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Flexibility in Parent-Child Interactions: The Application of Dynamic Systems Methodology to Dyadic Processes in Children with Behaviour Problems

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A thesis submitted in partial fulfillment of the requirements for the degree in Doctor of Philosophy

Flexibility in Parent-Child Interactions: The Application of Dynamic Systems Methodology to Dyadic Processes in Children with Behaviour Problems

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Abstract

Dynamic systems theory (DST) can provide a comprehensive account for how parent-child interactions evolve over time to produce stable patterns of interacting and can result in seemingly divergent trajectories. Recent methodological advances using state space grids (SSGs) have provided a graphical means to examine real-time dyadic processes, as well as measures of dyadic *flexibility*, or the ability to adapt emotional and behavioural responding in response to contextual demands. Higher levels of dyadic flexibility have been associated with improvements in child behaviour problems after treatment (Granic et al., 2007), while its converse, rigidity, has been associated with increases in behaviour problems over time (Hollenstein et al., 2004). The type of task (e.g., structured versus unstructured) in which the dyad is engaged may also impact the relative importance of dyadic and parental characteristics (e.g., warmth) on the interaction. The present study examined parent-child interactions involving clinically-referred children ages 3 years, 11 months, to 6 years of age with externalizing behaviour problems (*n*=33 dyads). Flexibility variables as identified in previous research were examined across task types using principal components analyses and a multiple discriminant function analysis, resulting in a standardized flexibility composite. Similarly, dyadic processes identified from SSGs were replicated and examined across tasks using a repeated-measures ANCOVA. Next, the differential prediction of dyadic flexibility by dyadic processes and parental characteristics across task types was examined using regression analyses. Finally, subgroups of children with behaviour problems were examined for differences in dyadic processes across tasks. Generally, positive parenting characteristics tended to vary more across tasks relative to negative parenting processes. Predictors of flexibility by dyadic processes and parental characteristics tended to differ by task type, illustrating the importance of looking at the demands of the task and changing contexts. Somewhat counterintuitively, negative dyadic and parental variables were found to predict flexibility, possibly reflecting a transitional reorganization of dyadic interaction processes in the preschool period. Synchronous parent-child interactions did not tend to predict flexibility. Dyadic flexibility and the differential impact of parental and dyadic processes across different task types appear promising as potential targets in early intervention programs for children with behaviour problems.

Keywords: parent-child interactions, dynamic systems, flexibility, externalizing behaviour, aggression, play, scaffolding, warmth, sensitivity, emotional development, socioemotional development

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It is normative for young children to display externalizing behaviours in early childhood. When looking at two children from apparently similar circumstances, what factors contribute to one child to 'growing out' of such behaviours, while the other child continues along a trajectory of behaviour problems? One factor that may increase the tendency to develop and maintain maladaptive behaviours is the relationship between the child and his or her primary caregiver(s) in early childhood. *Dynamic systems theory (DST)* provides one framework within which to examine how individual and dyadic processes develop and emerge into stable phenomena. Until children enter school, they typically spend the vast majority of their time with their parents. Within the parent-child relationship, children learn how to negotiate increasingly complex emotions and perceptions, as well as conflict between their own and other people's needs and desires. One result of the numerous parent-child interactions throughout development may be that parent-child dyads come to default into specific stable patterns of interacting that come to form the template and expectations children hold for interpersonal interactions. As children increasingly interact with peers and other adults, they may bring such expectations and biases into other interpersonal interactions, further reinforcing and potentially amplifying maladaptive interpersonal processes. For example, if a child has not learned to adequately modulate strong emotional arousal, he or she may experience rejection by peers, which could lead to further distress and emotion dysregulation.

A characteristic that has been examined relatively little is the level of *flexibility* within a relationship, or the ability of two people in an interaction to adapt to the contextual demands of changing situations, and adjust their emotional responding and behaviours accordingly. The expression of negative emotions may not be problematic per se as children learn how to appropriately express negative affect and negotiate conflict; what may be more problematic in an interpersonal interaction is a lack of flexibility in the interaction. Methodology derived from dynamic systems theory has been increasingly applied in recent years to the study of interpersonal interactions and provides measurements of flexibility in dyadic interactions. The present study examined which parental characteristics and dyadic processes tended to predict dyadic flexibility goals in a sample of young children with clinical behaviour problems, and whether these predictors varied according to changing contextual demands of each task type.

Externalizing Behaviours

Externalizing problems in children can have significant and long-lasting impacts on their social and emotional development. Many young children under the age of 5 years display some level of behaviour difficulties; however, those children displaying clinical-level behaviours above the norm at such a young age may be beginning on a trajectory of chronic behaviour problems. The preschool years appear to be a critical time as the aggressive behaviour problems that emerge and become stabilized in the preschool years are highly predictive of antisocial behaviours in later childhood, adolescence, and adulthood (Bégin, 2004; Campbell, Shaw, & Gilliom, 2000; Tremblay & LeMarquand, 2001). Early aggressive tendencies in children tend to crystallize around age 8 years without intervention (Eron, 1990). The risk seems especially acute in high-risk, low-socioeconomic status (SES) populations, with rates as high as 35% for Oppositional Defiant Disorder and/or Conduct Disorder (Webster-Stratton & Hammond, 1998). Societal costs of aggression and delinquency are significant. One study of four low-SES communities in the US found that public costs related to Conduct Disorder per child exceeded $70,000 over a seven-year period (ages 7 through 13 years) compared to youth with no diagnosis (Foster, Jones, & The Conduct Problems Prevention Research Group, 2005). The need to prevent and treat children's externalizing behaviours early is paramount in terms of both societal costs and distress of individuals who suffer from or are victimized by aggression and delinquency.

It has long been observed that parent-child interactions can be dysfunctional in families with children with behaviour problems; however, the maladaptive processes that contribute to the maintenance of behaviour problems have been relatively understudied. Interactional problems experienced with parents will affect children's relationships with peers and teachers when they enter school (Pepler, 2003). Empirically-supported interventions exist for the treatment of childhood behaviour problems (e.g., Triple P parenting program; Webster-Stratton et al., 2001), yet a high proportion of families with behaviourally-disordered children do not receive, participate in, or benefit from existing treatments. Less than 10% of school-aged children and fewer preschool-aged children who need intervention for aggressive behaviours receive them (Kazdin & Kendall, 1998), and less than half of those children who access such services receive empirically-validated interventions (Chambless & Hollon, 1998). In addition, relatively little is known about whether interaction processes differ in subgroups of children with behaviour problems. One study found differences in parent-child processes between children with externalizing problems and children with both externalizing and internalizing behaviour problems, but only when a stressor was introduced (Granic & Lamey, 2002).

Studies have shown that parental training is the single most effective treatment for reducing aggression in children ages 2 through 5 years, and can prevent the entrenchment of patterns and cycle of aggressive interactions with peers in the school years (Webster-Stratton, 2003). However, the majority of intervention programs for aggression have been developed for children in elementary school and adolescence, when treatment can be difficult and costly (Bégin, 2004; Webster-Stratton, 2003). The early childhood years are a crucial time for the development of emotion regulation and interpersonal skills, and typically, the primary caregiver is the predominant influence. It can be puzzling that, while externalizing behaviours can characterize a normal pattern of development in early childhood, some children continue to manifest behavioural difficulties and may develop chronic aggressive tendencies. Dynamic systems theory (DST) provides one mechanism through which to analyze dyadic interactions at a microscopic level and examine how such processes unfold, accumulating over time into the emergence of stable patterns of interactions. A fundamental assumption in DST is sensitivity to initial conditions: that two points that start off as close together can amplify and become exponentially farther away from each other through repeated interactions (Guastello & Liebovitch, 2009). Thus, DST can help to provide an explanation for how one child may develop significant behavioural difficulties over time, while another child with an apparently similar profile in infancy and early childhood "grows out" of developmentally normal externalizing behaviours.

Dynamic Systems Theory

A dynamic system is a complex, self-organizing system within which its components can affect and modify its trajectory over time. The term, dynamic, emphasizes systems that change constantly over time, yet result in the emergence of relatively stable patterns. Dynamic systems theory is based on chaos theory, or the idea that very small differences in a system's starting conditions can result in a confluence of effects from which apparently new forms may emerge (i.e., emergent phenomena). 'Chaos' in DST refers to patterns that appear to be extremely disorderly and random, but in fact show a stable, underlying order (Thelen & Smith, 1994). Van Geert (2003) identified the most important feature of chaos as the ability to emerge spontaneously as certain variables that control the behaviours of simple, orderly systems cross a specific threshold value. Chaos theorists have shown that randomness and chaotic variation does not need to come from outside the system: chaos can be produced by the system itself if conditions are right (Shinbrot, Grebogi, Yorke, & Ott, 1993; van Geert, 2003). Of particular interest to dynamic systems theorists is how complex systems, including developing humans, produce patterns that evolve in time (Thelen & Smith, 1994).

A dynamic system changes because it is affected by other systems (i.e., environment), as well as by itself (i.e., self-organizing). The notion of chaos represents a divergence from the traditional psychological focus on linear processes of change. Dynamic systems theory can thus provide a set of conceptual, mathematical, and methodological tools by which complex, self-organizing processes can be described, explored, and studied (van Geert, 2003). There are a number of tenets in DST that make it particularly relevant to the study of developmental systems. The two tenets that are most central to the present study include attractors and phase transitions.

Attractors. Although dynamic systems theoretically have the potential to exhibit a huge number of behavioural patterns, they tend to stabilize within a small number of possibilities. Components of a system are consistently drawn into, or 'default' into certain patterns of interacting (i.e., attractors). Thus, a parent-child dyad which frequently argues and fails to effectively resolve conflict may come to quickly default into arguments in most instances in which potential conflict is perceived, and require a major 'push', or perturbation, to change such attractor patterns. Conversely, systems have patterns or states that they tend to avoid (i.e., repellors). Some attractor states are so stable that they look almost intrinsic; yet, even though they may require very large perturbations to move them from their preferred positions, they are still dynamic and malleable (Thelen & Smith, 1994). Many apparently permanent patterns in behaviour, cognition, and interactions may be considered to be "stable attractors whose stability limits may indeed be shifted under appropriate circumstances" (Thelen & Smith, 1994; p.61).

Phase transitions. Phase transitions consist of global reorganizations in the pattern of interacting system elements (Granic, Hollenstein, Dishion, & Patterson, 2003). Destabilization of the dynamic system results in a period of discontinuous increase in the behavioural variability of a system that then settles down as the system re-stabilizes, and is thus characterized by interrelated changes in real and developmental time (Granic et al., 2003). Stable dynamic systems are likely to show increased variability as they approach such transition points, and as they shift into new stable patterns, variability should once again decrease (Thelen & Smith, 1994). Thus, while variability is often considered a 'nuisance variable' in traditional statistical analyses, DST views such variability as adding crucial information in its own right, as it may signal that the system is transitioning to new patterns (de Weerth, van Geert, & Hoijtink, 1999). Within-system variability might be a necessary precondition for adaptation and learning: without variability, no exploration can take place and the system's ability to create new pathways and patterns is undermined (Lichtwarck-Aschoff, Kunnen, & van Geert, 2009). Clinically, the identification of phase transitions in child development may point to more effective periods to target intervention. If a parent-child dyad is going through a period of increased variability in how they interact with one another before renegotiating new modes of interacting, they may be more malleable to the introduction of strategies through intervention.

Psychology researchers have expressed interest in the application of dynamic systems to the study of psychological phenomena for a number of years. Staddon (1984) noted that even very simple systems can behave in unexpectedly complex ways and advocated for the generation of dynamic models for studying social interactions. Neufeld (1999) argued for the consideration of dynamic systems when examining the temporal unfolding of behaviours within individuals. Studies of intra-individual processes have shown that greater 'chaos' or variability and unpredictability in mood fluctuations characterized the mood states of individuals with no depression as compared to individuals with depression (Heath, Heiby, & Pagano, 2007) and bipolar disorder (Gottschalk, Bauer, & Whybrow, 1995).

Thelen and Smith (1994) were one of the first researchers to apply dynamic systems principles to developmental psychology. They delineated how, through important relationships involving developing children, coherent patterns can emerge over time that could not have been predicted on the basis of its individual components.

> What started out as an aggregation of…individual parts…with no particular or privileged relations may suddenly produce patterns in space and regularities in time…These emergent organizations are totally different from the elements that constitute the system, and the patterns cannot be predicted solely from the characteristics of the individual elements. (p. 54)

In the years since Thelen and Smith's (1994) original publication, dynamic systems have begun to be applied to several areas of developmental psychology, including motor development (e.g., Corbetta & Thelen, 1996), cognitive development (e.g., Spencer, Simmering, Schutte, & Schöner, 2007), and socioemotional development (e.g., Lewis et al., 1999).

Relevance of Dynamic Systems to Developmental Psychopathology

Human development implies increasing complexity, structure, and order (van Geert, 2003). Yet, developmental psychologists have historically examined development retrospectively, thinking about developmental processes from the perspective of the end state, thus viewing preceding states in light of that end state. Most children in Western society are raised in an interpersonal environment with at least one primary caregiver, with whom they spend the majority of time until they enter school. The constant and frequent interplay between a child and his or her primary caregiver, particularly during early childhood, can set into motion seemingly small changes in that dyad's trajectory that can gradually accumulate and eventually result in an outcome that differs from that of another parent-child dyad. Consequently, a parent-child dyad can be considered a complex, dynamic system.

Throughout infancy and early childhood, affective exchanges with the caregivers can help to regulate changes in the infant's physiological and emotional states (Schore, 1994). These types of parallel and reciprocal interactions involve the adaptation of behaviours and emotions to one another, creating a dynamical system of contingent and mutual responsivity (Schore, 1994). If an infant does not have an adequate experience of being part of a dynamic system with an emotionally responsive caregiver, the infant may develop poor coping abilities to deal with the stressful chaotic dynamics that exist in many interpersonal relationships (Feldman, Greenbaum, & Yirmiya, 1999; Schore, 2000; Wright, 1991).

Three principles have been identified as being central to the dynamic systems framework, particularly as it pertains to developmental psychology (Granic, 2005; Granic et al., 2003). The hallmark principle is the *discontinuous* nature of change in developmental systems. A historical argument in developmental psychology concerns whether the nature of developmental change is continuous or qualitative. Dynamic systems theory can account for both types of change in that the constant fluctuations in the dyadic system can accumulate to such a point that an apparently new state emerges (Granic, 2005). Coping strategies that have become incompatible with current goals and contexts have to be replaced with new coping strategies that not just modify, but replace the old ones, at least in a given context (Lewis, Lewis, Zimmerman, Hollenstein, &

Lamey, 2004). The second principle is that *variability* represents critical data, not simply error variance, as it may indicate that the dynamic system is nearing a transition point. Measurements of variability in dynamic systems are often considered "the signal, not the noise" (e.g., Ford & Lerner, 1992; Thelen & Ulrich, 1991). The third principle relevant to the study of interpersonal processes is that DST is fundamentally concerned with the interrelations between the time scales of development, and a large focus is on understanding the changing patterns of *real-time* behaviour as they are related to broader changes in developmental patterns (Granic et al., 2003). When studying development in real-time, one can observe 'default' socioemotional behaviour and interactions emerge in seconds, as children and parents fall into one of the habits in their repertoire. Then, over developmental time, one can see habits emerging and consolidating while others fade, as individuals and dyads self-organize with age.

Dynamic Systems Methodology

Researchers in the developmental psychopathology field have increasingly espoused the advantages of taking a systems-level approach to the study of child and family dysfunction. Interaction paradigms may be particularly useful in assessing caregiving quality, particularly for developmental periods after infancy (Allen & Land, 1999; Crowell, O'Connor, Wollmers, Sprafkin, & Rao, 2002; Kobak et al., 1993). A methodological contribution of DST is the construction of *state space grids* (SSG; Lewis et al., 1999), which plot the dyad's behavioural trajectory (i.e., sequence of behavioural states) as it proceeds in real time (Granic et al., 2003). Each axis represents a member of the dyad, and each point on the grid represents a two-event sequence (i.e., a dyadic state). Unlike traditional statistical approaches, such as sequential analyses or growth curve modelling, information can be represented and analyzed at a dyadic system level (Granic et al., 2003). For example, Lewis and colleagues (1999) have argued that sequential analyses may not be appropriate when studying the clustering or 'pooling' of behaviour or the tendency for behaviour to move from one given state to particular target states, rather than the sequential path by which some events lead to others. Another advantage over traditional statistical methods is that SSGs are designed to measure qualitative patterns of dyadic interactions (Granic et al., 2003). Not only do SSGs provide a visually intuitive way of understanding the interaction, they also can be used to categorize interactions in order to perform more traditional statistical analyses with the data. For example, researchers have used SSGs to examine parent-child interactions by further classifying the coded behaviours into categories such as: positive, neutral, negative, hostile. By looking at the location of behaviours on a SSG, one can examine the content of emotional communication, while the pattern of movements across SSGs provides information about the dynamic processes of the interaction, such as dyadic flexibility (Hollenstein & Lewis, 2006).

Flexibility. The ability to shift from one emotional state to another according to contextual demands is referred to as *flexibility*, and is considered to be important to effective perspective-taking and emotion regulation (Granic, O'Hara, Pepler, & Lewis, 2007). Conversely, *rigidity* in an interaction may interfere with individual's ability to accurately perceive the situation and adjust behaviour according to changing demands and the behaviour of the other person. Rigidity, whether behaviourally, cognitively, or emotionally, has been implicated in a variety of disorders and biases, such as hostile attributional biases (i.e., attributing hostile intent to ambiguous acts by others; Crick &

Dodge, 1994; Weiss, Dodge, Bates, & Pettit, 1992) and anxiety disorders (Barrett, Rapee, Dadds, & Ryan, 1996; Shortt, Barrett, Dadds, & Fox, 2001). What may be common to these dysfunctions is a tendency to respond to environmental change in a rigid manner, a limited behavioural repertoire, an inability to adapt effectively to environmental changes, and a tendency to perseverate (Hollenstein, Granic, Stoolmiller, & Snyder, 2004). The inability to transition from one task to another and to experience a broad array of emotional states in dyadic interactions can be problematic, even if negative emotions are not involved (Hollenstein et al., 2004). Granic (2006) has hypothesized that rigidity may be a general feature of the state space of individuals or families experiencing psychopathology, regardless of the specific attractors, or specific emotions or behaviours. Since the content of behaviour of children without behaviour problems is often similar to that of children with clinical problems (e.g., anxiety, aggression, anger). Granic (2006) surmised that the differentiating factor may be the extent to which one can flexibly navigate in and out of negative states. For example, if parents do not respond to extended periods of high emotional arousal in their children with a range of down-regulatory responses, even if the arousal involves positive emotions, the dyad will not move through a varied number of dyadic states. This may leave children with an inability to adapt well to shifting environmental demands (Hollenstein et al., 2004). Several measures of flexibility and rigidity have been identified:

(1) *Transitions*, or the number of movements between cells on a SSG. A greater number of movements, or transitions, indicates higher flexibility. In contrast, a lower number of transitions indicates a limited capacity to switch among behaviours in response to changes in the environment.

(2) *Dispersion*, or the sum of squared proportional durations across all cells, corrected for the number of cells and inverted. Higher values indicate greater flexibility. A lower value indicates a diminished behavioural repertoire.

(3) *Average Mean Duration (AMD)*, or the mean duration of each behavioural 'event'. A lower duration (of each event) indicates greater flexibility since the dyad is not getting 'stuck' in a behaviour. In contrast, a higher duration indicates a tendency to perseverate in any particular behaviour.

(4) *Total Number of Unique Cells (TUC)*, or the number of cells on the SSG the dyad entered at least once during the interaction. A higher number indicates greater flexibility.

Table 1 lists the studies that have used SSGs to measure flexibility in dyadic interactions and the combination of variables that comprised each Flexibility construct. A group of developmental psychology researchers have devised a computer program, *GridWare* (Lamey, Hollenstein, Lewis, & Granic, 2004), that not only generates SSGs with inputted dyadic data, but also extracts numerical values for the flexibility variables listed above.

Application of the Dynamic Systems Approach to Developmental Psychopathology

Until relatively recently, the possible application of dynamic systems models to psychological research was intriguing, but remained methodologically difficult. Dynamic systems theory is a mathematical concept consisting of abstract terms and mathematical equations which had been difficult to translate into the social sciences. Marc Lewis and his colleagues were among the first psychology researchers to

Table 1

Flexibility Variables Identified in Previous Research

Flexibility Measure	Study	Other Variables in Flexibility Construct
Transitions	Granic, Hollenstein, Dishion, & Patterson (2003)	TUC
	Granic, O'Hara, Pepler, & Lewis (2007)	AMD; Disp
	Hollenstein, Granic, Stoolmiller, & Snyder (2004)	AMD
	Hollenstein & Lewis (2006)	Disp
Average Mean Duration	Granic, O'Hara, Pepler, & Lewis (2007)	Trans; Disp
	Hollenstein, Granic, Stoolmiller, & Snyder (2004)	Trans
Dispersion	Granic, O'Hara, Pepler, & Lewis (2007)	Trans; AMD
	Hollenstein & Lewis (2006)	Trans
Unique Cells	Granic, Hollenstein, Dishion, & Patterson (2003)	Trans
	Hollenstein, Granic, Stoolmiller, & Snyder (2004)	*dropped due to reducing reliability

incorporate DST into their study of socioemotional development processes, and devised methods to examine dynamic systems and dyadic processes. Lewis and his colleagues (1999) first applied DST methodology to the study of socioemotional development in infants, theorizing that socioemotional behaviour and the underlying psychological states should self-organize in interpersonal situations, converging to one or more attractor states. The researchers constructed intra-individual SSGs for changes in infants' facial expressions (e.g., distress) and direction of eye gaze (i.e., attention) during separation and reunion sequences with their mothers. Lewis and his colleagues found that the infants' distress and attention (i.e., attractor states) stabilized more quickly at 26 to 28 weeks than at 10 to 12 weeks, suggesting that self-organization becomes more coherent and cohesive with development. Consistent with Thelen and Smith (1994), Lewis and colleagues concluded that increasing attractor strength is one sign of skill development. Lewis et al. were some of the first developmental psychology researchers to devise a visually intuitive method to examine a real-time process through SSGs.

Flexibility and rigidity. A major advantage of SSG methodology is the ability to measure flexibility in individual or dyadic systems. Lewis and his colleagues have examined flexibility and rigidity in parent-child interactions in a number of different age groups, from infancy through adolescence. One longitudinal study examined behavioural rigidity in parent-child interactions at four time points: from early kindergarten to the end of the first grade in boys and girls at high-risk for developing externalizing behaviour problems (Hollenstein et al., 2004). Rigidity was associated with externalizing behaviours at all time points. Children who showed consistently high levels of externalizing and/or internalizing difficulties, and children who did not have high levels at time 1 but developed high levels of externalizing behaviours two years later had parent-child interactions with greater levels of rigidity. Conversely, children who were rated high on externalizing behaviours but whose interactions did not show high levels of rigidity at time 1 no longer exhibited externalizing difficulties at the end of the first-grade. Thus, Hollenstein and his colleagues concluded that the decreased ability of parent-child dyads to adapt to changes in the environment was associated with chronically high externalizing and internalizing difficulties, as well as the development of later behaviour problems.

Another longitudinal study that examined changes in the structure of dyadic interactions over time followed boys in a high-risk community sample at five time points from ages 9 or 10 years through 18 years (Granic et al., 2003). Using SSGs, the researchers found that dyadic interactions showed the greatest variability at the 13- to 14-year age range. Granic and her colleagues concluded that this increase in variability reflected a phase transition, or a reorganization of the structure of the parent-child interaction. That is, these researchers argued that parents and their early adolescent boys in this sample underwent a phase in which their old modes of relating to one another were no longer adaptive and had to negotiate new ways of effectively interacting with each other. Granic et al. argued that this variability did not simply reflect higher levels of conflict at that age as their longitudinal analyses revealed that dyads showed the most conflict at the next time point (i.e., 15 to 16 years).

Hollenstein and Lewis (2006) used SSGs to examine flexibility in mother and daughter (11- to 12-years) dyads during conflict discussions, and found that interpersonal flexibility was lowest when negative emotion was heightened. Interestingly, they also found that girls who reported more stressful life events and showed less negative emotion overall, displayed greater flexibility during conflict discussions even while expressing more negative emotions. Hollenstein and Lewis interpreted this latter finding as indicating that the expression of negative emotions during dyadic interactions is not necessarily a detriment; rather, it is the lack of flexibility in thinking and negotiating that can result in greater distress.

