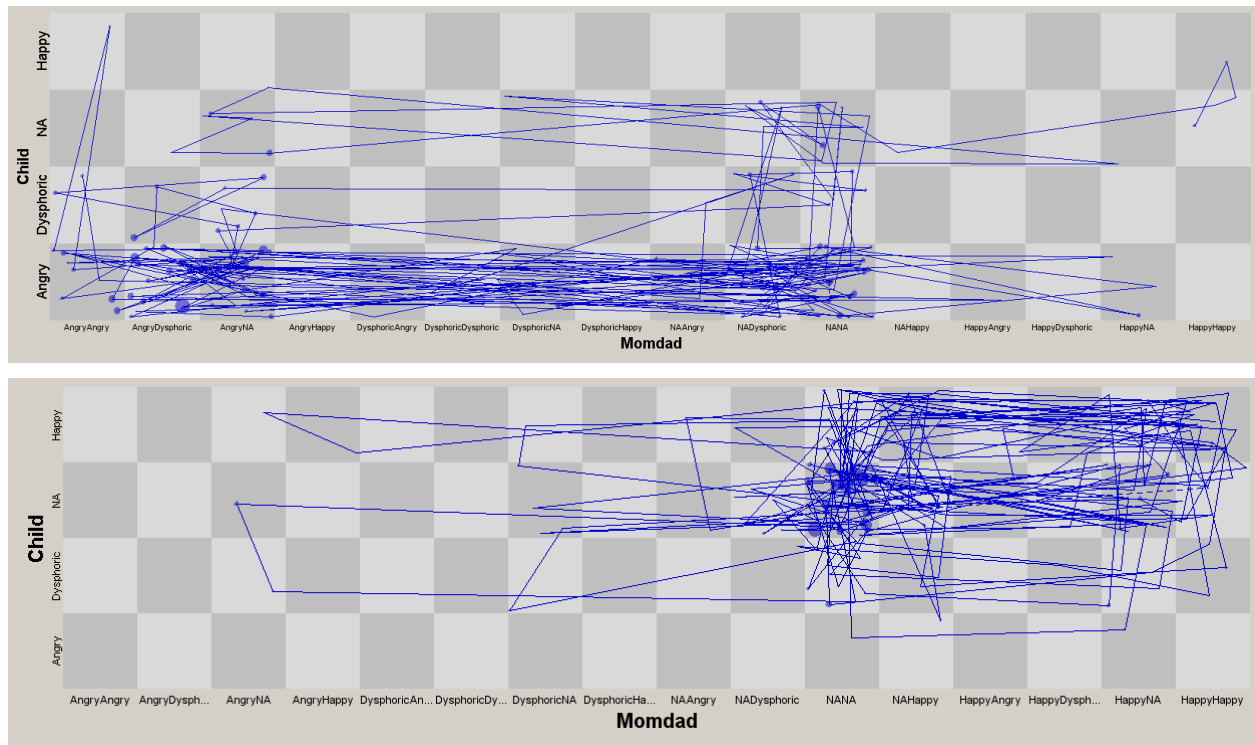
Figure 1. Two Example Triadic State Space Grids. The grid on the top is from the interaction of family with an adolescent who frequently expressed Angry affect. The grid on the bottom is from a triad with a high degree of Happy affect. Labels on the x-axis depicting the parents' affect are identified by the mother's affect then the fathers' affect. Hence, "DysphoricAngry" pertains to a state in which the mother was dysphoric and the father was angry.
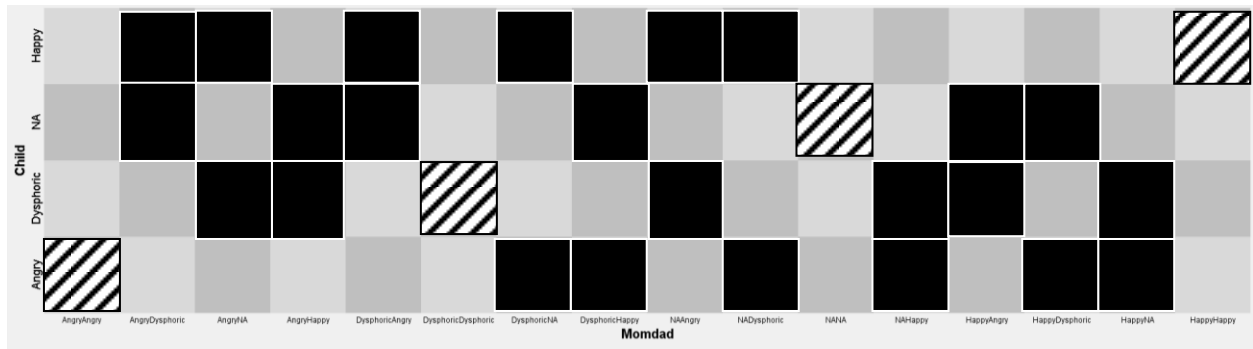
Figure 2. State space grid cells included in the Discrepancy Region (black cells) and Matching Region (stripped cells).