An advantage of examining parent-child interaction processes is the ability to target interventions, which typically may be administered in a similar fashion across families. Rather than a sole focus on interaction content (e.g., mutual negative engagement), it may be more beneficial to focus on more global processes, such as increasing flexibility in interpersonal interactions. Granic and colleagues (2007) view real-time parent-child interactions as the "proximal engines of development" (p.846), and therefore hypothesized that, if antisocial behaviours emerge out of moment-to-moment, day-to-day direct experiences, then these interactions must also be the context through which outcomes change. But they pointed out that it remains unclear which components of the interaction change when children become less aggressive. Using SSGs, Granic et al. (2007) found that improvements in behavioural problems after treatment were associated with increased flexibility. They examined children with aggression problems ages 7 through 11 years of age who received empirically-supported treatments and either improved or did not improve in terms of symptomatology. The researchers identified dyadic processes of: Mutual Positivity; Mutual Hostility; Mother Attack (i.e., mother shows contempt or anger while child shows affection, joy, interest, neutral, anxiety, or sadness); and Permissiveness (i.e., mother shows interest, joy, or affection while child displays whining, anger, or contempt). After 12 weeks of treatment, improvements in externalizing symptoms were associated with increases in parent-child emotional flexibility during problem-solving discussions as the dyads acquired the skills to repair conflicts. That is, dyads were still able to express negative emotion, but were better able after treatment to shift out of negative interactions to mutually positive patterns. Families that participated in treatment but did not improve became *more* rigid after intervention. The results of this study highlight one process through which intervention can successfully reduce problem child behaviours: via increasing the flexibility of the parent-child interaction. Therefore, it would benefit intervention research to shift from a focus on pre- to post-treatment outcomes to examining the mechanisms through which change occurs.

Differentiating clinical subgroups. While few researchers have examined differences between children with externalizing behaviour and children with both externalizing and internalizing difficulties, one study was able to differentiate the two groups based on their interactional processes with their parents, suggesting that different processes may need to be targeted in subgroups of children (Granic & Lamey, 2002). Granic and Lamey asked parent-child dyads involving boys with clinical behaviour problems (ages 8 to 12 years) to discuss a moderately conflictual problem, after which time a stressor was introduced. They used SSGs to identify the processes of Mutually Hostile (i.e., both child and parent hostile) and Permissiveness (i.e., child hostile and parent neutral or positive). Granic and Lamey found that the parent-child interaction between dyads involving externalizing-only difficulties as compared to children with both externalizing and internalizing problems (i.e., “mixed”) appeared similar during a relatively low-stress task, but diverged upon the introduction of a stressor. Whereas parents in both groups showed a permissive pattern during the first task, the parents of children with mixed psychopathology shifted to a mutually hostile pattern, while the externalizing-only group continued their permissive pattern. Thus, while parents in both externalizing subgroups demonstrated a pattern of responding indiscriminately to children's noncompliance when not stressed, when mothers of children with mixed psychopathology became stressed, they exhibited hostility. As children are often unaware of parental stress, Granic and Lamey theorized that this tendency by parents to default to hostility when stressed may be perceived by the child as unpredictable. They also argued that individual differences are best viewed under stressful conditions, and that, by increasing arousal levels, participants may rely on overlearned and automatic response patterns that have stabilized over development across similarly repeated episodes.

Foundational principles of dynamic systems theory such as attractor states, phase transitions, and self-organization (i.e., emergence of increasingly stable phenomena) appear to have particular relevance for developing humans, both intra-individually and interpersonally. It is now possible to examine real-time interactions between two individuals and visually 'map out' the trajectory of the dyad throughout an interaction. As children and their primary caregivers typically interact constantly and frequently throughout their daily lives, the ability to examine real-time interactions and how they shape a child's emotional and social development delineates a process that has traditionally relied on retrospective measures which, although they may adequately assess the content of interpersonal processes, can fail to capture processes within dyadic interactions. The focus in the previous studies using SSGs has been primarily on dyadic interactions involving potential conflict in order to increase the number of opportunities to examine negative parent-child processes and how dyads resolve conflict. Primary caregivers play a crucial role in helping children to navigate both positive and negative emotions, and certain types of tasks are likely to give rise to different emotions. The type of task in which the dyad is engaged may be expected to impact the nature of the parent-child interaction as the demands of the task change.

Dyadic Nature of Parent-Child Interactions

Children learn to integrate complex nonverbal emotional experiences with emerging verbal communication through environmental input, such as parental scaffolding, that fosters the appropriate integration of language and emotional processes (Cole, Armstrong, & Pemberton, 2010). One developmental task involves learning to modulate, tolerate, and endure experiences of negative affect (Kopp, 1989). Children can benefit from negative emotion experiences (Demos, 1986) because psychological discomfort serves as a "catalyst to move the immature human to adaptive emotion regulation in the service of physiological and psychological well-being" (Kopp, 1989; p.343). Securely attached four-year-old children have been found to score higher on measures of negative emotion understanding (i.e., understanding and explaining the causes of others' negative feelings) than insecurely attached children, but did not show differences on an index of positive emotion understanding (Laible & Thompson, 1998). Therefore, it appears that it is not the expression or discussion of negative emotions that can be detrimental to relationships; rather it is how one thinks about and handles negative emotions. There are a multitude of interaction types that parents and children can engage in with somewhat different skills and purposes involved that can help children to attain importance developmental skills.

Different types of situations in which a parent and child are interacting are expected to make certain characteristics more relevant than in other situations (Tamis-LeMonda, Užgiris, & Bornstein, 2002). *Warmth* refers to parents' expressions of affection and respect toward their children, while *sensitivity* typically refers to parents' attunement to their children's cues, emotions, interests, and capabilities in ways that balance children's needs for support with their needs for autonomy (Lugo-Gil & Tamis-LeMonda, 2008). Conversely, parents who exhibit low levels of these positive characteristics often have children who exhibit a variety of psychological and school adjustment problems (McFayden-Ketchum, Bates, Dodge, & Pettit, 1996; Mize & Pettit, 1997). Children of warm parents are thought to find interpersonal interactions to be more rewarding than children with parents expressing low levels of warmth, and they should be more motivated to socialize with peers as they have come to expect social exchanges to be pleasurable (MacDonald, 1992). Warmth and sensitivity also appear to foster cooperation in children, and encourage them to consider other people's feelings and regulate negative emotions in social interactions (Campbell, 2002; Denham et al., 2000; Eisenberg & Fabes, 1998; Olson, Sameroff, Kerr, Lopez, & Wellman, 2005; Pettit, Laird, Dodge, Bates, & Cross, 2001). Parental displays of positive regard, as well as the setting of clear limits and/or expectations, have been shown to predict lower levels of externalizing behaviours over time, even after controlling for initial levels of externalizing problems (Collins, Maccoby, Steinberg, Hetherington, & Bornstein, 2000). For parents to be effectively attuned to the developmental needs of their children, they require the ability to infer their children's needs, and to have a wide repertoire of childrearing strategies and problem-solving skills in order to discriminate between the situations in which intervention is needed and when it is not (Azar, 2002).

Davidov and Grusec (2006) have hypothesized that parental warmth would strengthen the parent-child bond, but may be somewhat less relevant than responsiveness to emotion regulation. They thought warmth might be displayed more frequently in neutral and positive interactions in which the child is not currently experiencing distress, resulting in fewer instances of modelling how to react to distress. They suggested that parental responsiveness to children's needs, particularly their distress, may be more relevant to emotion regulation because it would help the child learn to cope with, regulate, and appropriately express negative emotions. For example, young children who have a history of receiving empathic and sensitive responses to their distress at 14 months can communicate their own distress more clearly at 24 months (Tonyan, 2005). Similarly, the ability to shift from one emotional state to another according to contextual demands may be essential for a parent to effectively monitor his or her child's level of distress and adjust behaviours and emotion regulation strategies accordingly. Rigidity in an interaction, however, will prevent dyadic partners from being able to perceive the situation accurately and adjust behaviour according to changing demands and the behaviour of the other person. Howe (2004) speculated that the rigidity construct does not reflect some broad, general risk characteristic, but that its effects would depend on the specific nature of the interaction and different influences in each context.

Types of Parent-Child Interactions

Parents and children engage in different types of tasks which tend to make certain characteristics more relevant than in other situations (Tamis-LeMonda et al., 2002). For example, warmth may be more relevant in a free play situation in which the child is exploring and interacting positively with the parent, whereas more structured situations with an objective goal may require parental attunement to signs of distress and negative emotions in the child (Davidov & Grusec, 2006). These latter types of tasks would require more structure and may provide opportunities for frustration and failure on the part of the child. In learning tasks, it is beneficial for parents to teach problem-solving skills and help the child learn to work his or her way through challenges within his or her developmental level (i.e., scaffolding) in a supportive and accepting manner in order for the child to learn and develop mastery and self-competence. Parents can structure the environment and guide problem-solving activities for their infants and young children, who eventually come to adopt these structuring and regulatory activities themselves (Valentino, Cicchetti, Toth, & Rogosch, 2006).

Structured interactions. As children get older, they are typically expected to take increasing responsibility for self-care, everyday tasks, and following rules and routines. The increase in responsibility and delay of gratification are important developmental tasks, but can be distressful at times for children. Young children are also acquiring cognitive and emotional skills at a rapid pace, but require guidance and assistance and will inevitably make errors. The ability of primary caregivers to be sensitive to children's levels of distress, developmental level, and individual differences and adjust their responses accordingly can fundamentally influence the development of their children's emotion regulation. The sensitivity with which caregivers manage children's negative emotions impacts the intensity and duration of these emotions and may influence the development of emotion self-regulation when the child learns that distress is manageable and workable (Thompson & Meyer, 2007). One study observing mothers and their toddlers found that mothers who showed higher levels of interfering behaviours had children who became more distressed during a frustration task, while mothers who offered more support, suggestions, and encouragement had children who utilized problem solving and distraction (Calkins & Johnson, 1998). Repeated interactions with caregivers over time in emotional or stressful contexts teach children that the use of certain strategies may be more useful for the reduction of emotional arousal than other strategies (Sroufe, 1996). Nonresponsive or interfering parent behaviours may lead children to develop maladaptive emotion regulation strategies that could undermine the development of appropriate skills and abilities needed to master later developmental tasks (Cassidy, 1994). As there are more opportunities for conflict to arise in a structured, problem-solving type of task as compared to an unstructured play situation, there is likely an increased probability of witnessing how a dyad copes with negative emotions and distress and how conflict is resolved.

Free play. Play is a quintessential child activity and plays a major role in children's cognitive, social, and emotional development (Pellegrini & Smith, 1998; Valentino et al., 2006). Peterson and Flanders (2005) regard interactive play as a form of early social cognition, in that each individual adapts his or her actions and reactions to the other person. In understanding the other's perspective, the dyad can work cooperatively towards a common goal. Beginning with primary caregivers, children learn to modulate both positive and negative overarousal in interpersonal interactions. Parents' active participation in play has been shown to be especially important to scaffolding children to higher levels of functioning, as parents expand on play themes that are new to children and initiate themes and ways of play that extend their children's cognitive and emotion regulation abilities (Tamis-LeMonda et al., 2002). Pretend play can help the development of social collaboration, understanding of mental states (Hughes & Dunn, 1997), and emotional understanding (Seja & Russ, 1999). Two main types of play have been identified in childhood as being especially relevant to dyadic interactions and development (Tamis-LeMonda et al., 2002), and are detailed below.

Interpersonal play. Beginning in early infancy, caregivers engage in brief, focused episodes of social interaction with their child, responding with animation to maintain the child in a positive emotional state by mirroring the child's positive expressions, and ignoring or responding with surprise to negative emotions (Thompson & Meyer, 2007). These repeated, brief interactions are thought to contribute to the emerging capacities for self-regulation as the child learns how to maintain manageable arousal in the context of supportive or insensitive responses by the caregiver (Feldman, Greenbaum, & Yirmiya, 1999; Gianino & Tronick, 1988; Roggman, 1991).

Object-focused play. The other major type of play in young childhood is object-focused play, in which the focus turns outward towards objects and events (Tamis-LeMonda et al., 2002). Object-focused play provides important opportunities for parent-child interactions including the sharing and extension of emotions as children experience the joys and frustrations of accomplishing and struggling in goal-directed activities. It also provides a context for caregivers to label and interpret children's feelings in response to their emotional expressions (Tamis-LeMonda et al., 2002). Through object-focused play, children can also develop a sense of mastery and self-competence if their parents support their efforts on challenging, structured tasks, are responsive to their initiatives, are accurate in assessing their need for help, and effective in helping them (Tamis-LeMonda et al., 2002).

Play and structured tasks are two of the numerous types of interactions that parent-child dyads engage in. Each task type has characteristics and objectives that are unique to that task, with one major differentiation being unstructured (e.g., play) and structured (e.g., teaching, chores). Researchers have traditionally focused on the effects of the parent's behaviour on the child and, somewhat less frequently, the child's behaviour on the parent. The dyadic nature of the relationship has been examined relatively less. Yet, parent-child synchrony, which captures the reciprocal and responsive nature of the dyad, can have a fundamental impact on the development of self-regulation and empathy across childhood and adolescence (Feldman, 2007). For example, Lindsey, Mize, and Pettit (1997) have argued that parent-child mutuality in play can provide children with an opportunity for mutual regulation and accommodation to one another, eventually leading to more cooperative peer play. What remains unknown, however, is how such patterns in a parent-child relationship evolve over time throughout repeated interactions, and whether these patterns differ with respect to the demands of the situation. Over time, parents and children increasingly fall into a pattern of interacting that becomes unique to the dyad and more than the sum of its two members. In DST terminology, the parent-child relationship emerges as its own self-organizing unit over numerous interactions.

The parent-child relationship has been studied by a multitude of researchers over a number of years. Flexibility in parent-child interactions appears promising as both a research enterprise and has clinical applications. There is also increasing recognition that the importance of dyadic and parental characteristics may differ according to the type of interaction the dyad is engaged in. Parents can assist children to develop emotion regulation skills in interpersonal interactions by helping them to recognize and understand emotions, learn to consider other perspectives, negotiate conflict, and help regulate overarousal. In more structured situations in which children require more guidance, more opportunities exist for frustration on the part of the child as he or she learns to delay gratification and is challenged to learn new skills. In these types of situations, parental sensitivity to signs of distress may be especially important to match his or her level of instruction or discussion to the developmental level of the child, and help him or her learn to manage frustration and other negative emotions.

Early childhood appears to be an optimal time to examine and target maladaptive processes in parent-child interactions. Self-organizing systems are more sensitive to change early in their organization; therefore, the more stable the interaction pattern, the greater the perturbation that is necessary to shift the system's trajectory (Lewis, 2000). This can be considered akin to 'sensitive periods', in which children more easily acquire skills during certain periods than others. While parent-child interactions begin from birth and will have stabilized into certain patterns by early childhood, they have not become as entrenched as later in childhood. When children enter school, maladaptive patterns of relating to others may become reinforced or exacerbated if they experience rejection from peers and teachers. Early childhood is also a time of exponential growth in terms of physical, neurological, cognitive, and emotional development. Targeting changes in dyadic interactions during early childhood may be somewhat easier due to possible increased variability in interpersonal processes.

The Present Study

The relatively recent dynamic systems approach in developmental psychology provides accessible methodology to examine dyadic flexibility and other dyadic processes in 'real-time'. The present study used the *GridWare* program to generate SSGs for each dyad across five different types of tasks, derive measures of flexibility, and identify dyadic processes. Dyads included clinic-referred children with externalizing behaviour problems ages 3 years, 11 months, to 6 years of age, and their mothers. Dynamic systems methodology has been applied to infants, middle childhood, and adolescents, but has been studied relatively little in early childhood. Similarly, DST methodology has been used to examine dyadic processes in children with clinical-level externalizing behaviours, but primarily in middle childhood. Flexibility in parent-child interactions has not yet been compared across different task types, and has mainly been studied in situations designed to provoke conflict. Whether the importance of flexibility may have differential importance in more or less structured situations (e.g., free play versus teaching) remains to be studied. Four measures of flexibility have been identified in previous studies, although all four have not been included in one study. The present study examined the four flexibility variables across task types, to examine whether they varied as task demands fluctuated, and to subsequently derive a 'flexibility' composite. Task types included free play, clean-up, and three types of tasks in which the parent verbally, but not physically, assists the child in completing a task. The various task types were assumed to require the parents' ability to assess and adjust to the contextual demands of changing situations.

In line with previous DST methodology, dyadic processes were identified from the SSGs that provided information not solely on content (e.g., positive, negative), but also the synchrony or asynchrony of parent and child processes (e.g., mutually positive). Four of the five dyadic processes in the present study have been examined in previous research: Mutual Positive Engagement, Mutual Negative Engagement, Permissiveness (i.e., parent engages in positive behaviour while child behaves negatively), and Parent Attack (i.e., parent acts negatively while child engages in positive, neutral, or structuring behaviours). A fifth dyadic interaction area, Scaffolding was included in the present study. Thus, a second purpose of the present study was to examine how dyadic processes varied across tasks. It was expected that mutual positive engagement would be higher during the free play task, while scaffolding would be higher in the teaching tasks. Negative dyadic processes were expected to increase during the more structured clean-up and teaching tasks.

Researchers have not yet examined characteristics that predict dyadic flexibility. The third objective of the present study was to examine how parental characteristics and dyadic processes differentially predicted dyadic flexibility across tasks. Specifically, parental warmth, sensitivity, and hostility as rated by independent observers were examined as potential predictors, along with dyadic processes. Scaffolding, parental sensitivity, and parental warmth were expected to positively predict flexibility, while parent attack and parental hostility were hypothesized to negatively predict flexibility.

Finally, subgroups of children with behaviour problems were examined to assess whether children with 'externalizing-only' behaviour and children with both externalizing and internalizing difficulties (i.e., 'mixed' symptomatology) differed in levels of flexibility and dyadic processes across task types. The identification of differences between externalizing subgroups can be clinically relevant because therapeutic interventions are often delivered to families despite a lack of knowledge on whether different underlying processes contribute to the development and/or maintenance of difficulties. An interaction between group and task types was predicted, such that the 'mixed' dyads would show greater parent attack and parental hostility during the more structured tasks because these goal-oriented tasks were thought to increase perceived stress on the parents, similar to Granic and Lamey's (2002) introduction of a stressor to the parent-child interaction.

The identification of parental characteristics and dyadic processes that promote adaptive parent-child processes such as dyadic flexibility can help illuminate avenues for further research and potential targets for intervention with children with externalizing behaviour problems. The present study used dynamic systems methodology to assess dyadic processes, including flexibility, and examined how they differed across tasks with varying demands. In exploring how flexibility may differ with respect to contextual demands, the present study derived a flexibility composite and offers evidence of the utility of studying flexibility in an independent sample of young, clinic-referred children with externalizing behaviour problems.

Method

Participants

The children and their families were clients in an intensive services program for children ages 2.5 through 6 years of age with externalizing behaviour problems at a local children's mental health agency. The current study examined data only for children ages 3 years, 11 months, through 6 years because family influences may be particularly salient during preschool and early childhood (Luthar & Zelazo, 2003), and the tasks for this age group differed from younger children in this study. To be eligible for this program, children had to exhibit no significant global developmental delay as assessed by the Child Development Inventory (Ireton, 1992), demonstrate significant externalizing behaviour problems (i.e., rated at or above the 90^{th} percentile of the Externalizing subscale of the Child Behavior Checklist: Achenbach, 1991; Achenbach & Rescorla, 2001), and be in a family situation assumed to put them at risk for developing later conduct problems (e.g., parental depression, family stress, low socioeconomic status). Dyadic interactions between the referred child and primary caregiver were videotaped for 84 families. Due to time and funding constraints, 50 dyads were randomly selected for analysis using the primary interaction coding scheme, the Relationship Process Code (RPC). To increase consistency across dyads, only interactions between the child and a primary female caregiver were included, leaving 45 dyads. Of these 45 dyads, 37 included children ages 3 years, 11 months or older, 33 of whom also had coding completed at pre-treatment with another coding scheme as part of a larger study (Parental Warmth and Control Scale; PWCS). Therefore, the following analyses involve 33 dyads, with coding across the five tasks. Because coding was conducted for frequent time points across a number of tasks, a large number of data was generated for analyses, potentially mitigating the size of the sample. Other studies have examined data derived from state space grids using similar sample sizes (*n*=24 dyads: Lewis et al., 2004; *n*=33 dyads: Granic & Lamey, 2002; *n*=38 dyads: Granic et al., 2003).

The 33 dyads included 27 boys (81.8%) and 6 girls (18.2%). The mean age of the 33 children included in the present analyses was 5.00 years (SD=.797 years), and ranged from 3.42 to 6.50 years at the time of referral. The total household income reported by caregivers was: less than $25,000 (n=9; 27.3%); $25-35,000 (n=12; 36.4%); $35-45,000 (n=2; 6.1%); $45,000 and up (n=6; 18.2%); missing (n=4; 12.1%). In terms of marital status, 14 (42.4%) children lived in a two-parent household, and 19 (57.6%) lived in single-parent households.

Measures

Videotaped interactions. Prior to beginning treatment, referred children and their primary caregiver were asked to participate in five interactive tasks designed to last approximately 50 minutes that were videotaped in the caregiver's home. The five tasks for children ages 3 years, 11 months, and older included:

(1) *Free play* (approximately 20 mins): A standard set of toys was provided to each dyad. Each dyad was asked to play together as they normally would. No other guidance was provided by the researchers.

(2) *Clean-up* (approximately 5 mins): Caregivers were instructed to ask their child to clean up the toys.

(3) *Teaching task #1: Puzzle* (approximately 10 mins): The child was given a puzzle and asked to solve it. The parent was encouraged to

help the child solve the puzzle, but was asked not to touch any of the puzzle pieces.

(4) *Teaching task #2: Etch-a-Sketch* (approximately 3 mins): Each dyad was given an Etch-a-Sketch® toy and asked to draw a staircase. The Etch-a-Sketch involves a screen on which a picture can be drawn using two knobs. The parent and child each controlled one knob and cooperated to draw the staircase. The parent was encouraged to verbally, but not physically assist the child.

(5) *Teaching task #3: Lego* (approximately 10 mins)*:* Each dyad was given a set of large Lego® pieces and a diagram which illustrated how to construct a truck from the Lego pieces. The parent was asked to assist the child in building the model without touching any of the pieces.

Table 2 lists the mean duration of each task in the present sample.

Relationship Process Code (RPC). The *Relationship Process Code (RPC*; Dishion, Rivera, Verberkmoes, Jones, & Patras, 2002) codes for frequency of behaviours and verbalizations for both parent and child for every 15-second interval. Two undergraduate-level research assistants were trained to minimum 80% agreement, with inter-rater reliability ranging from *intraclass coefficient (ICC)* =.81 to 1.00 for the mother ratings and from *ICC*=.89 to 1.00 for child ratings. The following 13 characteristics were coded for each dyad member using the RPC (Dishion et al., 2002) coding scheme: *Positive Verbal*; *Negative Verbal*; *Talk*; *Directive* (i.e., requesting behaviour change); *Positive Directive*; *Negative Directive; Structure* (i.e., providing framework to help the child know what to do in a game, task, or activity); *Vocal*, or any audible vocal

Table 2

Duration of Tasks

Task	n	Mean (secs)	SD (secs)	Min (secs)	Max (secs)
1. Free Play	33	1167.6 [19.45 mins]	191.15	704	1694
2. Clean-Up	33	285.5 [4.76 mins]	110.85	74	629
3. Teach – Puzzle	33	555.7 [9.26 mins]	186.66	254	1034
4. Teach – Etch	31	121.3 [2.02 mins]	66.84	29	344
5. Teach – Lego	33	459.3 [7.66 mins]	230.67	135	1079

expressions when other behaviour descriptions do not apply (e.g., laughter, sobbing); *Physical Contact*; *Positive Physical*; *Negative Physical*; *Comply*, or following the other dyad member's request within five seconds of request for behaviour change or 'structure' provided by parent; *Non-Comply*, or not following the other person's request within five seconds or at all. Table 3 shows the RPC variables and examples of each category. Thus, for each 15-second interval, frequency for each of the 13 characteristics was recorded for each dyad member, resulting in 26 variables per interval, or 104 variables per minute. If two behaviours appeared to occur simultaneously, the RPC specifies priority rules to decide which code is more important. In order of precedence, the codes were: (1) Verbal, Physical (with Directives taking precedence over other verbal); (2) Compliance; (3) Vocal; and (4) Nonverbal. For example, if a mother praised her child while also hugging him or her, the behavioural event would be coded as Positive Verbal.

All variables for each dyad member for every 15-second interval were entered into the *Statistical Package for the Social Sciences (SPSS*) program, and subsequently transferred in text format to Notepad in order to format it for input into GridWare. Coding categories from previous studies (e.g., Granic, Hollenstein studies) were used as the basis for the present study, with the addition of the Structure category. Each variable for each 15-second interval was grouped into one of four sub-groupings, resulting in a frequency count for each of the four new categories:

Positive: Positive Verbal; Positive Directive; Positive Physical Contact; Comply

Structure: Structure

Neutral: Talk; Directive; Vocal; Physical Contact

Table 3

Coding for and Examples of Relationship Process Code (RPC; Dishion et al., 2004)

SSG Category	RPC Category	Description	Examples
Positive	Positive Verbal	Verbal expressions of approval of dyad member's behaviour, appearance, or state. Verbal expressions of support, endearment, or empathy. Non-verbal actions that clearly indicate approval or positive regard.	Apologies, thanks, compliments "Good job!" "I'm sorry that I hurt your feelings." Thumbs-up signal
	Positive Directive	Rewards offered as incentive for compliance or other behaviour change.	"If you do this now, we'll go to the park later."
	Positive Physical	Physical behaviour which involves affections and/or extended positive contact between 2 people.	Hugs, embraces, kisses, sitting with arm around person 'High-fives'
	Comply	Responding voluntarily to dyad member's bid for behaviour change or to Structure provided by parent within 5 seconds.	Cleaning up as requested. Playing along with game.
Structure	Structure	Verbal behaviour relates to potential behaviour change on the part of dyad member, and which provides a framework to know what to do in a game, task, or activity. Used when parents prompt child to change behaviour without being directive. Prompts may provide 2 or more choice, involve teaching, game-like prompts, song, music, suggestions, etc.	"Do you want to put the cars away first or the dinosaurs first?" Singing a clean-up song
	Talk	General conversational verbal interaction. Teaching or lecture not directly relevant to task at hand. Jokes and teasing that is not critical or complimentary.	"What should we have for dinner tonight?" "There you go." "Can all the blocks fit in the box?"

Neutral	Directive	Commands or requests for behaviour change. Compliance must be potentially observable. Clear demands not to repeat a previous behaviour.	"Clean up." "Pick up the toys and put them in the box." "Should we put it back in the bucket?"
	Vocal	Any audible vocal expression including, but not limited to, laughter, sobbing, or neutral vocal expressions of acknowledgement.	"Uh huh" Humming, whistling
	Physical Contact	Any physical contact between 2 people which is inherently neutral or non-intrusive, or not delivered with intention to harm.	Holding child back to ensure safety. Holding arm to assist in task or activity.
Negative	Negative Verbal	Verbal expressions of approval of dyad member's behaviour, appearance, or state. Complaints, cursing, insults, personal attacks, teasing that is critical. Non-verbal actions that clearly indicate disapproval or negative regard.	"You aren't doing that right." "You're not cleaning up very fast." Making face of contempt.
	Negative Directive	E.g., warnings of unpleasant consequence, threats or implied threats (e.g., physical reprimand, loss of privilege, or withholding of favourable consequence). Can be verbal or nonverbal.	"You just open that door and see what happens." "If you don't pick up the toys, we're not going to get ice cream later."
	Negative Physical	Intrusive physical contact with other person that is likely to be experienced as unpleasant and/or aversive. Low-grade physical contact with objects not part of clean-up task. Destruction of objects.	Light hitting, pinching, slapping, grabbing other's hand, shove. Restraining child for reasons other than safety or protection. Throwing objects away from toy box.
	Non Comply	Clearly ignoring, disagreeing or refusing to cooperate with dyad member's bid for behaviour change. If no compliance observed within 5 seconds of bid for behaviour change.	Not picking up toys as requested.

Negative: Negative Verbal; Negative Directive; Negative Physical Contact; Non Comply

Separate files were created for each dyad and for each task within each dyad in order to graphically depict and obtain flexibility variables (see below) for each dyad in each task. After grouping all RPC data into one of the above four categories, all data were then transferred into the Gridware program.

Parental Warmth and Control Scale. The *Parental Warmth & Control Scale (PWCS*; Rubin & McKinnon, 1994) codes for parent behaviours and verbalizations for every 20-second interval of the dyadic interaction. Research assistants coded for overall quality of the rated characteristic using a 3-point Likert scale, with the exception of Sensitivity, which was rated on a 4-point scale. Codes were derived for seven parent characteristics. *Proximity & Orientation* assesses the parent's physical location with reference to the child and parental nonverbal attentiveness. *Positive Affect* is a measure of the positive quality of parental emotional expressiveness toward the child, such as warmth, positive feeling, pleasantness, and enjoyment toward the child. *Hostile Affect* reflects parental verbal and nonverbal behaviour arising from feeling hostile toward the child, and includes anger, irritability, annoyance, or hostility. *Negative Affect* assesses the negative quality of maternal expressiveness and includes verbal and nonverbal behaviour that do not involve hostility, such as sadness, anxiety, fear. *Sensitivity* is a measure of the parent's ability to respond to the child's verbal and nonverbal requests for attention, and can involve verbal or nonverbal behaviour. *Negative Control* assesses the amount of control a parent exerts over his or her child and is ill-timed, excessive, and inappropriately controlling relative to what the child is doing. The parent dictates the activities of the child regardless of the child's wishes. *Positive Control* assesses the extent to which the parent facilitates his or her child's behaviour. The parent actively and positively provides guidance which allows the child to direct or structure the ongoing activities, and provides well-timed supportive assistance and facilitates the child's competent functioning. Table 4 details the PWCS coding scheme and examples. Due to the different coding intervals between the two coding schemes (i.e., 20-second intervals for PWCS; 15-second for RPC), PWCS variables were not entered into the GridWare program for each interval as coded. Rather, PWCS variables were consolidated into categorical variables before input into GridWare. For the purposes of the present study, only Positive Affect, Hostile Affect, Positive Control and Guidance, and Sensitivity were of interest. These variables were further forced into dichotomous variables for analyses with the following cut-off scores below designated for the present study. The number of events per minute for each variable (e.g., number of 'Warm' events) were extracted for each dyad for each task type through GridWare. For each 20-second interval, the parent was considered *Warm* if Positive Affect was rated as 2 or 3 (i.e., moderate or high). Similarly, the parent was rated as *Hostile* if she was rated as 2 or 3 on Hostile Affect. The parent was described as *Sensitive* if one of two conditions was met: (1) Sensitivity = 4; or (2) Sensitivity = 3 AND Positive Control and Guidance > 1. For the latter coding, the parent was rated as exhibiting a moderate level of sensitivity as well as constructively helping to guide the child's activity. The parent was not rated as Sensitive if: (1) Sensitivity = 3 AND Positive Control and Guidance = 1; or (2) Sensitivity was less than 3. That is, if the parent demonstrated a moderate level of sensitivity but did not help to

Table 4

Coding for Parental Warmth and Control Scale (PWCS; Rubin & McKinnon, 1994)

Behavioural Code	Rating	Description	Examples
Proximity & Orientation	1=Within or beyond arms length and inattentive	Parent focused on person, place, or thing other than child. May be within or beyond child's reach.	Parent reads a magazine.
	2=Beyond arms length and attention	Parent focused & looking at child. Nonverbal acknowledgement of child's presence.	Parent looks up regularly from magazine. Watches child's activity.
	3=Proximal and attentive	Looking at child, facing child, and making positive effort to get close to child. Within child's reach.	Parent and child play game together.
Positive Affect	1=None	No instances of parental affection, positive feeling, or enjoyment observed.	--
	2=Moderate positive expression	Facial expressiveness indicates positive feeling. Communicates in positive tone of voice.	Smiles, winks. Parental laughter, enjoyment. Parent use of pet names.
	3=Outright affection	Displays affectionate gestures and touches toward child. Verbalized affection for child. Expresses positive statements of praise.	Hugging; kissing; "thumbs up"; tickling. "I love you"; "I like you". "That's great!" "You're doing a good job!"
Hostile Affect	1=None	No instances of hostility, anger, and/or annoyance are evident.	--
	2=Moderate hostile expression	Parental tone of voice is negative. Rebuffs child by turning and moving away. Facial expression indicates irritation and annoyance, but no escalation in intensity or parental loss of control.	Frowns; scowls; clenched teeth

	3=Outright hostility	Parent insults and criticizes child. Yells or physically punishes child. Vocalized negative sarcasm.	"Don't be stupid." "Sometimes you're such a klutz." Slaps hands; grabs arms and pulls child. "All washed out like you, eh?"
Negative Affect	1=None	No instances of parental sadness, anxiety, or fearfulness observed.	--
	2=Moderate negative expression	Parent exhibits sad expression, is unable to relax, and/or looks worried. Expresses a flat, sullen tone of voice and/or anxious tone of voice.	Parent frequently looks around and fidgets.
	3=Outright negative expression	Parent verbally expresses sadness, embarrassment, and/or wariness in response to child's behaviour.	"I am unhappy with your behaviour!" "Remember what I said at home, we do not talk like that!"
Sensitivity	1=No sensitivity	Parent missed some occasions to set limits; leads to disorganization of child.	Child's behaviour is inappropriate and parent does not intervene.
	2=Low sensitivity	Parent does not respond to child's attempts to gain attention, or to the child's questions. Parent is unaware that child needs help, even though child's nonverbal behaviour indicates need for attention.	Child struggles with Lego and parent does not ask child if they need assistance.
	3=Moderate	Parent gives non-contingent response. Parent responds to child, but does not attempt to extend the exchange.	Parent's response is not relevant to child's question.
	4=High sensitivity	Parent extends the exchange.	Parent elaborates the conversation. Parent contributes to the activity in response to child's cues.
	N/A	Situation does not require maternal response.	
	1=None	No instances of parental intrusiveness or control are observed.	--

Negative Control	2=Moderate negative control	Parent is verbally intrusive or momentarily distracts child. Parent quizzes child in interfering way.	Parent talks to child but does not allow time for child to respond. Child is busy playing with toy and parent directs his/her attention elsewhere.
	3=Outright negative control	Parent uses unnecessary dictatorial instructions to control the child's behaviour. Instruction leave little room for child's autonomous functioning. Parent uses physical intrusiveness that clearly change or stop child's behaviour.	"Don't do that." "Don't play with this." Grabs toy from child to demonstrate use of toy. Pulls child aside.
Positive Control & Guidance	1=None	No instances of parental guidance observed.	--
	2=Moderate positive control and/or guidance	Parent determines/chooses activity for child, but allows child time to adjust to activity. Does not interfere with child's play. Parent suggests a few activities for child but allow child opportunity to determine the activity; child unoccupied at the time.	"We could play with the cars or animals. What would you like?"
	3=Outright positive control and/or guidance	Child chooses the activity and parent provides guidance. Parental behaviour clearly unobtrusive.	Parent offers help if required. Verbally assists child. Explains activity.

guide the child's activity or they were rated as showing low or no sensitivity, they were not rated as sensitive.

Flexibility variables. Based on previous research, the GridWare (Lamey et al. 2004) program was designed to display dyadic data in the form of state space grids. GridWare provides a visualization and data manipulation tool for multivariate time series of sequential data. Two major advantages of GridWare are that: (1) it can map all possible states of a system and plot a trajectory for the dyad as their interaction changes over time; and (2) it visually depicts and provides variables for states that 'attract' the dyad from other states.

In addition to visually depicting dyadic interaction patterns, the GridWare program also provides numerical values for variables indicating degrees of flexibility in dyadic interactions (i.e., how flexible the dyad is in being able to move to different types of interactions such as negative to positive to neutral). One can examine differences in flexibility within each dyad, across different types of tasks (see Figure 1 for an example of one dyad engaging in four different task types). Patterns in flexibility within task type, can also be examined across dyads. Figures 2 through 4 show four different dyads engaged in the same tasks (free play and two teaching tasks). In the SSGs, plot points for behavioural events were laid out within each cell using the 'Random' layout mode of GridWare. Thus, there is no specific pattern for location of plot points within each cell.

In line with previous research, four variables measuring flexibility were of interest in the present study and extracted from the GridWare program for each dyad, within each task and across all tasks. The following measures of dyadic flexibility have demonstrated predictive validity in previous research:

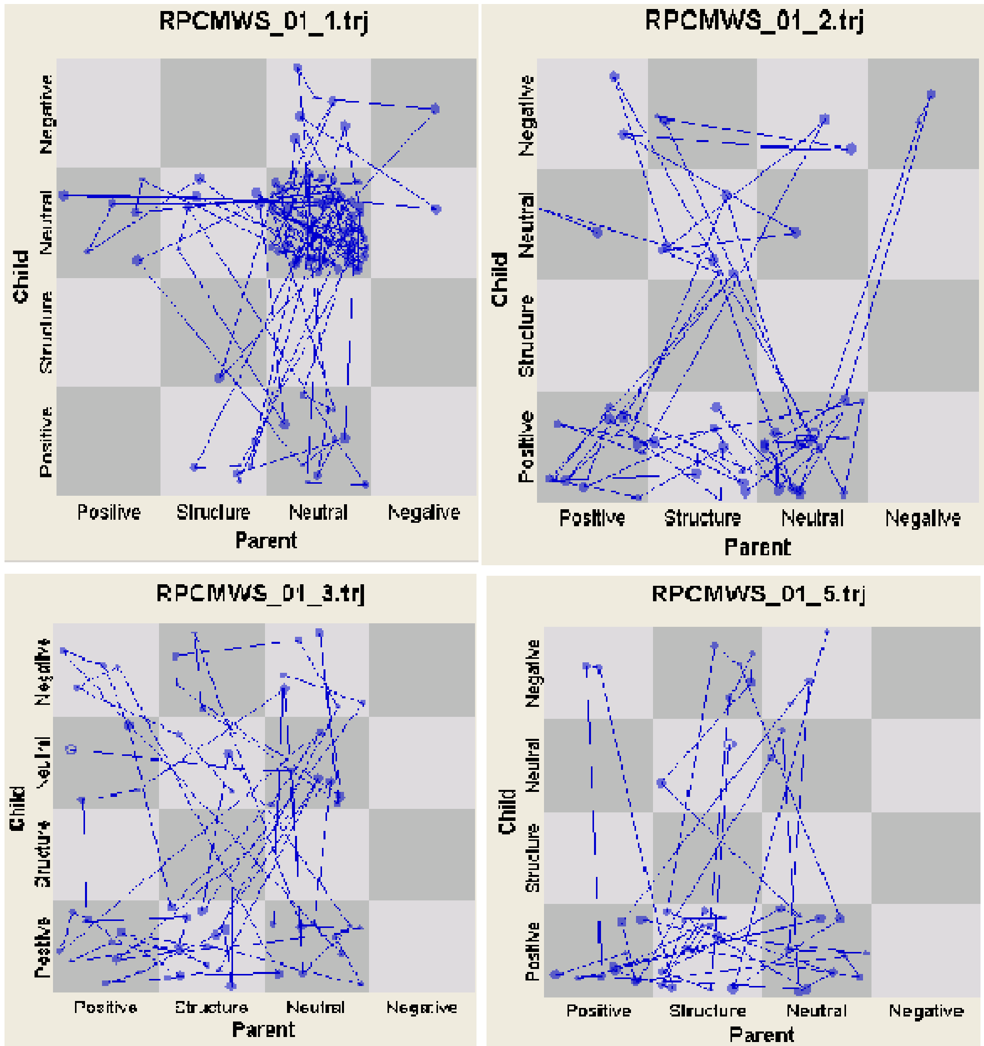

Figure 1. An example of within-dyad differences in flexibility across task types. Top left displays the dyad engaged in the free play task, top right shows the same dyad in the clean-up task, and the bottom two quadrants show the dyad interacting in two teaching tasks. It can be seen that the dyad appears to show more flexibility (i.e., more spread in cell variation) in the clean-up and teaching tasks than in the free play task. The latter also shows that the dyad spends more time in a mutually neutral state.

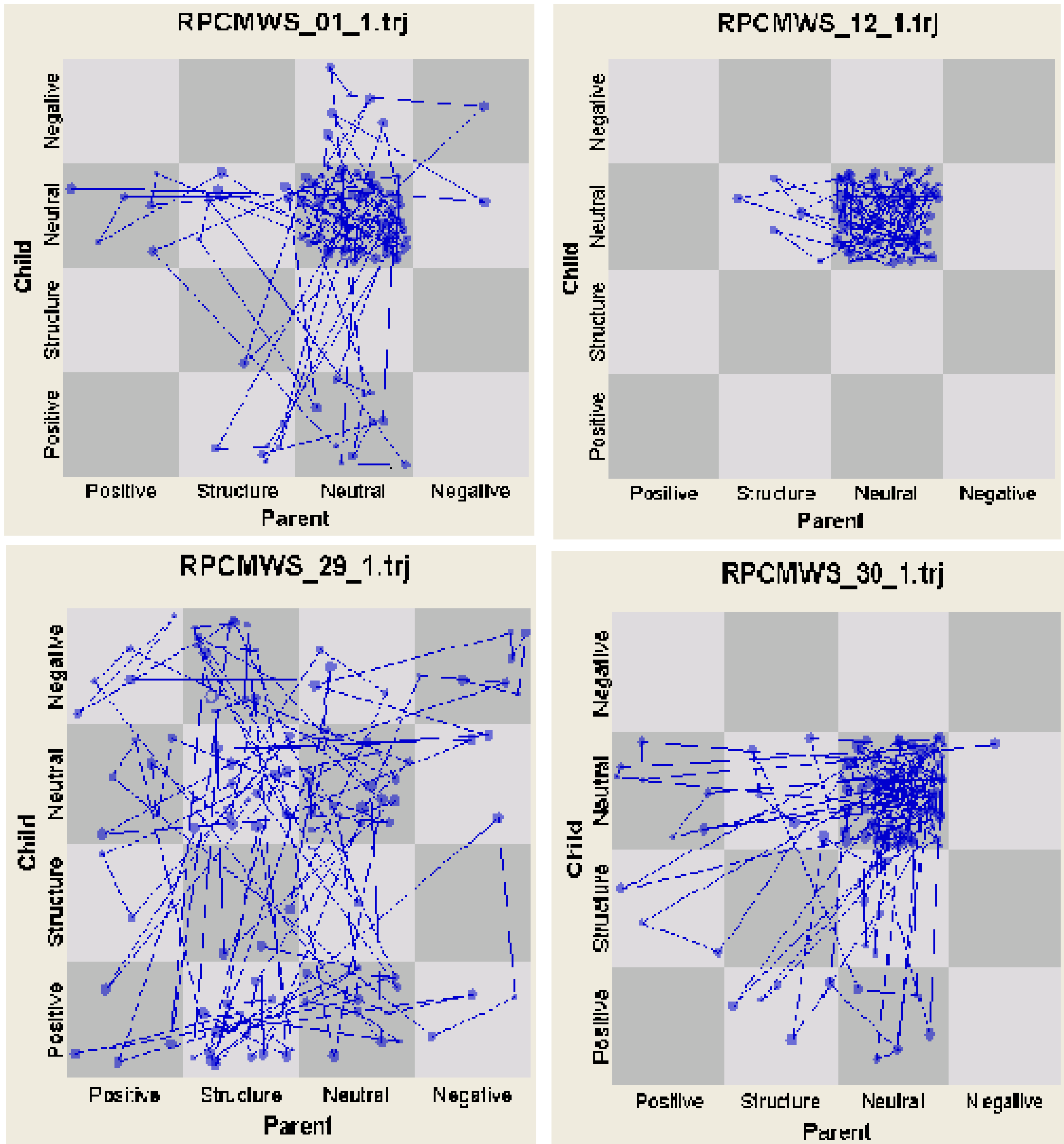

Figure 2. An example of four dyads engaged in the free play task. It can be seen the dyad in the top right quadrant shows much less flexibility (i.e., more rigidity) than the other dyads depicted. The dyad in the lower left quadrant shows greater flexibility in their interaction that the other three (i.e., shows greater movement in and out of affective states).

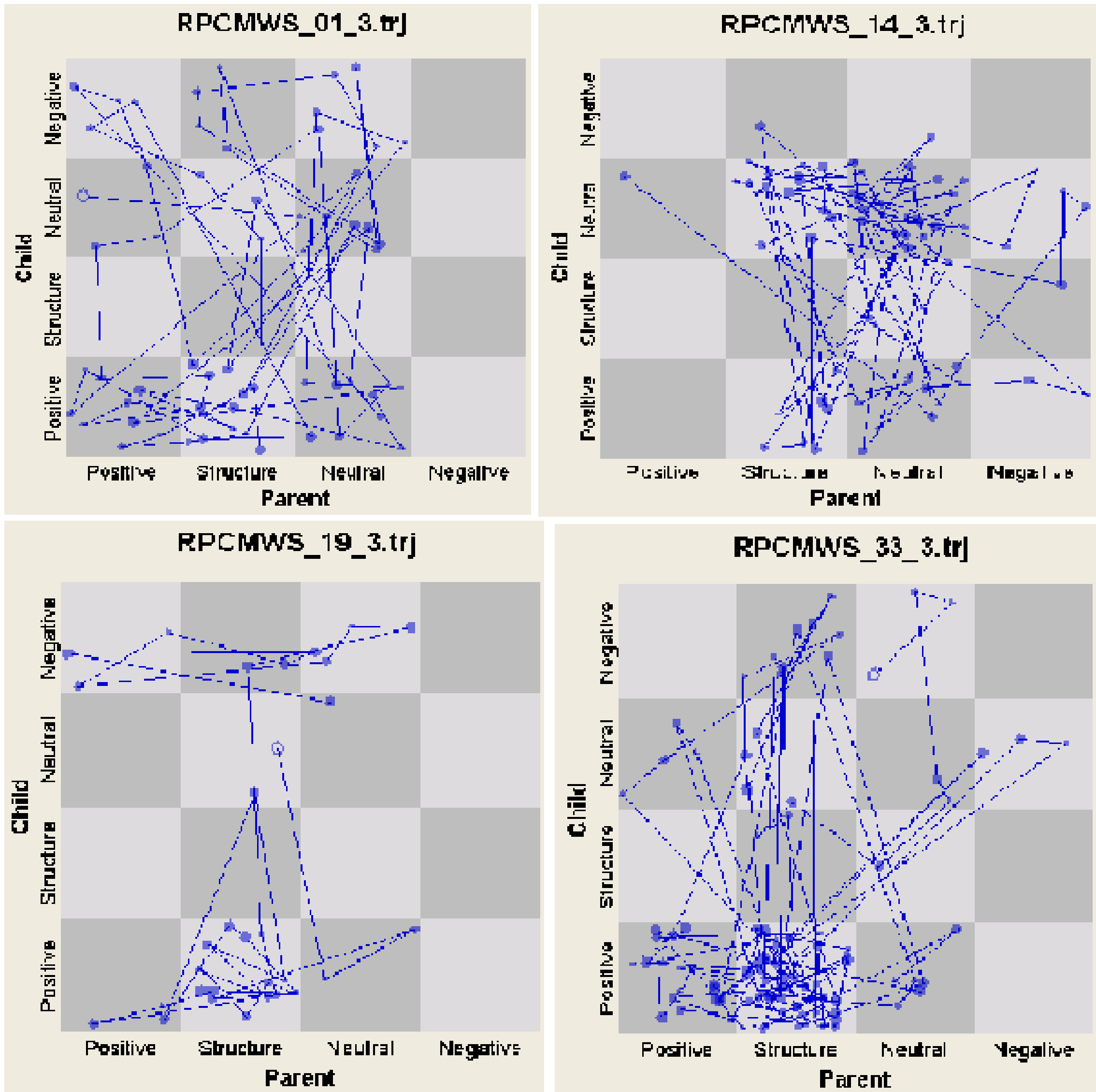

Figure 3. An example of four dyads engaged in a teaching task (Puzzle) in which the parent verbally assists the child complete the puzzle.