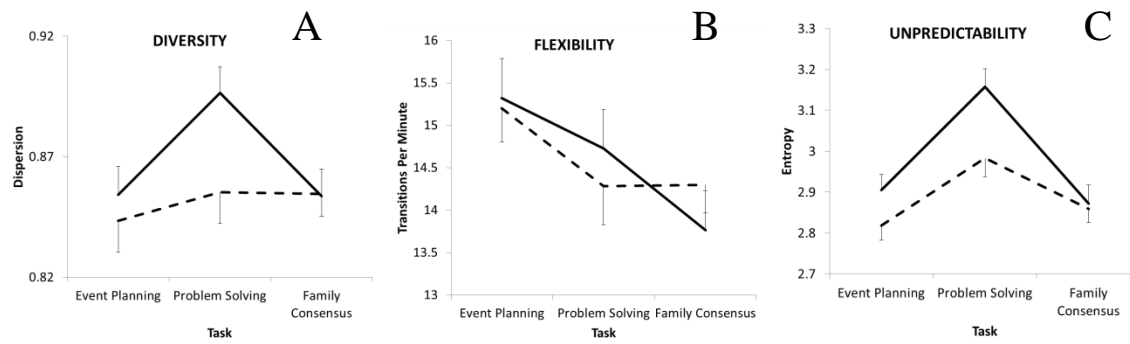
Figure 3. Triadic Diversity, Flexibility, and Predictability across the Three Discussions by Depression Group. In each graph, the depressed group is plotted in solid lines and the control group in dashed lines. Panel A shows the pattern for Diversity; Panel B shows the pattern for Flexibility; Panel C shows the pattern for Unpredictability.
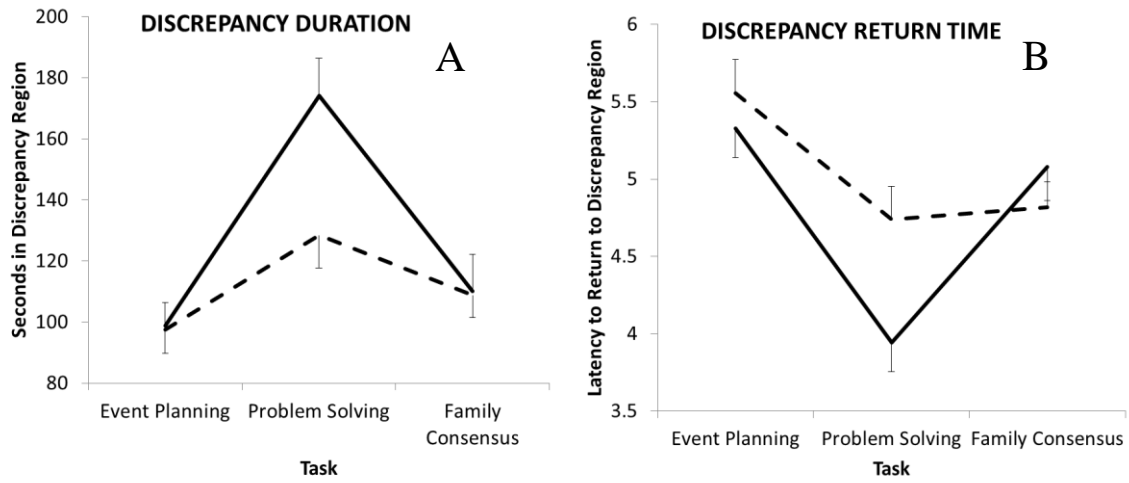
Figure 4. Duration and Return Time in Discrepancy Region across Discussions. In each graph, the depressed group is plotted in solid lines and the control group in dashed lines. Panel A shows the pattern for duration; Panel B shows the pattern for return time.
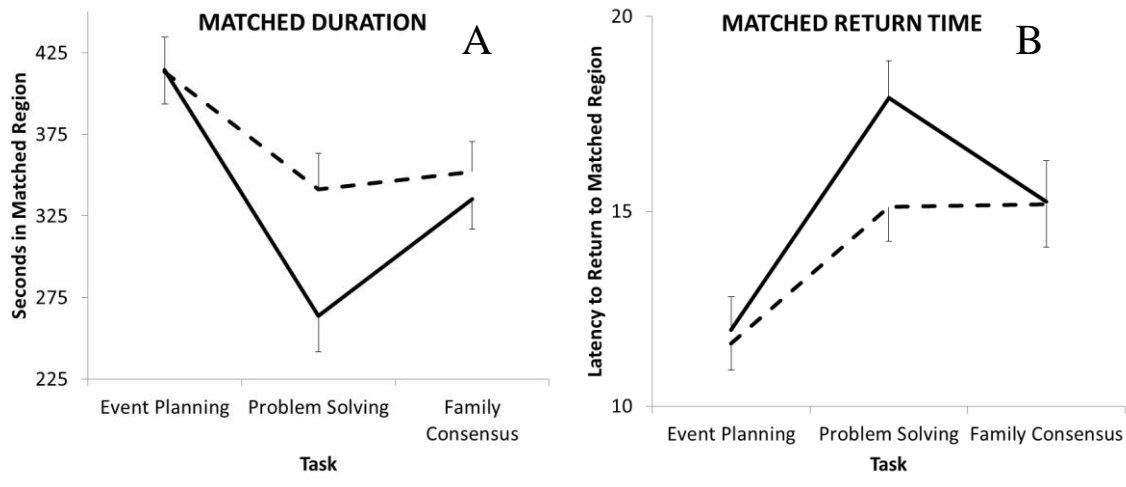
Figure 5. Duration and Return Time in Matching Region across Discussions. In each graph, the depressed group is plotted in solid lines and the control group in dashed lines. Panel A shows the pattern for duration; Panel B shows the pattern for return time.