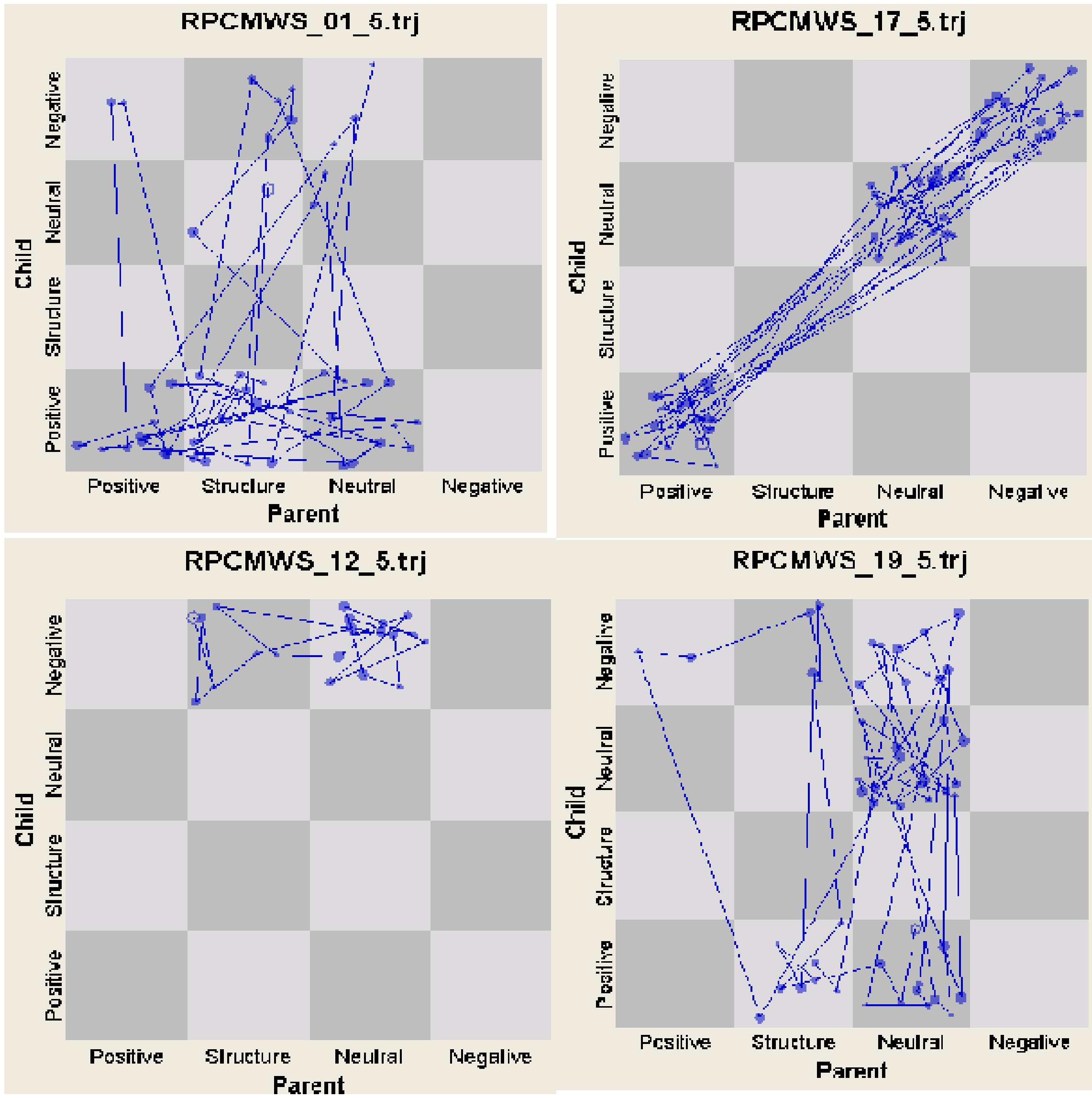

Figure 4. An example of four dyads engaged in a teaching task (Lego) in which the parent provides verbal assistance to help the child build a Lego model from diagram.

(1) *Transitions*, or the number of movements between cells on a SSG. In Gridware, the number of transitions is called 'gridEvents', or the mean, across trajectories, of the total duration of each trajectory of interest. Due to varying durations between tasks and dyads, gridEvents was transformed to number of events per minute. A greater number of movements, or transitions, indicates higher flexibility.

(2) *Dispersion*, or the sum of squared proportional durations across all cells, corrected for the number of cells and inverted so that values range from 0 (no dispersion at all: all behaviour in one cell) to 1 (maximum dispersion). Higher values indicate greater flexibility. In GridWare, Dispersion is referred to as 'gridDispersion'. Dispersion is calculated by the formula:

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

Where D is the total duration, d_i is the duration in cell i and n is the total number of cells.

(3) *Average Mean Duration (AMD)*, or the mean duration of each behavioural 'event'. Lower duration (of each event) indicates higher levels of flexibility. In GridWare, AMD is referred to as 'gridDurPerVisit', or the mean, across trajectories, of the duration of each trajectory displayed divided by its number of visits.

(4) *Total Unique Cells (TUC)*, or the total number of cells visited during the interaction. In GridWare, 'gridRangeM' refers to Mean Cell Range, or the mean number of cells visited across all trajectories. As

the SSGs in the present study were 4x4 grids, the minimum value for TUC was 1 and the maximum was 16. The higher the number of TUC, the greater the degree of flexibility.

Dyadic process variables. In line with previous research (Granic & Lamey, 2002; Granic et al., 2007; Hollenstein et al., 2004), different dyadic interaction regions were highlighted, and the total number of events in each dyadic region for each dyad was computed for each task type and across all tasks. Regions included: *Mutual Positive Engagement*; *Mutual Negative Engagement*, *Parent Attack* (i.e., parent reacts negatively to child's neutral or positive behaviours), or *Permissiveness* (i.e., parent reacts positively or neutrally to child's negative behaviours). Thus, in addition to seeing how often each dyad was emotionally synchronous (e.g., mutually negative or positive), one could see when the dyads were asynchronous with each other. Figure 5 provides an illustration of the regions on the SSG.

Child psychopathology. Due to the different age ranges of the children in the study, different versions of the parent-rated Child Behavior Checklist (CBCL; Achenbach, 1991; Achenbach & Rescorla, 2001) were used, for ages 1.5-5 years or 4-18 years, resulting in different total scores between measures. Therefore, T-scores were used in analyses in order to facilitate comparisons between children. The Externalizing and Internalizing subscales were used in the present analyses. Children were also grouped by whether they are clinically significant on *Externalizing* difficulties or both externalizing and internalizing (i.e., *Mixed*) on the Externalizing and Internalizing subscales of the CBCL. The psychometric properties of the CBCL have been extensively studied and validated (Achenbach & Rescorla, 2001).

	Negative	**Permissiveness**			**Mutual Negative Engagement**
	Neutral				
CHILD	Structure	**Mutual Positive**	**Scaffolding**		**Parent Attack/ Hostile**
	Positive	**Engagement**			
		Positive	Structure	Neutral	Negative

Figure 5. Dyadic regions derived from state space grids.

Potential Covariates

Maternal depression. Data from the present study were collected over several years as part of a larger study. Depending on when they entered the present study, parents completed either the *Beck Depression Inventory I (BDI-I*; Beck & Steer, 1987) or *II (BDI-II*; Beck, Steer, & Brown, 1996) after the agency updated to the second edition during the span of the study. Both versions of the BDI have been used extensively in research and clinical populations. Internal consistency in the present study was very good for both versions of the BDI: BDI-I (Cronbach's α =.882), and BDI-II, (Cronbach's α =..949). The BDI-II has shown to have high test-retest reliability and validity with other measures of depression (Beck et al., 1996). Both versions of the BDI have the same range of scores (i.e., 0-63); therefore, depression scores were collapsed together across the sample, resulting in a general 'BDI' variable.

Parenting stress. The *Parenting Stress Index* – Short Form (*PSI-SF*; Abidin, 1995) is a 36-item self-report measure of parenting stress, with items are rated on a 5-point Likert scale (1=Strongly Agree; 5=Strongly Disagree). The Total Stress score was examined as a potential covariate. Internal consistency for the PSI-SF in the present study was very good Cronbach's α =.925). Scores on the PSI-SF have been found to be related to parent reports of children's behaviour one year later (Haskett, Ahern, Ward, & Allaire, 2006), and the measure has been validated in a low socioeconomic populations (Reitman, Currier, & Stickle, 2002).

Procedure

Prior to beginning intervention services, each parent provided informed consent, completed questionnaires, and participated in videotaped interactions with the referred child. Parents were mailed the questionnaires prior to involvement in the program. The parent-child interaction was videotaped in each participant's home or other setting of their choosing. All dyads completed the tasks in the same order: Free Play, Clean-Up, followed by the teaching tasks (Puzzle, Etch-a-Sketch, Lego). Fifty dyads were randomly selected for coding by trained research assistants with both the RPC and PWCS, with 33 dyads meeting the inclusion criteria of female caregivers and children aged 3 years, 11 months, and older. The data for all participants were entered into a SPSS database at the community agency. Data for all participants with coded RPC data were then entered in a text file to calculate frequency counts for each of four categories (see RPC above) and formatted for input into the GridWare program. Coding for the PWCS was transformed into categorical variables for maternal Warmth, Sensitivity, and Hostility (see PWCS above) and entered into a text file for format for GridWare input. See Figures 6 through 8 for examples of number of Warmth, Sensitivity, and Hostility events as graphed in GridWare. Variables of interest (i.e., flexibility variables, number of events in dyadic regions) were exported from GridWare and entered into a new SPSS file for analyses. Due to different durations between tasks and dyads, the dyadic process and parental characteristic variables were transformed from number of events per task, to number of events per minute per task.

Analyses

Please see Table 5 for summary of main analyses used, variables involved, and rationales.

Deriving the Flexibility composite. Bivariate correlations were first run to examine the strength of associations among the four Flexibility variables across the

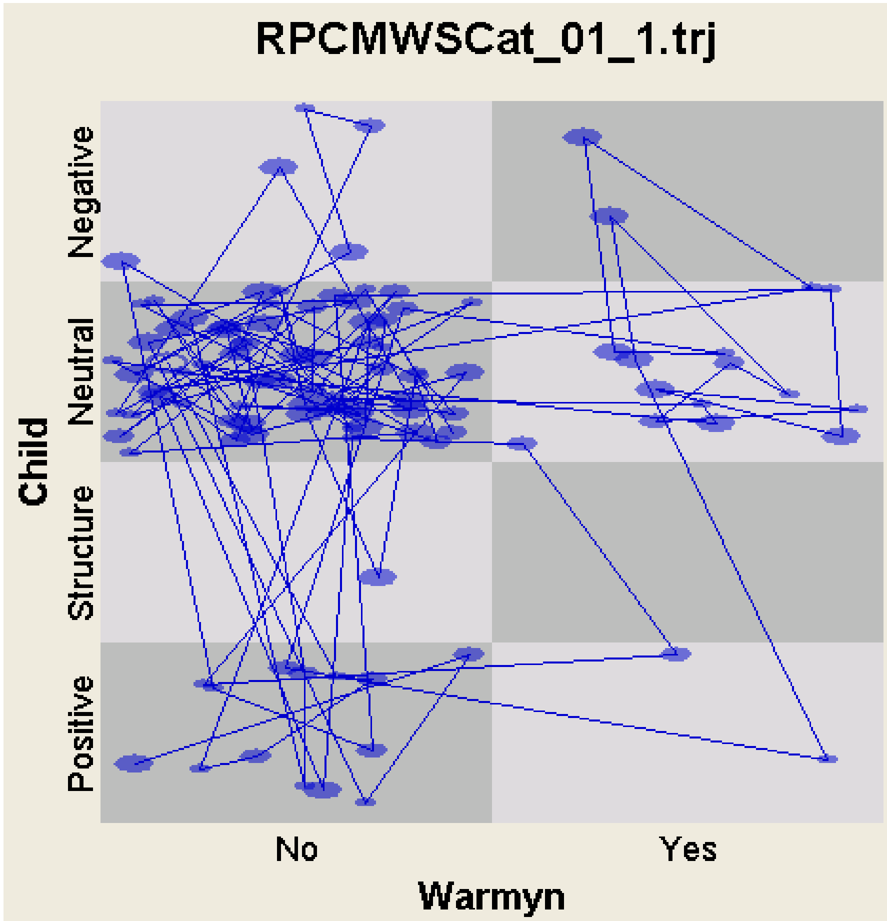

Figure 6. Example of number of parental Warmth events for one dyad during a Free Play task.

Note: Position of events within each cell is random.

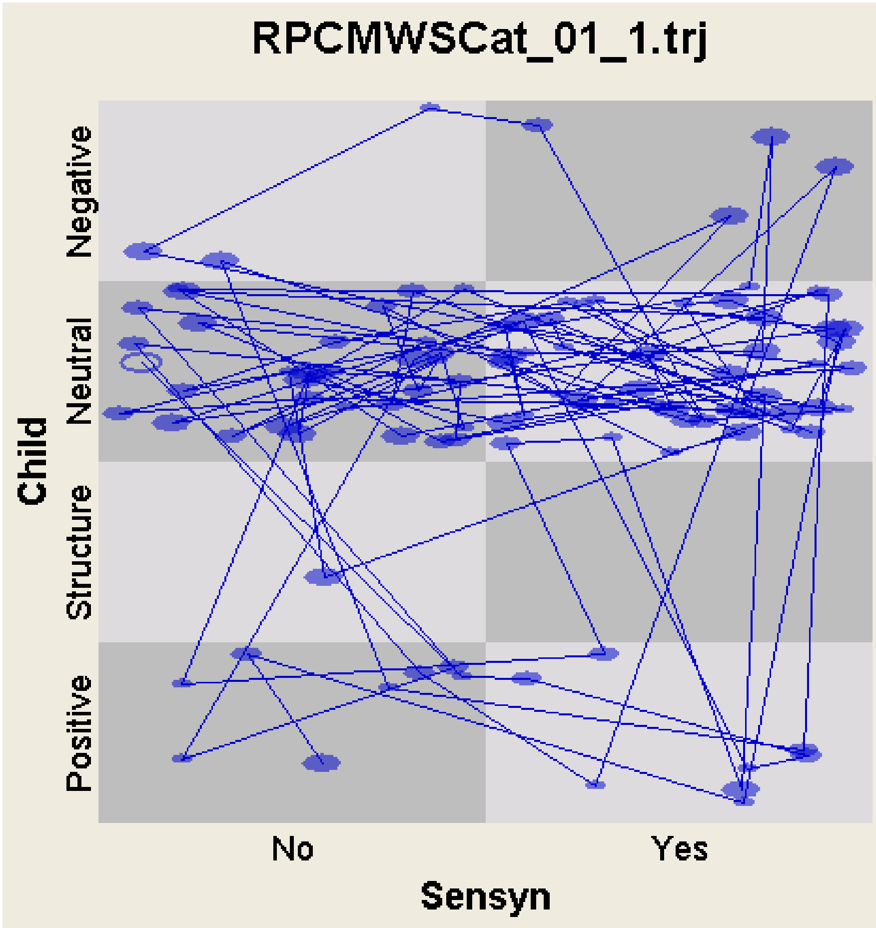

Figure 7. Example of number of parental Sensitivity events for one dyad during a Free Play task.

Note: Position of events within each cell is random.

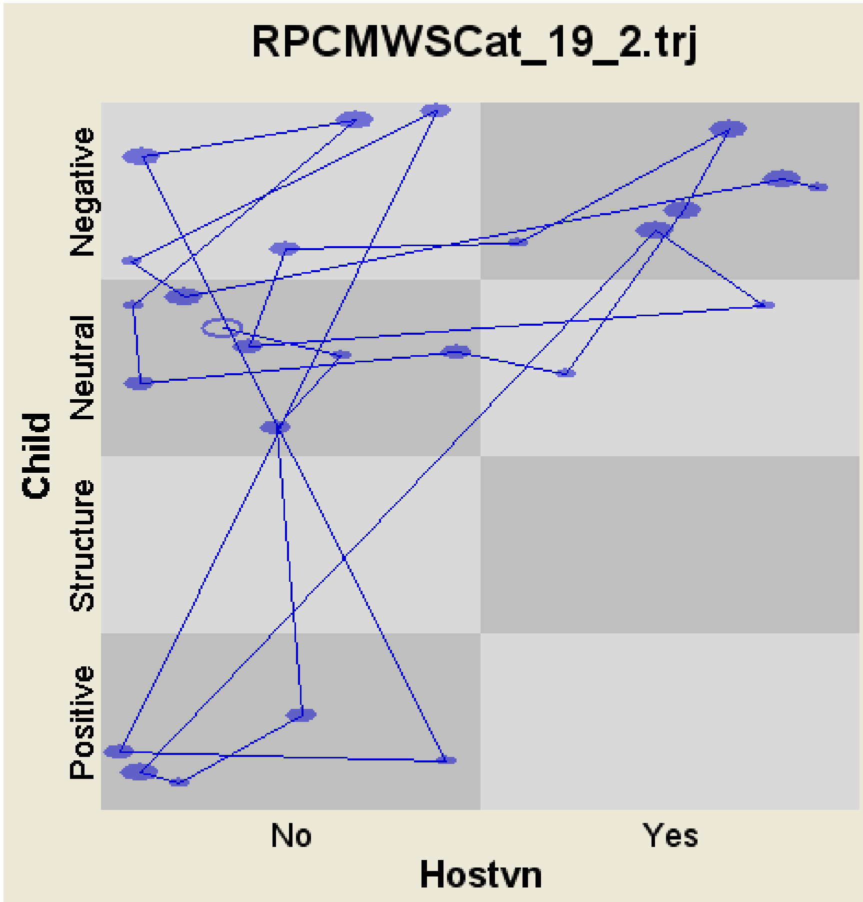

Figure 8. Example of number of parental Hostility events for one dyad during a Free Play task.

Note: Position of events within each cell is random.

Table 5

Analyses Conducted in Present Study

Analysis	Variables	Purpose
Principal Components Analysis	Transitions; Dispersion; Average Mean Duration; Total Unique Cells	To assess whether the four measures of flexibility comprised one latent component in each task.
Repeated Measures Multiple Discriminant Function Analysis	Transitions; Dispersion; Average Mean Duration; Total Unique Cells	To examine how measures of flexibility varied across tasks in order to derive a 'Flexibility' composite that maximized differences across tasks. To detect orthogonal patterns of variation (i.e., constituent discriminant functions).
Redundancy Index Analysis	CV1: Flexibility CV2: Dyadic Processes; Parental Characteristics; Parenting Stress; Parental Depression	To examine the average predictability of the Flexibility composite across tasks from the set of predictor and covariate variables.
Repeated Measures ANCOVA	Dyadic Processes (Mutual Positive Engagement; Scaffolding; Permissiveness; Mutual Negative Engagement; Parent Attack) by Task Type Covariate: Parenting Stress	To examine how dyadic processes differed as the nature and goals of the tasks varied.
Sequential Multiple Regression	Criterion: Flexibility Predictors: Dyadic Processes and Parental Characteristics (Warmth, Sensitivity, Hostility) Covariates: Parenting Stress; Parental Depression	To explore which dyadic processes and parental characteristics predicted dyadic flexibility and the associations varied by task.
2x5 MANCOVA	IV: Externalizing subgroup IV: Task Type DVs: Dyadic Processes and Parental Characteristics	To explore whether externalizing subgroups would show differences in dyadic processes or parental characteristics as task demands varied. To examine externalizing subgroup differences in dyadic process and parental characteristics.

different tasks. As a primary purpose of the present study was to determine which flexibility components optimally comprise an overall Flexibility construct, a principal components analysis (PCA) was run with the four flexibility variables for each task type to identify possible latent components by extracting the maximum variance from the data with each component. Of particular interest was whether the grouping of flexibility variables differed by task. Components were extracted using a minimum eigenvalue criteria of 1, followed by Varimax rotation, which simplifies factors by maximizing the variance of the loadings within factors, across variables (Tabachnick & Fidell, 2001).

A multiple discriminant function analysis (DFA) using MANOVA syntax that accounts for the within-subjects repeated measure of task type was then run to examine the nature and strength of the associations among the four flexibility variables and how these associations varied depending on task type. Discriminant function analyses can identify how strongly variables are associated with grouping distinctions (e.g., task type) and assess how much variance in the dependent variable (e.g., task type) is explained by the independent variables (e.g., flexibility variables; Tabachnick & Fiddell, 2001). Each function maximizes the difference between the values of the dependent variable, while the next function is orthogonal to the prior function(s) and maximizes the differences while controlling for the prior factors (Tabachnick & Fiddell, 2001). The four flexibility variables in the current study have been examined in varying combinations in previous studies. Because a primary objective of the present study was to examine dyadic flexibility as assessed in previous studies using state space grids and identify which of the four flexibility variables were most applicable when looking across different types of tasks, discriminant function analysis can identify whether and which predictors (e.g., flexibility variables) can be combined to reliably predict task type (Tabachnick & Fiddell, 2001). An overall standardized 'Flexibility' composite was constructed based on how flexibility variables grouped together across task types.

Finally, a redundancy index analysis was run with canonical correlation for Flexibility across tasks with all 10 variables (i.e., five dyadic processes, three parental characteristics, two covariates). It should be noted that the covariate variables (i.e., parental stress and depression) did not act as covariates in the canonical correlation; rather, the variables were all assessed simultaneously within the context of all the others (Woodward & Overall, 1975). The redundancy index analysis was run to examine the proportion of variance in dyadic flexibility that could be explained by the set of predictor and covariate variables (i.e., level of redundancy; Cramer & Nicewander, 1979; Gleason, 1976; Israels, 1984; Stewart & Love, 1968).

Covariate analyses. Self-rated parenting stress and parental depression were examined as potential covariates for subsequent analyses by running bivariate correlational analyses between these variables and parental characteristics and dyadic processes.

Investigating dyadic processes across task types. The nature of the associations between dyadic regions (e.g., Mutual Positive Engagement) identified on the SSGs was assessed using a repeated-measure analysis of covariance to examine differences across task types. Adjustments for multiple comparisons included the relatively conservative Pillai's Trace statistic for ANCOVA and Sidak adjustment for multiple posthoc comparisons. The Sidak (1967) adjustment holds the familywise error rate constant and is less conservative than the Bonferroni correction.

The prediction of flexibility by parental characteristics and dyadic processes. Sequential multiple regression analyses were run for within each task in order to identify variables that add a unique contribution to flexibility within that task type. To account for the effects of the covariates, they were entered in one block, with the predictor variables in the second block to examine any changes to their prediction over and above the first block.

Differences in dyadic processes and parental characteristics by Externalizing subgroups. As previous studies have found differences in dyadic processes for children with externalizing difficulties versus children with both externalizing and internalizing problems, of interest in the present study was how levels of dyadic flexibility varied between the two subgroups, and whether subgroup would interact with task type. A 2x5 multivariate analysis of covariance (MANCOVA) was conducted with Externalizing subgroup and Task type as the independent variables and Flexibility as the dependent variables. The multivariate statistic of interest was Pillai's Trace as it is the most robust of the multivariate statistics when sample size is small (Olson, 1976, 1979). Previous researchers have used repeated-measures ANOVAs or ANCOVAs to examine flexibility variables across time (e.g., Granic et al., 2003; Hollenstein et al., 2004) and pre- to post-treatment (Granic et al., 2004).

Results

Inspection of data. Three of the four flexibility variables showed significant violations of normality. Tests of normality indicated significant skewness and kurtosis for the flexibility variables of Transitions, AMD, and Dispersion, with Transitions and Dispersion demonstrating negative skewness. The AMD variable showed positive skewness, although higher levels of AMD indicate *less* flexibility in contrast to the other three variables; thus, it demonstrates similar skewness patterns as Transitions and Dispersion. Negative dyadic processes (i.e., Permissiveness, Mutual Negative Engagement, Parent Attack) and parental Hostility also demonstrated negative skewness, while the positive dyadic processes (i.e., Mutual Positive Engagement, Scaffolding) and parental characteristics (i.e., Warmth, Sensitivity) tended to follow a normal distribution across tasks. Because all of above variables were derived from the SSGs, removing some values could potentially distort subsequent findings. Negative emotional states and their variability were of particular interest in the present study; thus, the decision was made to continue with data analyses with no further changes (please see Discussion for further detail), similar to the use of SSG variables in Granic et al. (2007).

The covariate variables of parental stress (PSI: skewness=-.279; kurtosis=-.287) and depression (BDI: skewness=.855; kurtosis=.324) did not demonstrate significant violations of the normal distribution).

Means and standard deviations for each of the flexibility variables across and within tasks are presented in Table 6. Four measures of flexibility have been previously identified from SSGs. A primary purpose of the study was to identify which of these flexibility variables were applicable to the present sample of children with behaviour problems. Principal components analyses were run across and within tasks to examine whether the flexibility variables comprised a latent component.

Construction of Flexibility Variable

Bivariate correlations. Tables 7 through 10 list the Pearson *r* correlation coefficients for the four Flexibility variables across the five tasks. Strength of association

Table 6

Descriptive Statistics for Flexibility Variables

Flexibility variables	Task	Mean	SD	Min	Max
Average Mean Duration (AMD) *(secs)*	Mean across all tasks	22.01	9.914	14.75	114.89
	Task 1 (Free Play)	26.10	16.482	18.45	114.89
	Task 2 (Clean-Up)	19.47	4.011	14.93	37.00
	Task 3 (Teaching – Puzzle)	21.80	7.766	15.73	62.14
	Task 4 (Teaching – Etch-a-Sketch)	21.10	8.339	14.75	59.00
	Task 5 (Lego)	21.50	7.702	15.00	52.50
Dispersion *(0-1)*	Mean across all tasks	.759	.172	.000	.958
	Task 1 (Free Play)	.721	.1668	.117	.958
	Task 2 (Clean-Up)	.818	.1224	.345	.948
	Task 3 (Teaching – Puzzle)	.785	.1427	.203	.938
	Task 4 (Teaching – Etch-a-Sketch)	.669	.2440	.000	.889
	Task 5 (Lego)	.795	.1276	.364	.904
Total Unique Cells (TUC) *(1-16)*	Mean across all tasks	7.23	2.921	1	15
	Task 1 (Free Play)	9.97	2.568	2	15
	Task 2 (Clean-Up)	7.03	2.481	2	11
	Task 3 (Teaching – Puzzle)	7.79	2.058	3	12
	Task 4 (Teaching – Etch-a-Sketch)	4.06	1.806	1	7
	Task 5 (Lego)	7.09	2.310	2	11
Transitions (*no. events per min*)	Mean across all tasks	5.79	.587	.55	6.21
	Task 1 (Free Play)	5.94	.123	5.29	6.01
	Task 2 (Clean-Up)	5.89	.140	5.59	6.16
	Task 3 (Teaching – Puzzle)	5.92	.089	5.53	6.02
	Task 4 (Teaching – Etch-a-Sketch)	5.35	1.206	.55	6.21
	Task 5 (Lego)	5.82	.317	4.21	6.02

Table 7

Bivariate correlations among the four Flexibility variables averaged across all tasks

	AMD	Dispersion	TUC	Trans
AMD	1.00	-.678***	-.302***	-.051
Dispersion		1.00	.601***	.328***
TUC			1.00	.320***
Trans				1.00

*** $p<.001$

Table 8

Bivariate correlations among the four flexibility variables in Task 1 (Free Play) and Task 2 (Clean-Up)

	AMD	Dispersion	TUC	Trans
AMD	1.00	**-.804***	**-.677***	**-.019**
Dispersion	-.801***	1.00	**.864***	**.046**
TUC	-.538**	.790***	1.00	**.081**
Trans	-.355*	.278	.258	1.00

Note: Correlations above the diagonal in bold are for Task 1 (Free Play). Correlations below the diagonal are for Task 2 (Clean-Up).

* *p*<.05

** *p*<.01

*** *p*<.001

Table 9

Bivariate correlations among the four flexibility variables in Task 3 (Teaching - Puzzle) and Task 4 (Teaching – Etch-a-Sketch)

	AMD	Dispersion	TUC	Trans
AMD	1.00	**-.865*****	**-.554****	**-.126**
Dispersion	-.657***	1.00	**.682*****	**.232**
TUC	-.504**	.787***	1.00	**.303**†
Trans	-.042	.362*	.281	1.00

Note: Correlations above the diagonal in bold are for Task 3 (Teaching - Puzzle). Correlations below the diagonal are for Task 4 (Teaching – Etch-a-Sketch).

† p<.10

* p<.05

** p<.01

*** p<.001

Table 10

Bivariate correlations among the four flexibility variables in Task 5 (Teaching - Lego)

	AMD	Dispersion	TUC	Trans
AMD	1.00	-.801***	-.515**	-.602***
Dispersion		1.00	.780***	.406*
TUC		.	1.00	.296†
Trans				1.00

† *p*<.10

* *p<.05*

** *p<.01*

*** *p<.001*

among the Flexibility variables varied by task, but was generally strong for Dispersion and TUC correlations, and strong to moderate for AMD correlations. Correlations for Transitions appeared moderate for structured tasks and very low during free play, which is not surprising because fewer demands were placed on the dyads and they were free to engage in activities for a relatively longer period of time.

Principal component analyses. To further examine the delineation of flexibility variables with task type, principal components analyses (PCAs) were run on the four variables for each of the five tasks to see how the variables grouped together by task. Varimax rotation with Kaiser normalization was indicated. Only one component including all four flexibility variables emerged for all tasks, with proportion of variance accounting for 60.6% (Etch-a-Sketch) to 68.4% (Lego). Table 11 shows the eigenvalues and percentage of variance accounted for by each component, while Table 12 shows the factor loadings of the four flexibility variables for each task. Thus, the four flexibility variables appear to represent one latent construct in both unstructured and structured tasks.

Multiple discriminant function analysis. As differences in dyadic flexibility variables across different types of tasks have not been studied in-depth, a multiple discriminant function analysis was run on the four flexibility variables and five task types (see Table 13) to assess how strongly variables were associated across task types and detect orthogonal patterns of variation. The within-subject factor of task type was incorporated by using MANOVA-based SPSS syntax. The DFA analysis in Table 13 revealed two discriminant functions (DF): DF1 had an eigenvalue of 2.520, while DF2 had an eigenvalue of .279 after removing the effects of DF1. Table 14 presents the

Table 11

Eigenvalues and Percent of Variance for Principal Component Analyses for Flexibility Variables Within Tasks

	Eigenvalue	% of variance
Free Play	2.571	64.28
Clean-Up	2.591	64.79
Puzzle	2.503	62.59
Etch-a-Sketch	2.424	60.60
Lego	2.734	68.35

Criteria: eigenvalues greater than 1.

Table 12

Component Matrix in Principal Component Analysis for Flexibility Variables Within Tasks

	Free Play	Clean-Up	Puzzle	Etch	Lego
Average Mean Duration	-.890	-.868	-.881	-.758	-.895
Dispersion	.963	.941	.943	.944	.927
Total Unique Cells	.918	.841	.830	.876	.796
Transitions	.086	.495	.386	.436	.663

Note: Lower AMD represents greater flexibility.

Table 13

Multiple Discriminant Function Analysis for Flexibility Variables

Discriminant Function	Eigenvalue	Canonical Correlation	Wilks' λ	F	df	Error df	p
1	2.520	.846	.221	14.320	16	358.08	.000
2	.279	.467	.777	3.493	9	287.33	.000
3	.006	.075	.993	.202	4	238.00	.937
4	.001	.033	.999	.134	1	120.00	.715

Table 14

Structure Coefficients for Discriminant Functions for Flexibility Variables

	DF1	DF2
Average Mean Duration	-.176	**.333**
Dispersion	-.046	**-.938**
Total Unique Cells	**-.750**	**-.423**
Transitions	-.218	**-.521**

structure coefficients for each of the four flexibility variables. Structure coefficients provide the relative importance of each variable, allows meaningful labels to be assigned to the discriminant functions, and can be considered akin to factor loadings are considered in defining the DF if .30 or greater (Tabachnick & Fidell, 2001). The first DF appears to be defined primarily by Total Unique Cells (-.750), and the second DF is defined by all four flexibility measures, with Dispersion (-.938) and Transitions (-.520) appearing to have the strongest influences (see Figure 9 for plot of structure coefficients). When considering task type, all four flexibility variables appear to capture slightly different elements of flexibility, with the number of unique cells reflected in both functions. Squaring the canonical correlation values reveals that different task types account for 71.6% of the variance in the first discriminant function, and 21.8% of the variance in the second discriminant function.

Flexibility composite. Although Transitions was found to have modest correlations with the other Flexibility variables, particularly during Free Play, the finding that it accounted for a strong component of variance across tasks led to the inclusion of Transitions into the Flexibility composite. To facilitate comparisons across tasks, Dispersion, Total Unique Cells, Average Mean Duration (reversed), and Transitions were transformed into Z-scores. The mean of the standardized Flexibility variables comprised the Flexibility composite for each dyad. Figure 10 graphs the flexibility scores of the standardized flexibility variables by task type, while Table 15 shows the means, SDs, and ranges for the standardized variables as well as the overall Flexibility composite. Table 16 shows descriptive statistics for Flexibility composite scores by task type.

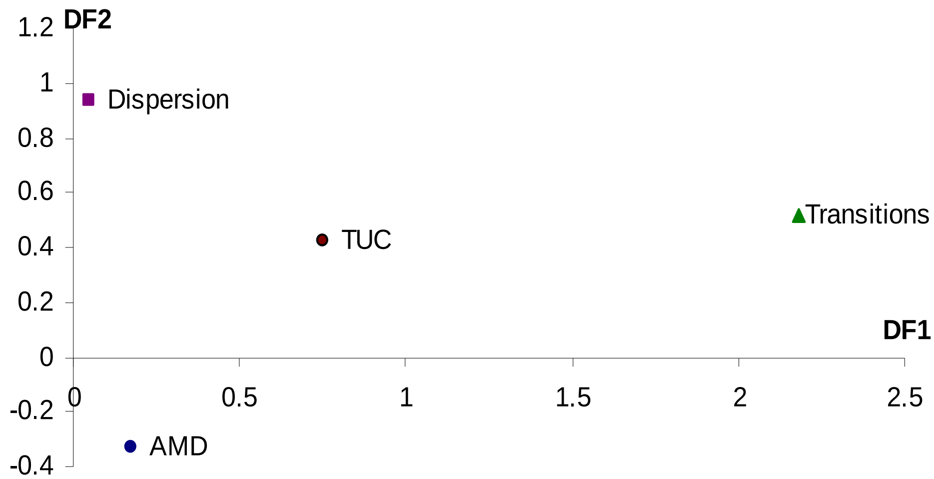

Figure 9. Structure coefficients of Flexibility measures on DF1 and DF2.

Note: Structure coefficients were computed within groups.

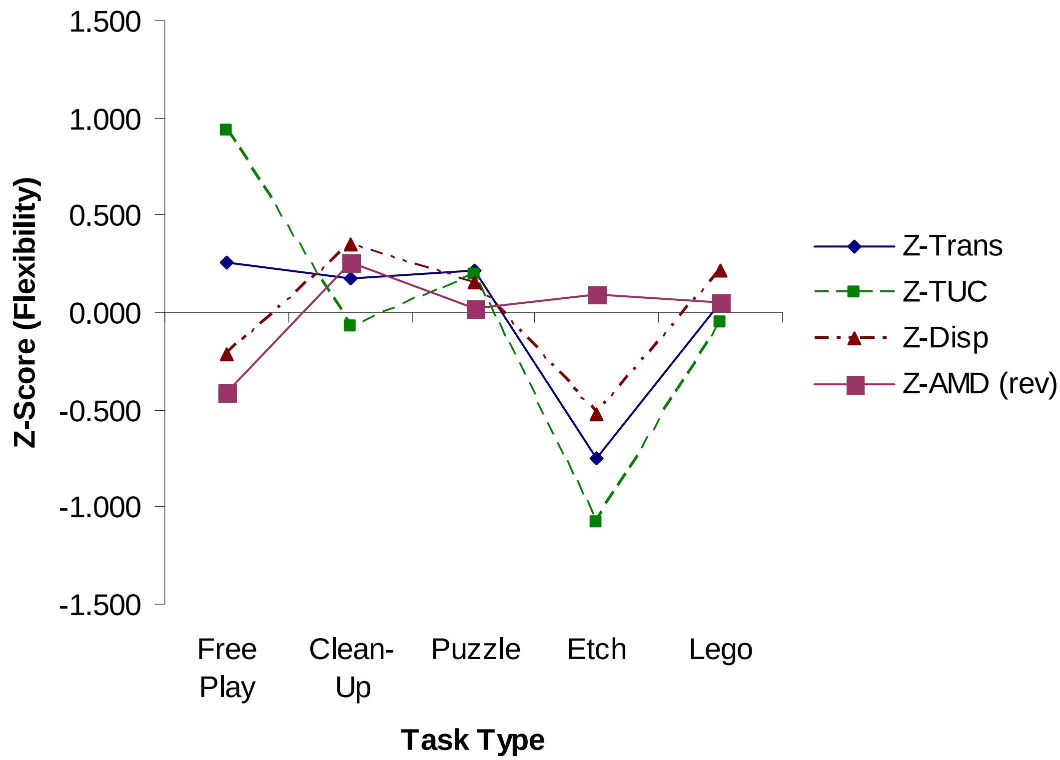

Figure 10. Graph of standardized flexibility variables by task type.

Table 15

Descriptive Statistics for Standardized Flexibility Variables and Composite across All Tasks

	Mean	SD	Min	Max
Average Mean Duration (Z-scores; reversed)	0.00	1.000	-9.37	.732
Dispersion (Z-scores)	0.00	1.000	-4.40	1.16
Total Unique Cells (Z-scores)	0.00	1.000	-2.13	2.66
Transition (Z-scores)	0.00	1.000	-8.92	.715
Flexibility (composite)	**0.00**	**0.731**	**-3.81**	**1.12**

Note: Flexibility composite is mean of all four standardized Flexibility scores.

Table 16

Means and Standard Deviations for Flexibility Composite

	n	*M*	*SD*	Min	Max
Free Play	33	.140	0.8147	-3.664	1.115
Clean-Up	33	.177	0.4677	-1.473	0.803
Teach: Puzzle	33	.146	0.5303	-2.142	0.857
Teach: Etch	31	-.565	0.9268	-3.813	0.298
Teach: Lego	33	.068	0.5926	-2.356	0.708

Canonical correlation and redundancy index analysis. Results of the canonical correlation analysis for the Flexibility composite with the 10 predictor and covariate variables are presented in Table 17. The results indicate that the two sets of variables were related in this omnibus analysis, and thus they were dissected further to the constituent multiple correlations, with the Flexibility measure for each task serving in turn as the predicted criterion variables (see e.g., Johansson, 1981). The redundancy index analysis for the Flexibility measure across the five tasks, given the 10 predictors, was .254, which was equal to the average R-squared obtained in the multiple correlation analyses. This result indicates that the group of predictor variables does constitute one aggregate and can therefore be run as such through multiple regression analyses. This result also indicates that 25.4% of the variance in Flexibility taken across the five tasks was accounted for by the set of 10 variables (i.e., predictors and covariates). It should be noted that the parenting stress and depression variables were not treated as covariates in the redundancy analysis; rather, flexibility was examined within the context of all 10 dyadic and parenting variables. Technical qualifications surrounding the interpretation of these results as well as for the PCA and DFA are presented in the Discussion below.

Covariate Analyses

*Parenting stress***.** Total scores on the PSI-SF greater than 90 are considered to be clinically significant; thus, parents in the present sample rated a high level of parenting stress (M=107.94; SD=20.331; range: 60-144). Bivariate correlational analyses were also run between total PSI scores and Flexibility, dyadic process variables, and parental characteristics across all tasks. Correlations were significant for parental Warmth (r=.263, p<.001) and Sensitivity (r=.184, p<.05). In terms of dyadic processes, parenting

Table 17

Canonical Correlation Analysis for Flexibility Composite with 10 Predictor & Covariate Variables

Canonical Variate	Eigenvalue	Canonical Correlation	Wilks' λ	*F*	DF_1	DF_2	*p*
1	.498	.577	.445	2.840	44	529.9	.000
2	.230	.433	.667	2.015	30	408.7	.001
3	.199	.408	.821	1.615	18	280.0	.056
4	.016	.126	.984	.284	8	141.0	.970

Note: PSI and BDI are entered simultaneously and therefore not treated as covariates in this analysis stress was significantly correlated with Mutual Positive (r=-.229, p<.01), with a trend for Permissiveness (r=.153, p=.058); therefore, PSI scores were entered as a covariate for the repeated-measures ANCOVA with dyadic processes, and regression analyses and MANCOVA with dyadic and parental variables.

Parental depression. Parental depression in the present sample was generally in the minimal to mild range (M=13.82; SD=10.295; range: 0-43). The lower two ranges of severity on the BDI include: minimal (0-13) and mild (14-19). Bivariate correlational analyses were run on maternal scores between BDI scores and Flexibility, five dyadic process variables (see Dyadic Processes below), and three parental characteristics (see Parental Characteristics below) across all tasks. Only parental Warmth was significantly correlated with maternal depression scores (r=.256, p<.001), with a trend towards Sensitivity (r=.152, p=.061). None of the dyadic processes were significantly correlated with BDI scores. Therefore, BDI scores were entered as a covariate for regression analyses (see Parental Characteristics) and MANCOVA (see Externalizing subgroups), and not for the repeated-measures analysis of covariance for dyadic regions below.

Dyadic Processes by Task Type

After designating the five dyadic regions on the state space grids (i.e., Mutual Positive Engagement, Mutual Negative Engagement, Scaffolding, Permissiveness, and Parent Attack), the number of events per region for each dyad was extracted from GridWare. Because the lengths of interactions differed between tasks and dyads, the number of events was divided by the total seconds of the task and multiplied by 60 to generate the number of events per minute. Thus, dyadic variables are expressed in number of events per minute for each dyadic variable. Table 18 lists descriptive

Table 18

Descriptive Statistics for Dyadic Region Variables (per min)

Dyadic Regions	Task	n	Mean	SD	Min	Max
Mutual Positive Engagement	Mean across all tasks	163	.55	.642	0	3.24
	Task 1 (Free Play)	33	.22	.182	0	0.63
	Task 2 (Clean-Up)	33	.74	.672	0	2.56
	Task 3 (Teaching – Puzzle)	33	.73	.613	0	2.64
	Task 4 (Teaching – Etch-a-Sketch)	31	.38	.747	0	3.24
	Task 5 (Lego)	33	.65	.700	0	2.71
Scaffolding	Mean across all tasks	163	1.70	1.056	0	5.08
	Task 1 (Free Play)	33	0.99	0.458	0	1.84
	Task 2 (Clean-Up)	33	1.31	0.752	0	3.62
	Task 3 (Teaching – Puzzle)	33	2.34	1.013	.14	4.09
	Task 4 (Teaching – Etch-a-Sketch)	31	1.90	1.323	0	5.08
	Task 5 (Lego)	33	1.98	0.987	0	3.53
Permissiveness	Mean across all tasks	163	.09	.186	0	1.00
	Task 1 (Free Play)	33	.06	.080	0	0.31
	Task 2 (Clean-Up)	33	.16	.284	0	1.00
	Task 3 (Teaching – Puzzle)	33	.11	.219	0	0.92
	Task 4 (Teaching – Etch-a-Sketch)	31	.03	.136	0	0.67
	Task 5 (Lego)	33	.08	.114	0	0.39
Mutual Negative Engagement	Mean across all tasks	163	.15	.416	0	3.02
	Task 1 (Free Play)	33	.08	.172	0	0.85
	Task 2 (Clean-Up)	33	.24	.434	0	2.16
	Task 3 (Teaching – Puzzle)	33	.04	.144	0	0.64
	Task 4 (Teaching – Etch-a-Sketch)	31	.29	.716	0	3.02
	Task 5 (Lego)	33	.13	.329	0	1.73

Parent Attack	Mean across all tasks	163	.16	.313	0	2.03
	Task 1 (Free Play)	33	.12	.166	0	0.63
	Task 2 (Clean-Up)	33	.18	.305	0	1.01
	Task 3 (Teaching – Puzzle)	33	.11	.168	0	0.56
	Task 4 (Teaching – Etch-a-Sketch)	31	.22	.527	0	2.03
	Task 5 (Lego)	33	.19	.279	0	1.18

information for the dyadic regions across the different task types, while Table 19 displays the bivariate correlations between the dyadic process variables and the Flexibility composite. All dyadic process variables were positively correlated with Flexibility.

Repeated measures analysis of covariance. State space grids provide a relatively new method for measuring dyadic processes, which were examined for replicability in the present study. Of particular interest was how these dyadic processes may vary across different tasks. A repeated-measures ANCOVA was run for the dyadic region variables by task type, with parenting stress scores entered as a covariate. Parenting stress was significantly associated with dyadic processes, *Pillai's Trace*=.085, $F(4,144)=3.357$, $p<.05$, partial $\eta^2=.085$ As would be expected, the nature of the dyadic interaction varied by the demands of the task at hand: *Pillai's Trace*=.325, $F(16,588)=3.249$, $p<.001$, partial $\eta^2=.081$. Posthoc comparisons using the Sidak adjustment revealed that Scaffolding was higher than Mutual Positive Engagement, which was higher than the other three dyadic processes across tasks ($p<.05$). Scaffolding was higher during teaching tasks, while Mutual Positive Engagement occurred more frequently during the Clean-Up and Puzzle tasks as compared to Free Play ($p<.05$). The three negative dyadic processes (i.e., Permissiveness, Mutual Negative, and Parent Attack) did not vary across task types. Thus, as expected, scaffolding behaviours increased when the parent was trying to help the child complete a new task, and negative processes remained somewhat stable regardless of task demands (see Figure 11).

Parental Characteristics and Dyadic Processes

Parental characteristics of warmth, sensitivity, and hostility have been studied by a number of researchers. The present study provided ratings of these characteristics

Table 19

Bivariate Correlations among Parental Characteristics, Dyadic Process Variables, Flexibility, & Covariates across All Tasks

	Flexibility	MutPos	Scaffolding	Permisssive	MutNeg	ParAtt	Warmth	Sensitivity	Hostility	PSI	BDI
Flexibility	1.00	.193*	.053	.278***	.071	.210*	.119	.226**	.164*	-.002	.136†
MutPos		1.00	.059	.105	-.035	-.058	.219**	.211**	.046	-.229**	-.055
Scaffolding			1.00	-.164*	-.238**	-.169*	.192*	.372***	-.122	-.007	.104
Permissive				1.00	.165*	-.013	-.009	-.076	.116	.153†	.127
MutNeg					1.00	.253***	.100	-.003	.232**	.079	.127
ParAtt						1.00	-.144*	-.081	.271***	-.014	.026
Warmth							1.00	.535***	-.092	.263**	.256**
Sensitivity								1.00	-.191*	.184*	.152†
Hostility									1.00	-.092	-.017
PSI										1.00	.524**
BDI											1.00

† *p*<.10
**p*<.05
***p*<.01
****p*<.001

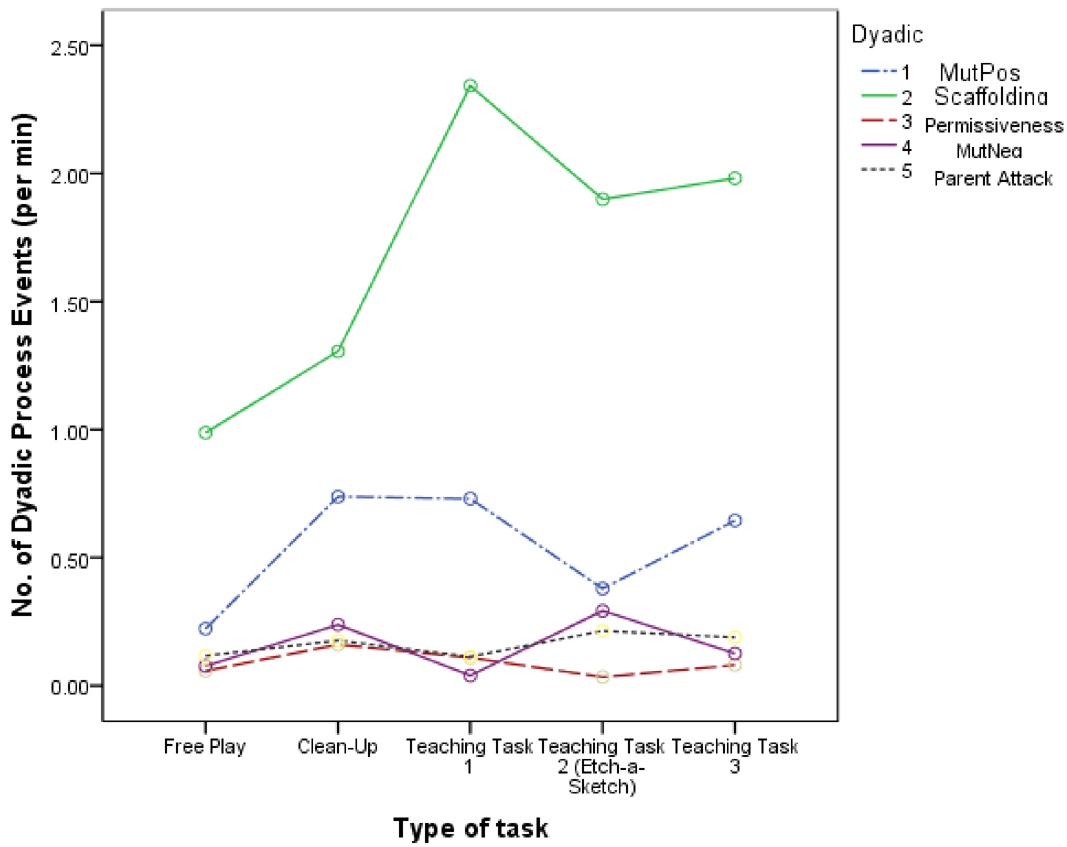

Figure 11. Graph of dyadic regions by task type.

across the interactions. The measurement of dyadic flexibility is a relatively recent contribution to the DST literature, so the parental and dyadic characteristics that predict flexibility were examined through regression analyses after looking at parental depression and parenting stress as potential covariates for subsequent analyses. Means and standard deviations are presented in Table 20 for number of events per minute for maternal characteristics (i.e., Warmth, Sensitivity, Hostility). Table 19 (above) also showed the correlations between parental characteristics, dyadic process variables, and flexibility.

Prediction of flexibility. Sequential multiple regression analyses were conducted for each task type. The three parental characteristics and five dyadic process variables were input as predictors in multiple regression analyses with dyadic flexibility as the criterion variable. Parental depression and stress scores were found to be significantly correlated with several parental and dyadic variables (see Covariates above); therefore, both BDI and PSI scores were entered as covariates in the regression analyses. The two covariates were entered in the first block in regression analyses, with parental characteristics and dyadic variables also entered in the second block. Table 19 (above) listed the correlations among the predictor and criterion variables across all tasks. Table 21 lists the results of the regression analyses within tasks. The first entry of the covariates, PSI and BDI scores, did not predict Flexibility within tasks. The second block including covariates and predictor variables showed a significant change in R-square from the first block of covariates for all tasks with the exception of the Etch-a-Sketch task. That is, while the covariates, parenting stress and parental depression, were significantly correlated with some parental and dyadic variables, when entered into regression analyses, they did not significantly predict Flexibility. More importantly, the

Table 20

Descriptive Statistics for Parental Characteristics (per min)

Parent Characteristic	Task	N	Mean	SD	Min	Max
Warmth	Mean across all tasks	163	1.85	1.556	0.00	5.96
	Task 1 (Free Play)	33	1.71	1.399	0.29	5.95
	Task 2 (Clean-Up)	33	1.46	1.562	0.00	5.86
	Task 3 (Teaching – Puzzle)	33	2.29	1.353	0.43	5.93
	Task 4 (Teaching – Etch-a-Sketch)	31	2.08	1.684	0.00	5.77
	Task 5 (Lego)	33	1.73	1.714	0.00	5.92
Sensitivity	Mean across all tasks	163	3.72	1.456	0.00	6.10
	Task 1 (Free Play)	33	3.24	1.258	0.70	5.95
	Task 2 (Clean-Up)	33	3.85	1.362	1.62	5.86
	Task 3 (Teaching – Puzzle)	33	3.80	1.274	1.09	5.93
	Task 4 (Teaching – Etch-a-Sketch)	31	3.82	1.899	0.00	6.10
	Task 5 (Lego)	33	3.92	1.405	0.00	5.92
Hostility	Mean across all tasks	163	0.12	.347	0.00	2.31
	Task 1 (Free Play)	33	0.08	.159	0.00	0.71
	Task 2 (Clean-Up)	33	0.18	.391	0.00	1.72
	Task 3 (Teaching – Puzzle)	33	0.07	.256	0.00	1.40
	Task 4 (Teaching – Etch-a-Sketch)	31	0.18	.577	0.00	2.31
	Task 5 (Lego)	33	0.08	.207	0.00	0.96

Table 21

Regression Analyses for Parental Characteristics, Dyadic Variables, and Covariates on Flexibility by Task

		R	Adj. *R-square*	df1	df2	*F*	R-square change	df1	df2	F change
Free Play	Block 1	.237	-.011	2	28	.836	.056	2	28	.444
	Block 2	.881	.665	10	20	6.949***	.720	8	20	8.056***
Clean-Up	Block 1	.163	-.043	2	28	.381	.026	2	28	.687
	Block 2	.729	.298	10	20	2.272†	.505	8	20	2.699*
Puzzle	Block 1	.203	-.027	2	28	.602	.041	2	28	.555
	Block 2	.801	.463	10	20	.3583**	.601	8	20	4.191**
Etch-a-Sketch	Block 1	.124	-.060	2	26	.202	.015	2	26	.202
	Block 2	.691	.187	10	18	1.642	.462	8	18	1.987
Lego	Block 1	.384	.087	2	28	2.426	.148	2	28	2.426
	Block 2	.768	.385	10	20	2.880*	.442	8	20	.2.699*

Block 1 – Covariates: Parenting Stress (PSI); Parental Depression (BDI)

Block 2 – Predictors: PSI; BDI; Warmth; Sensitivity; Hostility; Mutual Positive; Scaffolding; Permissiveness; Mutual Negative; Parent Attack

†$p<.10$

*$p<.05$

**$p<.01$

***$p<.001$

parental characteristics and dyadic variables significantly predicted Flexibility over and above the effects of parental stress and depression across both unstructured and structured tasks. Specifically, the group of predictor variables significantly predicted Flexibility across all tasks and within Free Play and the Puzzle and Lego teaching tasks. The predictors showed a trend towards predicting Flexibility in the Clean-Up task.

The standardized regression coefficients (β) and *t*-values for each predictor variable are shown for Free Play and Clean-Up in Table 22, and for the three teaching tasks in Table 23. In Free Play, Sensitivity positively predicted Flexibility while Warmth negatively predicted Flexibility, accounting for 49.4% of the variance in Flexibility. The group of predictor variables showed a trend towards predicting Flexibility in the Clean-Up task (p=.071), accounting for 27.5% of the variance in Flexibility, with Parent Attack and Permissiveness comprising a larger proportion of the variance. In the teaching Puzzle task, Permissiveness, Sensitivity, and Parent Attack predicted Flexibility, with the predictors together accounting for 32.6% of the variance in Flexibility. The group of variables did not predict Flexibility in the Etch-a-Sketch task. Scaffolding and Hostility positively predicted Flexibility in the teaching Lego task, while the covariate of parenting stress negatively predicted Flexibility, with the predictors together accounting for 42.6% of the variance in Flexibility. Thus, in general, sensitivity and/or scaffolding, or being attuned to the child's needs and adjusting behaviours to those needs, predicted flexibility across most tasks. Mutual processes, whether mutually positive or mutually negative, did not tend to predict flexibility across most tasks. Somewhat surprisingly, parental permissiveness and parent attack (i.e., parent acting negatively towards the child acting in a neutral or positive manner) also tended to predict flexibility in more structured tasks.

Table 22

Regression Coefficients for Parental Characteristics, Dyadic Variables, and Covariates on Flexibility for Free Play and Clean-Up

	Free Play			Clean-Up†		
	β	t	Partial r	β	t	Partial r
PSI	.141	.593	.132	-.150	-.740	-.115
BDI	.001	.007	.001	.035	.182	.028
Warmth	-.581	**-2.661***	-.511	-.110	-.469	-.073
Sensitivity	.738	**3.094****	.569	.192	.904	.140
Hostility	.242	1.176	.254	.083	.429	.067
MutPos	.303	1.841†	.381	.300	1.696	.264
Scaffolding	.273	1.623	.341	.093	.537	.084
Permissiveness	.097	.471	.105	.381	**2.107***	.327
MutNeg	.188	.903	.198	.281	1.462†	.227
Parent Attack	.302	1.768†	.368	.419	**2.323***	.361

†$p<.10$

*$p<.05$

**$p<.01$

Table 23

Regression Coefficients for Parental Characteristics, Dyadic Variables, and Covariates on Flexibility for Teaching Tasks

	Puzzle			Etch-a-Sketch			Lego		
	β	t	Partial r	β	t	Partial r	β	t	Partial r
PSI	-.377	-1.618	-.340	-.203	-.716	-.167	-.419	**-2.197***	-.441
BDI	.179	.701	.155	-.165	-.698	-.162	.318	1.771	.368
Warmth	-.168	-.703	-.155	-.023	-.097	-.023	.315	1.636	.344
Sensitivity	.726	**2.693****	.516	1.040	**2.637***	.528	-.238	-1.234	-.266
Hostility	.327	1.946†	.399	.202	1.182	.268	.417	**2.362***	.467
MutPos	.018	.078	.018	-.319	-1.297	-.292	.250	1.554	.328
Scaffolding	-.035	-.179	-.040	-.580	-1.639	-.360	.618	**3.497****	.616
Permissive	.476	**2.561***	.497	.203	.763	.177	.027	.182	.041
MutNeg	-.005	-.030	-.007	.007	.029	.007	.139	.799	.176
ParAtt	.427	**2.494***	.487	.025	.093	.022	-.151	-.974	-.213

$^{\dagger}p<.10$

$^{*}p<.05$

$^{**}p<.01$

Externalizing Subgroups

As one of the study inclusion criteria, all children in the sample were clinically elevated on the Externalizing subscale of the Child Behavior Checklist (CBCL; Achenbach, 1991; Achenbach & Rescorla, 2001). Research studies have considered a T-score of 63 or above to signify clinical elevations (Achenbach & Rescorla, 2001). Children with 'Externalizing-only' scores (*EXT*; $T_{EXT} >= 63$; $T_{INT} < 63$) were compared with children with who were rated by caregivers as clinically elevated on both CBCL Externalizing and Internalizing subscales (*MIXED*; $T_{EXT} >= 63$; $T_{INT} >= 63$). CBCL ratings were missing for two participants, resulting in 11 children in the EXT subgroup and 20 children in the MIXED group.

MANCOVA. A two-way MANCOVA was conducted on the maternal characteristic and dyadic process variables with both Externalizing subgroup and Task type as IVs, and PSI and BDI scores as covariates. In terms of the covariates, the main effect of PSI was significant, *Pillai's Trace* = .196, $F(9,133) = 3.601$, $p<.01$, partial η^2=.196, while the main effect of BDI was not, *Pillai's Trace* = .073, $F(9,133)$ =1.172, p=ns, partial η^2=.073. The interaction between Externalizing groups and Task type was not significant, *Pillai's Trace* = .250, $F(36,544)$ =1.007, p=ns, partial η^2=.062. The main effect of Externalizing group, however, was significant, *Pillai's Trace* = .168, $F(9,133)$ = 2.982, $p<.01$. The partial η^2 value was .168, indicating that 16.8% of the variance between group, task, and the DVs was accounted for by the Externalizing subgroup. Posthoc analyses using the Sidak adjustment indicate that the MIXED subgroup was higher than the Externalizing-only subgroup across tasks on parental Hostility, Parent Attack, and Flexibility ($p<.05$; see Table 24). Figures 12 through 20 show scores on the

Table 24

Univariate Analyses for Main Effect of Externalizing Subgroup on Parental Characteristics and Dyadic Process Variables.

	F (1, 133)	Partial η^2	EXT -Only (*n*=55)		MIXED (*n*=99)	
			M	*SD*	*M*	*SD*
Flexibility	5.796*	.039	-.19	.906	.10	.602
Warmth	2.077	.015	1.65	1.243	1.97	1.741
Sensitivity	1.023	.007	3.60	1.522	3.77	1.457
Hostility	13.504***	.087	.03	.116	.155	.387
Mutual Positive	.075	.001	.63	.741	.47	.548
Scaffolding	.183	.001	1.71	1.194	1.72	.981
Permissiveness	2.523	.018	.04	.080	.11	.221
Mutual Negative	.142	.001	.10	.283	.17	.446
Parent Attack	10.727**	.071	.08	.192	.20	.316

*p<.05

**p<.01

***p<.001

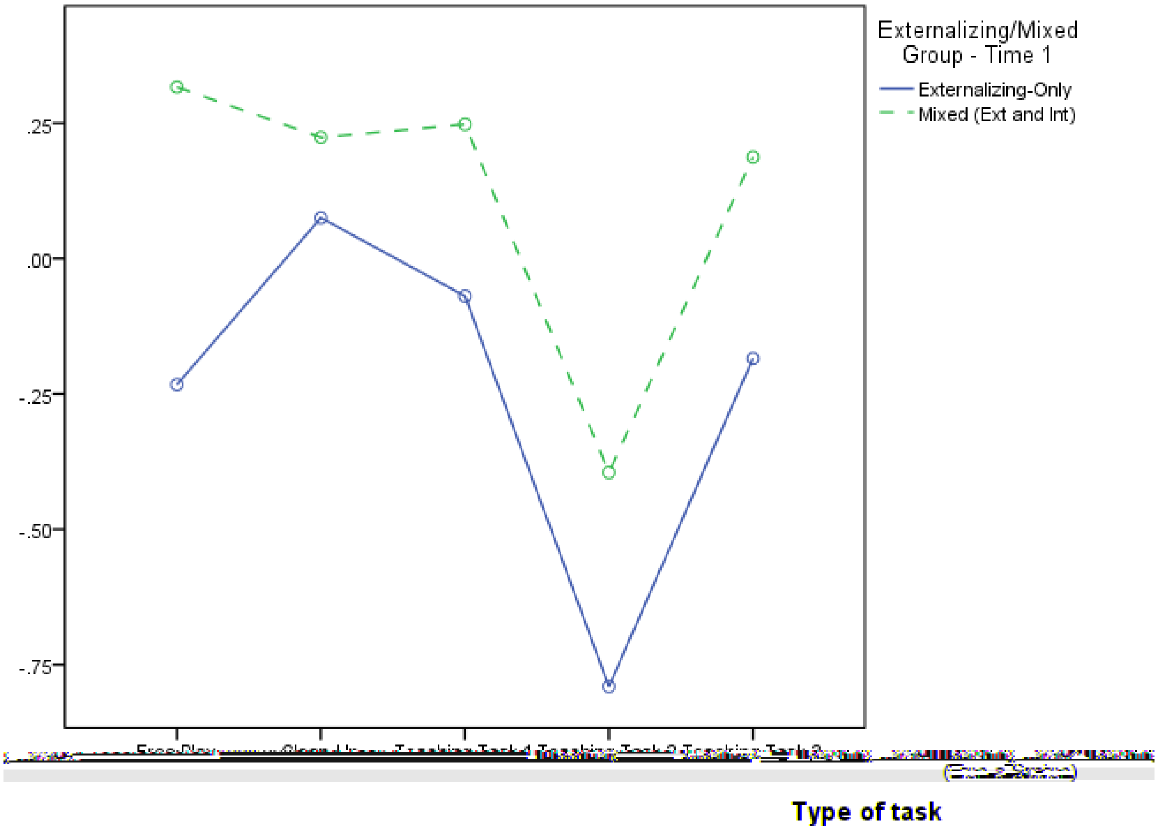

Figure 12. Flexibility scores for EXT and MIXED groups across tasks. The MIXED group had higher Flexibility scores overall (p<.05).

Note: Covariates appearing in the model are evaluated at the following values: PSI - Total - Pre-Tx = 107.7516, BDI (I or II) - Pre-Tx = 13.6307.

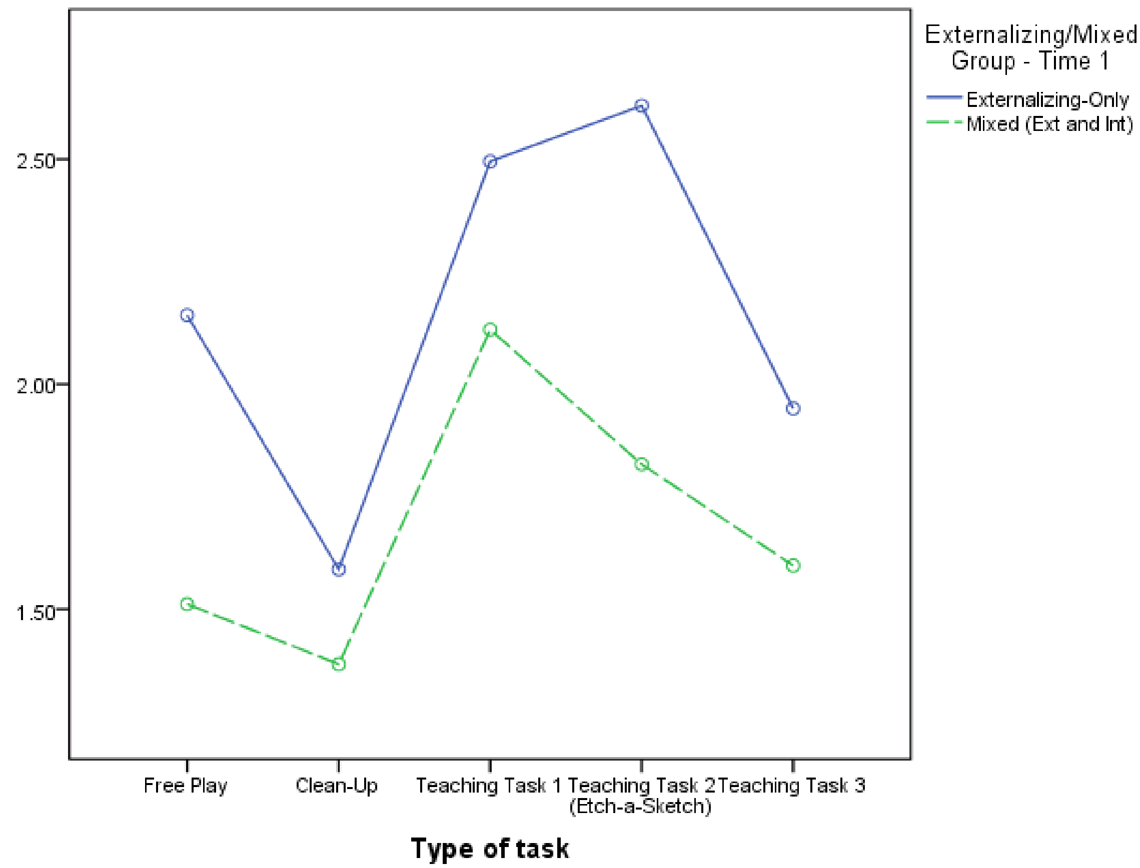

Figure 13. Warmth scores for EXT and MIXED groups across tasks.

Note: Covariates appearing in the model are evaluated at the following values: PSI - Total - Pre-Tx = 107.7516, BDI (I or II) - Pre-Tx = 13.6307.

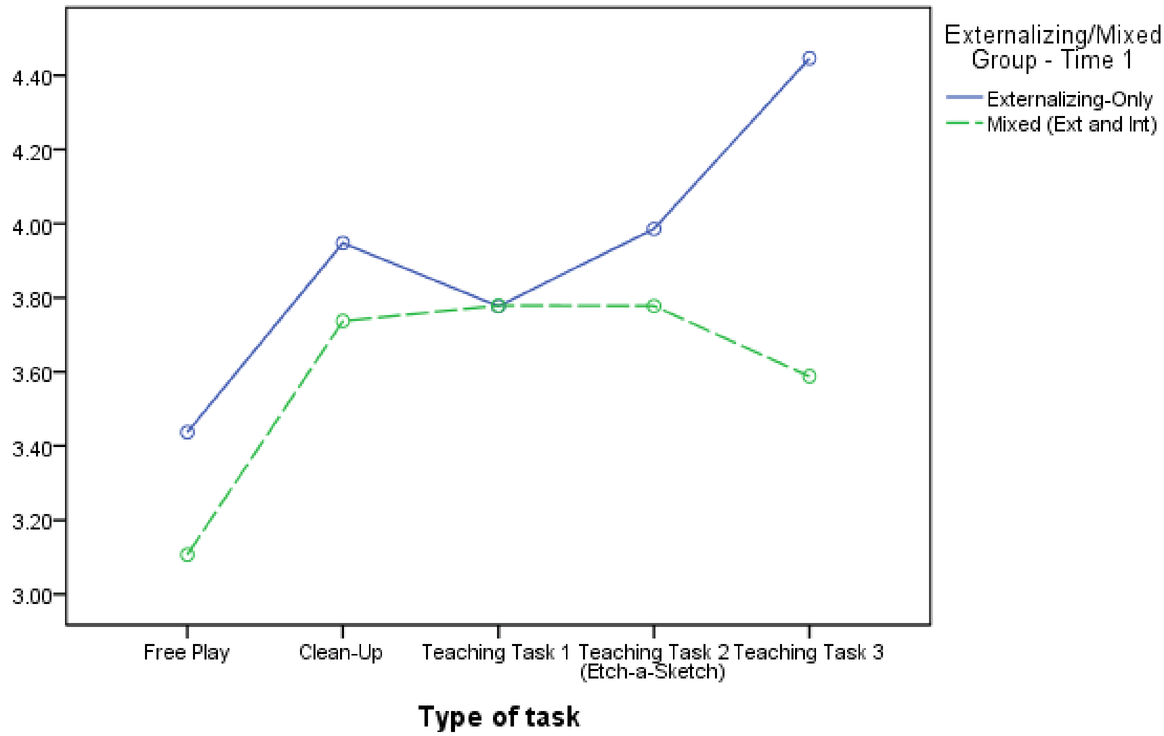

Figure 14. Sensitivity scores for EXT and MIXED groups across tasks.

Note: Covariates appearing in the model are evaluated at the following values: PSI - Total - Pre-Tx = 107.7516, BDI (I or II) - Pre-Tx = 13.6307.

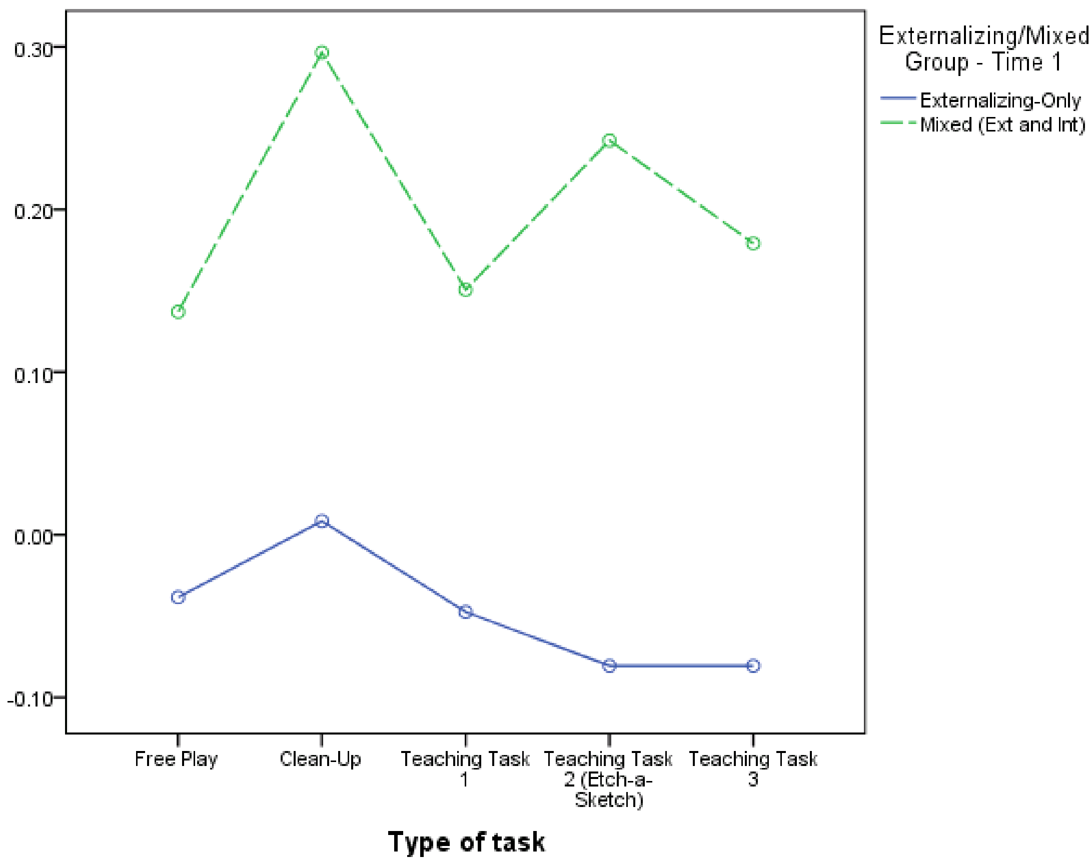

Figure 15. Hostility scores for EXT and MIXED groups across tasks. The MIXED group had higher Hostility scores overall (*p*<.001).

Note: Covariates appearing in the model are evaluated at the following values: PSI - Total - Pre-Tx = 107.7516, BDI (I or II) - Pre-Tx = 13.6307.

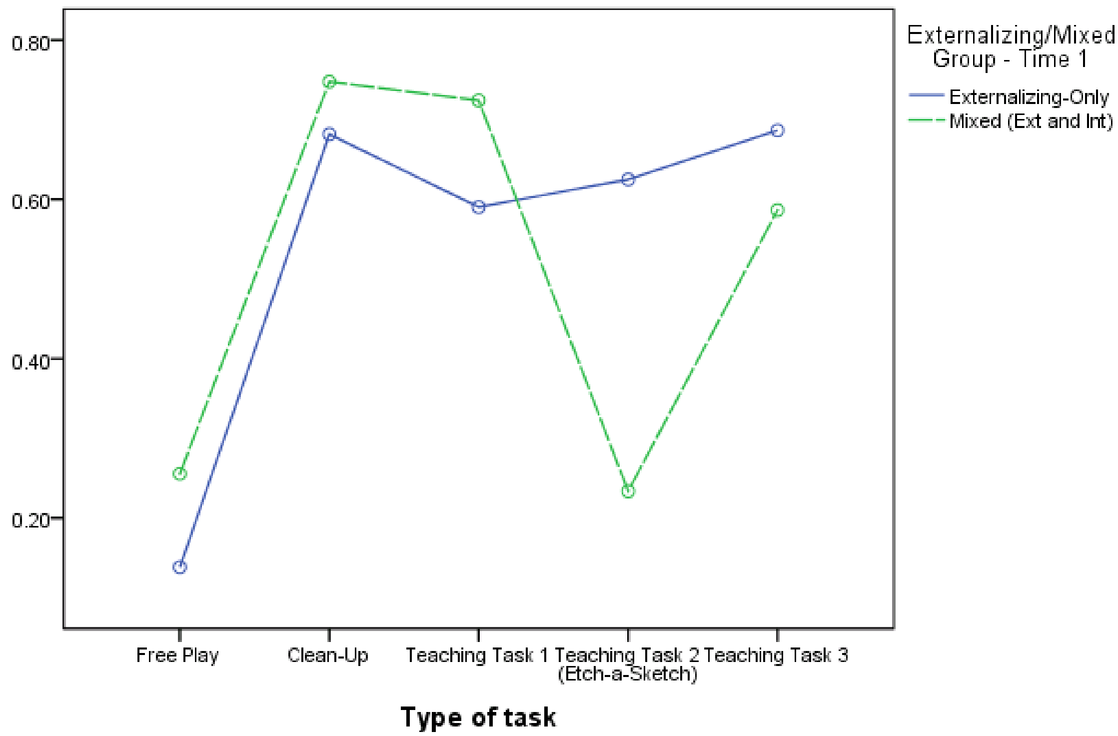

Figure 16. Mutual Positive Engagement scores for EXT and MIXED groups across tasks.

Note: Covariates appearing in the model are evaluated at the following values: PSI - Total - Pre-Tx = 107.7516, BDI (I or II) - Pre-Tx = 13.6307.

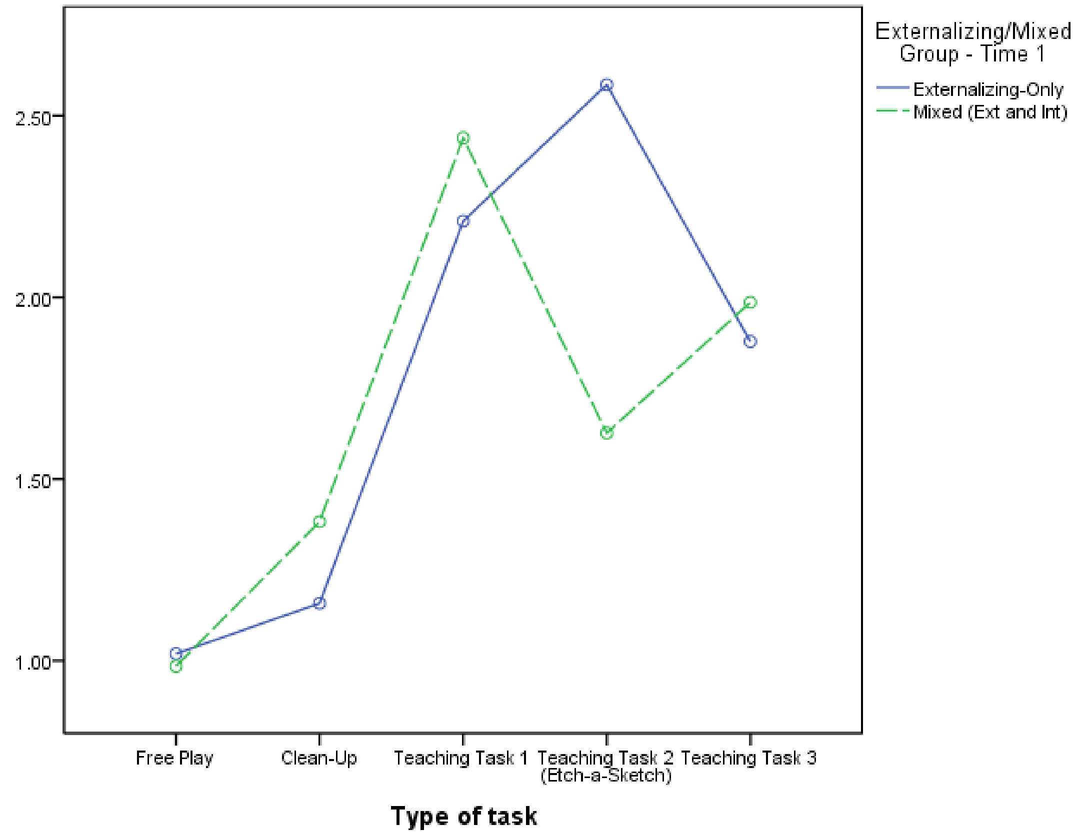

Figure 17. Scaffolding scores for EXT and MIXED groups across tasks.

Note: Covariates appearing in the model are evaluated at the following values: PSI - Total - Pre-Tx = 107.7516, BDI (I or II) - Pre-Tx = 13.6307.

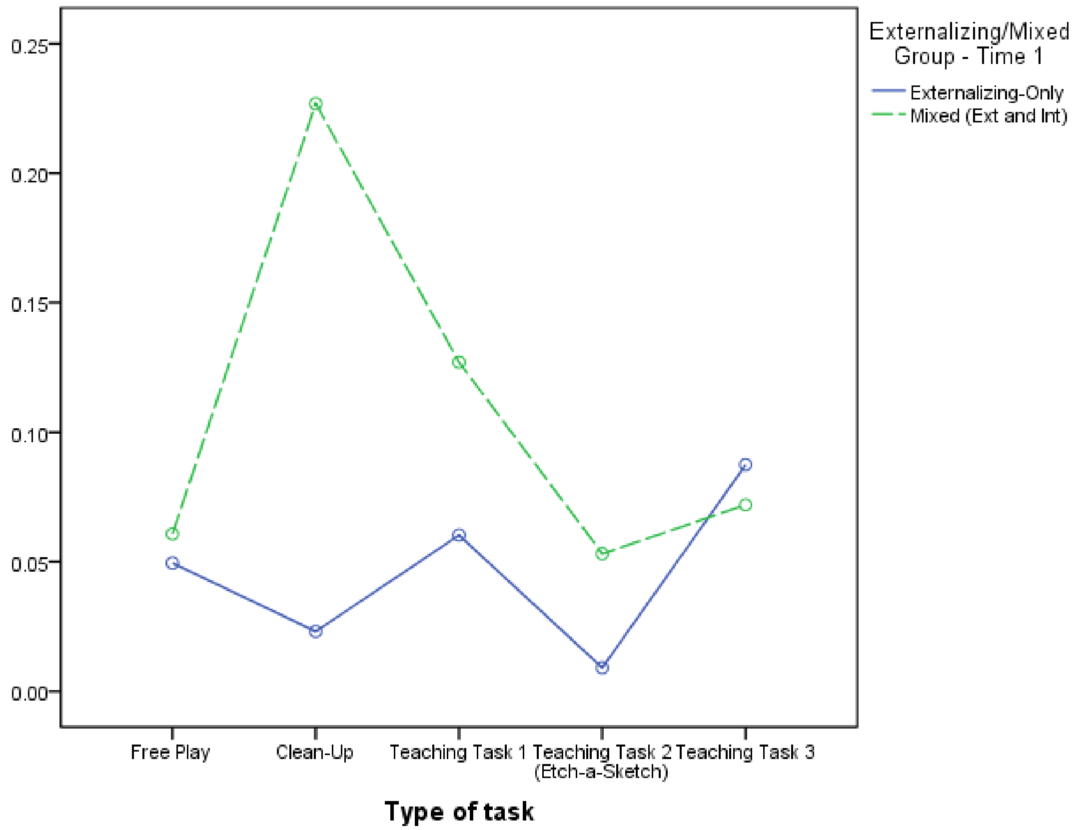

Figure 18. Permissiveness scores for EXT and MIXED groups across tasks.

Note: Covariates appearing in the model are evaluated at the following values: PSI - Total - Pre-Tx = 107.7516, BDI (I or II) - Pre-Tx = 13.6307.

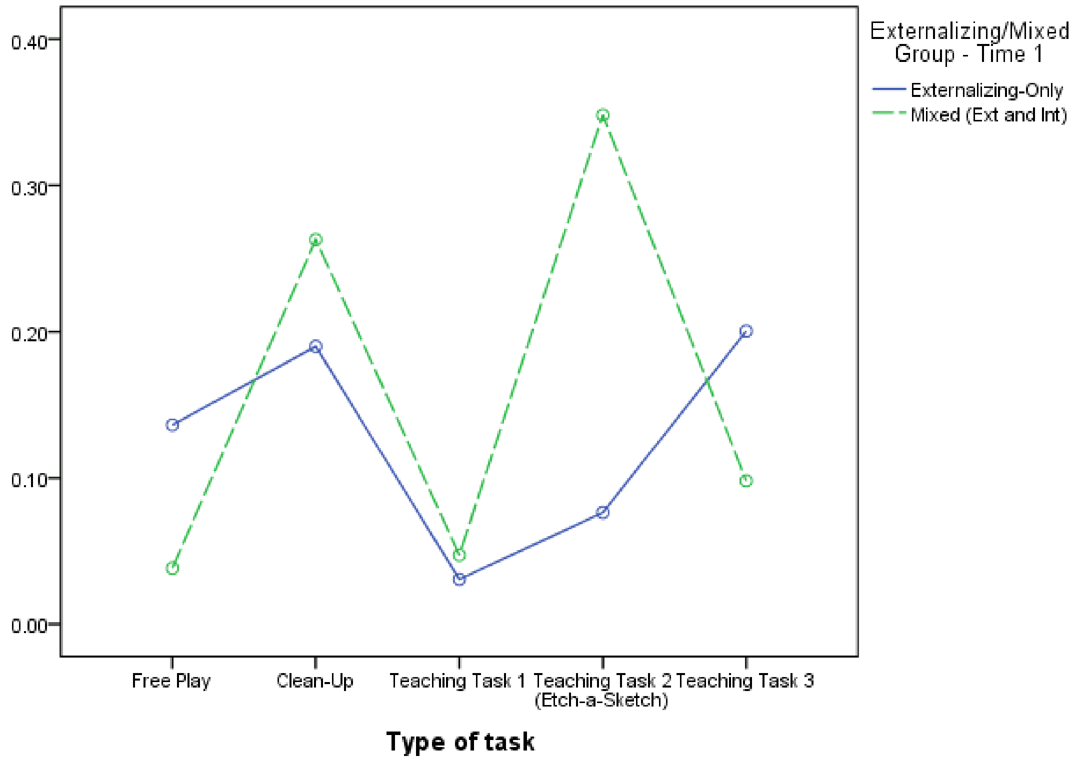

Figure 19. Mutual Negative Engagement scores for EXT and MIXED groups across tasks.

Note: Covariates appearing in the model are evaluated at the following values: PSI - Total - Pre-Tx = 107.7516, BDI (I or II) - Pre-Tx = 13.6307.

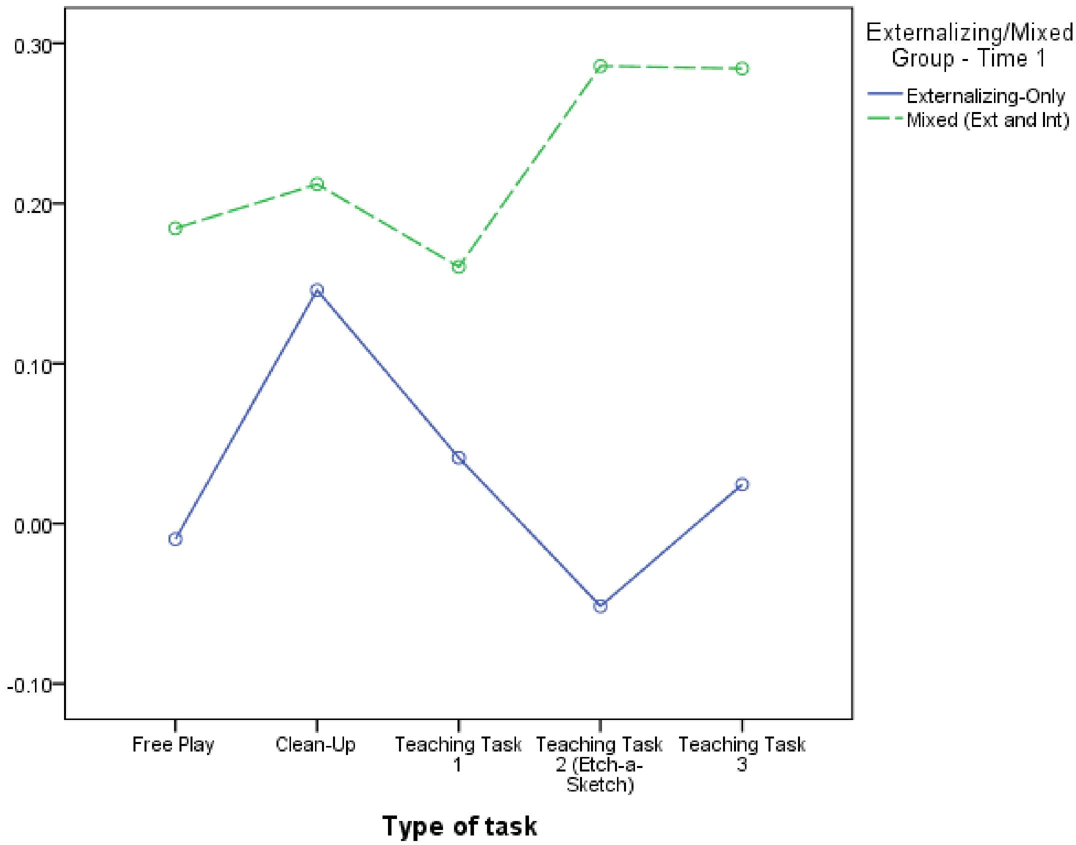

Figure 20. Parent Attack scores for EXT and MIXED groups across tasks. The MIXED group had higher Parent Attack scores overall (*p*<.01).

Note: Covariates appearing in the model are evaluated at the following values: PSI - Total - Pre-Tx = 107.7516, BDI (I or II) - Pre-Tx = 13.6307.

DVs across tasks. The proportionality of the univariate F-ratios for Externalizing subgroup was compared to the structure coefficients for the dependent variables. The univariate F-ratios were not proportional to the structure coefficients, indicating the possibility of highly correlated response variables (Harris, 1985). It was noted that the univariate F-ratios were proportional to the standardized canonical discriminant function coefficients (see Table 25).

Discussion

The primary goal of the present study was to apply measures of flexibility derived from prior DST research to a sample of young children with behaviour problems across different types of parent-child interactions. The majority of previous studies using dynamic systems methodology to study dyadic interactions have assessed the structure of interactions using situations designed to provoke some form of conflict, often in the form of a problem-solving discussion regarding a topic pre-identified as medium-to-high conflict by the participants. Flexibility in interactions is important not only with respect to pressured situations involving negative emotions, but also in the daily, reciprocal nature of unstructured free play time with caregivers. Thus, both an unstructured, pleasurable task and structured tasks with specific end goals were assessed in the present study.

Derivation of the Flexibility Composite

Several measures of dyadic flexibility had previously been identified using state space grids (SSGs), but had not been examined together in one study. The flexibility variables most applicable to the young, clinical sample in the present study were identified to construct a general flexibility composite.

Table 25

Structure and Standardized Coefficients for Discriminant Functions by Externalizing Subgroups

	Structure coefficients	Standardized coefficients
Parenting stress	.170	.739
Parental depression	.618	.467
Flexibility	.193	.139
Warmth	.099	-.092
Sensitivity	.059	.005
Hostility	.190	.389
Mutual Positive	-.129	-.067
Scaffolding	.006	.062
Permissiveness	.208	.104
Mutual Negative	.094	.032
Parent Attack	.202	.333

Note: Structure coefficients consist of the pooled within-group correlations between the single discriminant function weighted sums and the variables in the model.

Principal components analyses. The four flexibility measures were run through principal components analyses for each task. Oblique rotation methods have been considered a more realistic representation of psychological constructs in exploratory factor analyses (Fabrigar, Wegener, MacCallum, & Strahan, 1999). Because it was anticipated that the flexibility measures would comprise one component, orthogonal rotation was considered to be more appropriate to the present study because it tends to maximize variance by reapportioning it among factors so they become relatively equal in importance (Tabachnick & Fidell, 2001). Indeed, one component comprising the four flexibility variables was extracted; thus, no components were rotated. Should more than one component have emerged, alternative rotation methods could have been considered, and would be more appropriate in future research. Criticisms have been levelled at the commonly-used 'eigenvalue-greater-than-one' decision rule in component extraction as it typically overestimates the number of components in an analysis (Zwick & Velicer, 1986). Procedures such as parallel analysis and Velicer's minimum average partial (MAP) test have been increasingly recognized as more robust means to determine the number of principal components to retain (O'Connor, 2000). For example, parallel analysis compares eigenvalues obtained from principal components analysis (PCA) to eigenvalues from random values of the same dimensionality; thus, it is less likely to over-extract components as compared to PCAs which use a minimum eigenvalue of one.

In the present study however, one component was expected based on previous research. The four variables subjected to PCA in the present analysis have been used interchangeably in several previous studies as measures of flexibility. Over-extraction of components tends to diffuse variables, resulting in a higher likelihood of factor-splitting or factors with few high loadings (Zwick & Velicer, 1986). Because the purpose of conducting PCA in the present study was to assess whether the flexibility variables would align as one component, *under*-extraction would have been more problematic as it tends to compress variables, one result of which could be a distorted fusing of more than factor (O'Connor, 2000). Over-extraction and subsequent over-interpretation in the PCA was considered less of an issue in the present due to previous research using these flexibility variables.

In regards to the relatively small sample size in the present study, Guadagnoli and Velicer (1988) have argued that components loading higher than .60 may be interpreted regardless of sample size, while Velicer and Fava (1998) later indicated that a minimum of three such large loadings would suffice. Three of the four flexibility variables in the present study met this standard throughout four tasks, while all four variables showed at least moderate loadings in the last task (i.e., Teaching: Lego). In light of the use of the four variables as measures of flexibility in previous research as well as their large loadings (i.e., saturation), it appears likely that the finding that the four variables generally comprised one component will be replicated in other studies. It would be informative, however, for future researchers to examine whether the Transitions variable (i.e., number of movements between cells) differs somewhat across tasks with respect to the other flexibility variables as it appears to in the present study. While previous studies have used the four variables in the present analyses as measures of flexibility, no studies have yet examined them all in one study and assessed how they grouped by task. The PCA presented above indicates that the four purported flexibility measures do appear to group as one construct, with some difference in the number of transitions per task.

Complementing the PCA, a discriminant function analysis was performed to examine how the flexibility variables collectively differed by task type, taking into account between- and within-task covariance structures.

Discriminant function analysis. Two discriminant functions emerged, with the first discriminant function structure coefficients indicating the main contributor for the first discriminant function to be the total number of unique cells, or range of movement between different states. All four flexibility measures contributed to the second discriminant function, with grid dispersion and the number of transitions per minute as the primary contributors. It should be emphasized that the second discriminant function was orthogonal to the first discriminant; that is, the relative contribution of each flexibility variable as indicated by the DFA should be interpreted with some caution as it involves the removal of the residual effects of the first discriminant, and any effect of each variable occurs in the context of the other three variables collectively (Neufeld, 1977). Thus, the relative contribution of each variable in the present analysis can be considered as an approximation or guide. The relative contribution of each flexibility variable to the discriminant functions should also be interpreted with some caution because the Wilks' lambda test for discriminating between functions is tested with respect to the chi-square distribution, which may tend to overestimate significance levels (Harris, 1975). The logic of the interpretation of the discriminant functions can be questionable (Neufeld, 1977). It should be kept in mind that, mathematically, the test for residual systematic covariation is based on the remaining relationships after the first discriminant function has been removed, and treats the remaining discriminant functions *collectively.* An inaccurate interpretation that can occur is: if the test of the residual covariation between two sets of variables is significant with the covariation by the first discriminant function included, but not significant upon its exclusion, then the first discriminant function was responsible for the significant relationship (Neufeld, 1977). In actuality, the test should be used as an omnibus test that treats the residual configurations of overlap simultaneously (Neufeld, 1977). Thus, due to the fallibilities and frailties of DFA, particularly with the small sample size, the relative contribution of each flexibility variable to the discriminant function can be considered to be an approximation in the context of the other flexibility variables. The first discriminant function had a high loading (i.e., eigenvalue), which indicates that it will be likely be more stable in future studies relative to the second discriminant function despite the small sample size in the present study as the 'saturation' or level of loading has been found to increase the replicability of multivariate results (Guadagnoli & Velicer, 1988).

Canonical correlation and redundancy index analyses. Results of the canonical correlation analysis for the Flexibility composite with the 10 predictor and covariate variables indicated that the two sets of variables were related in this omnibus analysis. The redundancy index analysis indicated that 25.4% of the variance in Flexibility was accounted for by the set of 10 variables (i.e., predictors and covariates) and was equivalent to the average squared multiple correlation (Johansson, 1981). This result indicates that a reasonable proportion of the variance in the flexibility measures as administered across the five tasks, approximately one-quarter of the variance, is captured by the 10-variable predictor set in the present sample.

Flexibility composite. The four measures of flexibility have been used in previous studies, but have not been studied in one study and combined as one aggregate measure.

The above three analyses indicate that the four flexibility variables do appear to align as one component overall, as well as indicate some unique contributions to a global flexibility composite when considered collectively across tasks. Therefore, the four flexibility measures were standardized and the mean of all four Z-scores comprise the aggregate Flexibility composite. The caveats listed above in terms of the potential fallibilities in the multivariate analyses, particularly in consideration of the small sample size, should serve as a caution, although high loadings in the PCA and DFA increase confidence in the replicability of the results (Guadagnoli & Velicer, 1988).

Another caveat regarding the subsequent regression analyses and MANCOVA concerns the fact that the flexibility composite is comprised of aggregated data (i.e., summed within each task) prior to analyses. Overall, however, Wainer (1976, 1978) has argued that significant variability can exist among regression weights with little detriment to prediction, particularly with behavioural data. With the above potential caveats in mind, the subsequent analyses using the flexibility composite are presented below.

Dyadic Processes Across Tasks

The present study also examined dyadic processes and whether they differed across task type. Parenting stress and maternal depression were considered as potential covariates for analyses. Levels of parenting stress were at clinically significant levels in the present sample, while depression was generally in the minimal to mild range. Self-rated parenting stress was significantly associated with parental warmth and sensitivity, and mutual positive engagement, with a trend towards permissiveness. Self-rated parental depression was associated with parental warmth, with a trend towards parental sensitivity. Because only parenting stress was associated with dyadic processes, only this covariate was entered in the repeated-measures ANCOVA with dyadic variables.

A repeated-measures ANCOVA was run for dyadic region variables to assess the strength of associations with task types. The covariate, parenting stress, was associated with dyadic processes. After accounting for parenting stress, dyadic processes were found to differ with respect to task types. As might be expected, mutual positive engagement appeared more often in structured tasks than in free play, and scaffolding appearing more often in teaching tasks. Negative dyadic processes varied little across task types. The differential associations of positive and negative parenting behaviours by type of interaction highlights the importance of examining task type in this sample of clinic-referred children.

Prediction of Flexibility by Parental Characteristics and Dyadic Processes

The eight parental and dyadic variables were entered into regression analyses to examine which variables predicted flexibility by task type. Because both parenting stress and depression were associated with parental characteristics, they were both entered as covariates in sequential regression analyses. In general, only those processes involving dyadic synchrony did not predict flexibility across tasks: when the mother and child were behaving mutually positively or mutually negatively towards one another, with the exception of mutual positive engagement during free play. Flexibility involves being attuned to the other person and adjusting emotional and behavioural responding as needed. If two dyad members are acting synchronously in a positive manner, presumably there is little need to adjust behaviour. Negative synchrony may make it especially difficult to be able to shift one's perspective and change responding or even recognize that adjustments may be needed. Of particular interest was how parental and dyadic predictors varied with respect to different task demands. Somewhat different predictors of flexibility emerged when examining regression analyses by task type.

Free play. Flexibility was positively predicted by parental sensitivity and negatively predicted by parental warmth, accounting for two-thirds of the variance. As free play was unstructured in the present study and continued for a relatively long duration (mean of 19.5 minutes), parent-child dyads were free to engage in a variety of interactions and activities. The nature of an unstructured task with relatively few goals aside from interacting and enjoying each other's company will likely bring forward a range of emotions and behaviours as dyad members engage in different types of imaginative and object-focused play. Thus, it is not surprising that more variability would be shown during an unstructured play interaction. That parental warmth negatively predicted flexibility is somewhat puzzling, although it showed a moderate and positive correlation with flexibility within free play. One possibility may be that parents do not feel the need to adjust their behaviours when they are acting warmly to their children, therefore decreasing variability in emotional states.

Clean up. In contrast to unstructured free play, engaging in tasks with a clear end goal may necessitate different characteristics for a successful resolution. There was a trend for parent attack and permissiveness to predict flexibility when parents directed their children to clean up the play area. Regarding permissiveness, one possibility may be that the parents were trying to allow their children the freedom to self-regulate and begin to figure out how to accomplish tasks themselves; however, not intervening effectively when children act inappropriately could mark the beginning stages towards a trajectory of externalizing behaviour problems in young children. If children did not initiate clean-up effectively and independently, parents may have become impatient due to their expectations of children's abilities, or they may have formed negative interpretations for their children's lack of immediate compliance and reacted negatively, thereby leading to parent attack. Parent attack refers to the parent acting negatively while the child acts in a positive or neutral manner. One possibility for the association between parent attack and flexibility in the clean-up task could be that the child was attempting to continue the play aspect of the interaction while the parent was feeling pressured to have the child comply with clean-up. Another possibility is that the child was complying with the mother's request made in a negative manner (compliance was subsumed in the positive category in analyses). Children are expected to increasingly take on responsibility as they age for household tasks such as cleaning up after themselves. When having to interrupt a pleasant and fun play period to clean up toys, children may experience frustration and disappointment that can manifest in delaying or refusal. Over time, parents may learn to anticipate negative responses or become frustrated if tasks are not completed efficiently or in a timely manner, and therefore may show negative behaviours more quickly.

Teaching tasks. The three teaching tasks were associated with different predictors of flexibility in the present study. The group of predictor variables did not predict flexibility in the Etch-a-Sketch task. Different predictors of dyadic flexibility emerged for the puzzle and Lego tasks. In the puzzle task, permissiveness, parental sensitivity, and parent attack accounted for almost half of the variance in flexibility. In the Lego task, scaffolding and parental hostility predicted flexibility, while the parenting stress covariate negatively predicted flexibility. The puzzle task was the first teaching task, coming immediately after the clean-up task. It involved a relatively simple task compared to building the toy truck in the Lego task. One possibility for the prediction of flexibility by negative maternal characteristics in the puzzle task may be that parents became impatient if their children could not quickly solve the relatively simple puzzle task. Another possibility is that, being the first teaching task, dyads were still transitioning from a fun play period and then having to clean up toys, to being asked to participate in more goal-oriented tasks. As the parents and children played with toys together in the play period, children may have kept pushing their parents to actively help them with the puzzle task, with parents becoming frustrated as they were directed not to touch the puzzle pieces or physically help the child solve the puzzle. Therefore, due to the sequencing of tasks, the puzzle task may not only have captured a teaching aspect of the interaction, but also the child adjusting to having to transition from an interactive, ‘hands-on’ fun period to a goal-oriented task in which parents had to remain ‘hands-off’.

It seems counterintuitive that coder-rated parental hostility would predict flexibility in the Lego task. One possibility could be that the Lego task was the last task, occurring approximately 30 minutes into the interaction. Parents may have become frustrated with their children if they had demonstrated noncompliance and/or difficulty with previous tasks. Another factor may involve over-estimation of their child’s capabilities. For example, Moorman and Pomerantz (2008) found that mothers demonstrated more hostility following their children’s helplessness during a difficult task if they believed they could influence their children’s self-control. Similarly, parents in the present study may have thought that showing greater flexibility with their children during a more complex task should have facilitated their children's ability to successfully complete the task, and if they perceived it did not, may have become frustrated as a result.

That scaffolding predicted flexibility in the latter, relatively more complex Lego task is what would be expected when parents are actively assisting and structuring their child to complete a multi-step solution on their own. This could be considered a relatively more 'pure' form of interaction in a structured, teaching task; however, daily interactions rarely occur in an emotional vacuum. Individuals inevitably carry stresses and expectations from other events and parent-child interactions occur in such a context. While the last teaching task may have more accurately captured the essence of a teaching task, the confluence of circumstances in the first teaching task may be more reflective of daily reality. This difference highlights the potentially confusing nature of interactions and unpredictability of individuals' responses when dyad members are unaware of how other factors influence their interactions. Thus, the nature and goals of the interaction in which a dyad is engaged is essential to consider when examining dynamics of the relationship. Also of importance is the context in which the interactions occurs; for example, the circumstances immediately preceding the studied interaction.

The relative lack of variation during the structured Etch-a-Sketch task is not surprising as the task involved a very circumscribed end goal with only one method to attain the end goal: each dyad member had to turn their respective dial in a specific manner to continue to the next step. Indeed, the length of time to completion of the Etch-a-Sketch task was much shorter than for other tasks. The other two teaching tasks also involved specific end goals, but they were more complex than the Etch-a-Sketch task and did not necessarily involve a specific order for successful completion.

The above results add to DST and developmental psychopathology research by examining dyadic processes across different types of tasks and looking at predictors of flexibility. Another area that has been examined relatively little is differences between subgroups of children with externalizing difficulties. The following section summarizes the results of examining externalizing subgroups across the various tasks.

Externalizing Subgroups

Researchers have studied children with externalizing behaviour problems for a number of years, but have examined relatively less whether processes differ between subgroups of children with externalizing behaviour problems. Granic and Lamey (2002) found that parent-child interactions with children with both externalizing and internalizing problems differed from those involving externalizing-only children only after a stressor was introduced. The increased pressures of specific outcomes in the clean-up and teaching tasks relative to the free play task were thought to introduce more stress to the dyads in the present study. Parenting stress and depression were entered as covariates, with the former showing a main effect. Contrary to expectations however, a two-way MANCOVA showed no interaction between externalizing subgroup and task type. That is, differences in maternal and dyadic processes between the externalizing subgroups did not change according to task type. Analyses did reveal that the mixed psychopathology group showed higher overall levels of parental hostility, parent attack, and dyadic flexibility than the externalizing-only group, although this did not vary by unstructured versus structured tasks, the latter of which are presumably more stressful.

This result differs from the Granic and Lamey’s finding that dyads involving children with mixed psychopathology shifted to a mutually hostile interaction following the introduction of a stressor. Thus, parent-child interactions involving children with both clinical-level externalizing and internalizing difficulties appear to involve more parental negativity and asynchronous negative interactions across a range of tasks compared to interactions involving children with ‘only’ externalizing behaviours. Somewhat counterintuitively, the interactions in the mixed psychopathology group also showed higher levels of flexibility. One possibility for this finding may be that parents may have attempted to adjust their responses to children; however, a history of maladaptive interactions or lack of adaptive responses in their repertoire may have resulted in a default tendency towards negative emotional and behavioural reactions.

There are several possibilities for the different results regarding the externalizing-only and mixed psychopathology groups between the present results and Granic and Lamey’s (2002) findings. One difference between the studies is that Granic and Lamey’s study involved children ages 8 through 12 years, whereas the present study included children ages 3 through 6 years. Parent-child interactions with older children necessarily have a longer history and patterns may differ over time as parents and children come to develop expectations for each other’s behaviours and responses. Older children with behaviour problems may have developed more extreme behaviours over time that parents anticipate and react to. The differences between subgroups in Granic and Lamey’s study involved a mutually hostile mode of interaction upon the introduction of a stressor. Methodologically, it was not possible to assess a mutually hostile interaction in the present study as hostile behaviours were not available separately for children. Granic and

Lamey did not have a flexibility variable; therefore, comparisons on dyadic flexibility between the two studies are not possible. Finally, the smaller numbers of participants in the present study resulted in 11 dyads in the externalizing-only subgroup and 20 dyads in the mixed group, possibly lacking statistical power to produce the hypothesized interaction between subgroup and task type, although Granic and Lamey's subgroups had a similar 14 externalizing and 19 mixed dyads.

The present study did not find that dyadic processes between externalizing subgroups differed only when a stressor was introduced as had been expected, but the finding of overall group differences on parent hostility and attack were not inconsistent with Granic and Lamey's (2002) findings. The potential implications of the results found in the present study in terms of flexibility and associated constructs in a young child population are discussed below.

Dyadic Flexibility and Processes with Parent-Child Interactions

The present study examined parent-child interactions with varying goals in children with clinical behaviour problems using a relatively new methodology derived from dynamic systems theory. Methodology based on DST appears to hold promise as a tool for examining adaptive and maladaptive parent-child processes across a range of interactions, particularly with the ability to generate measures of dyadic flexibility. That flexibility was predicted by both positive and negative parent characteristics and behaviours fits with Granic et al.'s (2003) assertion that both the content and structure of the parent-child interaction are important to examine. The expression of negative emotions can be adaptive if parents help to modulate a child's negative arousal and learn more adaptive ways to regulate and express negative emotions (Granic et al., 2007).

Therefore, the associations between negative parental characteristics and dyadic processes with flexibility may indicate that their child's negative arousal needs to be modulated or that there is conflict in the interaction that needs to be addressed. If parents can recognize such needs and adapt their responses accordingly, they can move the interaction in a more flexible and adaptive manner. Thus, negative parent behaviours, lack of warmth, and/or parental permissiveness when children are acting negatively may become signals that something in the interaction requires attending to and needs to be addressed, either directly or indirectly through the adjustment of one's behaviours and mannerisms in response to the child's level of emotional distress. The findings that flexibility was predicted by negative characteristics as well as by parental sensitivity and scaffolding indicate that flexibility captures important aspects of parental attunement to individual differences in child emotional reactivity, and can lead the parent to repair conflict or help the child to modulate his or her emotional arousal with respect to task demands and contextual variables.

Phase transitions. While it is somewhat counterintuitive that negative dyadic processes of permissiveness and parent attack, and the parental characteristic of hostility would predict dyadic flexibility, these results may highlight the impact of an earlier developmental period during preschool ages. It is possible that parents were attempting different parenting behaviours in response to child behaviours that may be ineffective, resulting in inadvertently reinforcing externalizing behaviours. As dyads become entrenched in their patterns of interaction, they may become less flexible over time. This period of early childhood may reflect a phase transition in which increased variability in the interaction may reflect a reorganization of the structure of the parent-child interaction, similar to the increased variability seen in the parent-child dyad during the early adolescent transition period found by Granic et al. (2003) in their longitudinal study. Indeed, Granic (2006) hypothesized that the 3- to 5-year age period and early adolescence may be the major phase transitions during child development.

The preschool period is typically a time of increasing social contact with peers and significant cognitive and emotional development; therefore, it is not surprising that this developmental period may represent a time of significant flux in the parent-child relationship. During the preschool period of 3 to 5 years of age, many children transition from spending the majority of their time in a family environment to an institutional care and/or peer setting. Children acquire the skills to play cooperatively with others around the age of 5 years (Case et al., 1996). Thus, during this period of significant social and cognitive development, children's interactions may be especially sensitive to relatively small influences, the effects of which are may be amplified during this period (Granic & Patterson, 1996). Interacting with a greater number of peers and adults in increasingly structured settings, along with becoming more vulnerable to social comparisons and peer rejection, may result in increased maladaptive behaviours and emotion regulation.

The children in the present study had already been referred for externalizing difficulties at a young age, indicating that they may have already developed an overly rigid repertoire of behaviours and interpersonal modes of interaction. Parents and children may have already experienced a history of maladaptive interactions (e.g., hostile or permissive), but parents may still have been attempting to engage in flexible behaviours. However, entrenched negative expectations based on their interaction history may have increasingly interfered with attempts at flexibility, which may have also been exacerbated by the unpredictability of the preschool transition period. Unfortunately, the present study did not include a comparison group or follow dyads over time, thus it is difficult to make definitive conclusions on whether the preschool age period involves a reorganization of the parent-child interaction at the present time.

Dyadic synchrony. Dyadic processes that were in synchrony with each other, particularly mutually negative engagement, were the only variables that did not predict dyadic flexibility in the present study. This finding illustrates that being attuned to the other person’s behaviours and emotional state when not entirely in synchrony with one’s own state may be necessary to recognize that something in the situation needs to be changed. This can help individuals to pause and examine what needs to be changed. When both individuals are interacting positively, there may not be a need to change one’s reactions or behaviours, and when each person is acting negatively, perhaps it is more difficult to pause and re-evaluate the interaction process. One implication may be that it could be particularly beneficial to target dyadic interactions in which both partners have become ‘locked into’ a negative process. It appears especially important to help dyad members develop the ability to ‘take a step back’ and even recognize when the interaction has become entrenched into a mutually negative process.

Both dyadic flexibility and synchrony have been studied relatively little in developmental psychology, although interest in both constructs has been expressed in recent years (e.g., Feldman, 2007; Hollenstein et al., 2004; Hollenstein & Lewis, 2006; Lindsey, Cremeens, Colwell, & Caldera, 2009). With dynamic systems theory providing new ideas and methods for studying dyadic interaction processes as they occur in real-time, the study of both processes looks promising to delineate adaptive and maladaptive parent-child processes. The present study provides evidence that flexibility and synchrony each capture different aspects of the parent-child interaction, and suggests that the preschool period may be an optimal time for parent-child intervention as it may be a period of reorganization of the parent-child interaction, potentially being more amenable to change.

The Application of Dynamic Systems Theory to Parent-Child Interactions

Research on child psychopathology has traditionally focused on outcomes. There has been an increasing focus on interpersonal processes that may contribute to maladaptive emotion regulation in children, but even then such research has often relied upon retrospective reports or been dependent on caregivers' recollections. Such reports can be biased by caregivers' perception, attention, and memory. Many of the foundational principles of DST appear to be applicable to the dynamic processes inherent in a child's socioemotional development and render the classic debate regarding quantitative versus qualitative change to be much less relevant. Real-time processes appear to continually impact the child's development and build upon previous processes, eventually emerging as what appears to be discontinuous change. As the child develops in infancy and early childhood, frequent, reciprocal, and affective interactions with caregivers can have enduring effects, particularly if they occur during sensitive periods of development (Schore, 1994, 2000).

The ability to transition from one task to another as demands change and to experience an array of affective states shows an awareness of and sensitivity to shifting contexts (Granic, 2005). A tendency to remain in one or very few affective states may indicate a lack of sensitivity to contextual demands, even if those states are neutral or positive; for example, remaining neutral in a conflict may be less effective than expressing some negative affect and attempting to resolve the issue (Granic, 2005). If children lack opportunities to experience a range of affective states and the dyadic regulation of these states, they may develop a very narrow range of coping behaviours, while children who learn to express a variety of emotions, including negative emotions, tend to become adept at regulating their physiological arousal and emotional expressions (Granic, 2005).

The present research contributes to a literature that is beginning to find that the expression of negative emotions per se in an interpersonal interaction may not be detrimental. Rather, a lack of flexibility (i.e., rigidity) in emotional and behavioural responding as circumstances require may be more detrimental not only to the relationship, but to a child's ability to learn appropriate emotion responding and behavioural regulation and negotiate interpersonal interactions. The ability to adjust to the changing demands of the context or needs of the other person (i.e., flexibility) is an essential characteristic that one must develop to interact with other people effectively. High levels of variability within a dyadic system, or interpersonal relationship, may enhance curiosity, exploration, reorientation, and learning, thereby enabling an individual to adapt to the increasing demands, challenges, and opportunities of adolescence and adulthood (Lichtwarck-Aschoff et al., 2009). Indeed, "a lack of emotional variability is associated with the risk of restricting and hampering the system's ability and potential to adjust to these new relational and situational demands" (Lichtwarck-Aschoff et al., 2009; p.1373). While stability is defined as the lack of variability, rigidity has been defined as a lack of both variability and adaptability (Lichtwarck-Aschoff et al., 2009).

The higher number of grids visited on a state space grid are thought to reflect greater levels of flexibility; yet, one might wonder whether these more frequent transitions between emotional states may simply reflect a form of disorganized variability. Preliminary studies have revealed that greater variability in mood states may be associated with more adaptive psychological functioning as compared to individuals with mood disorders because there is a greater influence of exogenous influences, leading to more irregular and complex mood fluctuations (Gottschalk et al., 1995; Heath et al., 2007; Heiby, Pagano, Blaine, Nelson, & Heath, 2003; Pagano, Barkhoff, Heiby, & Schlicht, 2006). Heiby et al. (2003) generated the Maladaptive Determinism Hypothesis, which posits that endogenous processes predominate during a depressive state, leading to greater determinism or regularity in mood dynamics, with little influence of environmental events. In contrast, a more transient and adaptive sadness in response to external events would require greater flexibility in mood regulation skills. Thus, individuals with bipolar disorder have shown more organized self-rated mood over time as compared to individuals with no mood disorder (Gottschalk et al., 1995), while depression has been associated with decreased variability or complexity and greater structure in self-rated mood fluctuations over 6 months as compared to no mood disorder (Heiby et al., 2003). It appears that higher levels of variability and fluctuations in emotional states may be associated with more adaptive psychological functioning; therefore, lending some support to the idea that more complex variability in dyadic interactions reflects a healthy and adaptive mode of interpersonal functioning.

Alternatively, results of the present study do provide mixed evidence for the adaptive nature of dyadic flexibility. As expected, parental sensitivity predicted flexibility in both unstructured (i.e., free play) and structured (i.e., puzzle) tasks. Negative associations emerged in terms of permissiveness, parent attack, and hostility predicting flexibility in structured tasks, and parental warmth showing a negative association with flexibility during free play. Dyads involving children with a broader range of psychopathology (i.e., externalizing and internalizing) showed greater parent attack and hostility as might be expected; however, they also demonstrated higher flexibility as assessed by the present study. Yet, previous research has provided some evidence for the adaptive nature of flexibility. For example, families in Granic et al. (2007)'s study who completed empirically-supported treatment and reported improvement in their children's externalizing behaviours showed greater flexibility after treatment, while families who completed treatment but failed to improve instead showed higher rigidity.

Both positive and negative affective experiences have been associated with higher levels of children's emotion regulation and fewer behaviour problems as long as negative behaviours are not too dominant (Dunn & Brown, 1994; Lunkenheimer, Shields, & Cortina, 2007; Roberts & Strayer, 1987). One possibility for the mixed flexibility findings in the present study may involve a certain 'threshold' of negative behaviours or adaptiveness for different populations. A recent study by Lunkenheimer and colleagues (Lunkenheimer, Olson, Hollenstein, Sameroff, & Winter, 2011) also examined dyadic flexibility in preschool-age children with subclinical or no externalizing problems. While they found an interaction between dyadic flexibility and positive affect at age 3 years and lower externalizing behaviours at 5.5 years, they also found that greater flexibility in mother-child dyads at age 3 predicted higher externalizing behaviours at 5.5 years, while higher flexibility in father-child dyads was associated with later lower behaviour problems. Lunkenheimer et al. posited that, for families who show little negative affect, movements between positive and neutral states can be adaptive. In contrast, for families who exhibit higher levels of negative affect, greater flexibility could be more adaptive as it can reflect more frequent emotional “repairs” from negative states. However, higher levels of variability may become less like flexibility and increasingly resemble disorganization. Thus, it will be crucial in future flexibility research to investigate whether there is some ‘threshold’ or certain ratio or of negative to positive states at which point increasing variability becomes maladaptive in clinical and community samples. For example, Lichtwarck-Aschoff et al. (2009) found an inverted U-shape association between emotional variability and number of conflicts in a sample of adolescent girls. Emotional variability increased up to approximately two conflicts per week; thereafter, the adolescents became increasingly more rigid as the number of conflicts increased.

In addition, it would be of interest to study families with low levels of negative interactions to examine whether children show difficulties with modulating strong emotions in general; that is, whether there may be a point at which experiencing too few negative emotional states provides the child with inadequate opportunities to learn to self-regulate high levels of arousal in situations requiring persistence and compliance. One illustration of the potentially detrimental effects of inflexible positive emotional behaviours was provided by Steenback and van Geert (2008) in their study of popular, average, and rejected children. While observing a real-time peer interaction, the researchers found that children who had been previously rejected by their peers displayed higher levels of positive emotional expressions to another child than did the popular children. In contrast, popular children had greater instances of mutual positive engagement, or reciprocity of positive emotions, with their peers during the observed interaction despite lower overall displays of positive emotion. These authors posited that the popular children were more effective by switching between positive and neutral states, rather than showing excessive positive emotion that was not necessarily in keeping with the other child. Thus, an ability to modulate overarousal, even involving positive emotions, such that one can focus and monitor another individual's responding appears to be important to adaptive social development.

Implications

Various researchers have discussed the importance of positive parental characteristics, parental scaffolding of cognitive and emotional skills, reinforcing positive child behaviours, and negotiating conflict. The importance of play, routines, and learning between parents and children has been recognized, although the emphasis is usually placed on routines and learning in goal-oriented tasks. The present study highlights the idea that different types of tasks can add unique aspects to the parent-child interaction, and that parents may need to adjust their responses to children depending on the nature and goals of the interaction in which dyads are engaged. For example, simply displaying warmth may be insufficient to improving the parent-child relationship without being attuned or sensitive to when a child requires additional modulation of their emotional overarousal. Free play appears to capture different elements of the parent-child interaction with a significant impact on a child's emotional and social development. There has been increasing focus on parent-child processes rather than an exclusive emphasis on content. Parents may have traditionally tried to suppress or immediately soothe negative child emotions, but what may be more important for the development of children's emotion regulation and interpersonal skills is the adaptive expression and negotiation of negative emotions and states.

Addressing dyadic content is important, but not always sufficient, as evidenced by high attrition rates or limited success in treating externalizing difficulties even in evidence-based interventions. For example, Parent Management Training (PMT; Kazdin, Siegal, & Bass, 1992; Patterson, 2002) addresses hostile and permissive parenting and focuses on content (e.g., respond in certain manner to certain behaviours) with some emphasis on process (e.g., consistent responding). PMT does not directly address helping parents to become more flexible with range of emotions with their children. There remains considerable variability in treatment outcome and effect sizes are generally moderate (e.g,. Brestan & Eyberg, 1998; Dumas, 1989; Kazdin, 2001), which illustrates an insufficient understanding of the mechanisms of change (Kazdin, 2002). As Granic and Patterson (2006) argued, information about the mechanisms responsible for successful interventions is critical for guiding clinicians in making informed decisions about how to tailor interventions to different contexts and individual families. Information about change mechanisms is also essential for the effective dissemination of treatment programs in community settings (Kazdin, 2000).

Fostering a type of meta-ability to pause during a dysfunctional interaction and evaluate dyadic processes, particularly when mutually negative, may be beneficial to target in treatment, while recognizing that the expression of negative emotions is not necessarily maladaptive per se. In a similar fashion, perseveration, or a rigid repetitive response or thinking style making it difficult to shift one's perspective or change responding, has been implicated in a variety of cognitive dysfunctions and psychopathologies (e.g., Fischer, Barkley, Smallish, & Fletcher, 2005; Matthys, van Goozen, de Vries, Cohen-Kettenis, & van Engeland, 1998; Séguin, Arseneault, Boulerice, Harden, & Tremblay, 2002). It seems intuitive that successful interpersonal interactions would require flexibility to shift one's mindset in relation to the other person's responses and behaviours as contextual demands change. The present study also points to the preschool period as being an optimal time to target treatment if the pattern of interaction between parents and children is already in a state of flux.

Some children may consistently experience an emotionally impoverished environment, which could be created through the absence of positive parenting, inadequate nurturing or affection through acts of omission, or lack of interactive experiences altogether. With respect to the present study, consistent patterns of permissive parenting and low levels of warmth and sensitivity could approximate mild forms of an emotional neglect. Indeed, children may be disadvantaged if they lack interactive experiences from which they can learn that interpersonal relationships can be rewarding in and of themselves. They would benefit from learning how to appropriately express and regulate emotions through the reciprocal nature of unstructured play situations; otherwise, they may have difficulties when they increasingly interact with people outside of their home (Peterson & Flanders, 2005). As early childhood is a period of substantial neurological development, neural regions implicated in emotion processing and regulation may be under-activated, possibly resulting in a relative under-development of those areas (Lee & Hoaken, 2007). Thus, research on parent-child interactions in high-risk families can not only inform the developmental psychology literature and interventions with high-risk families, but also point to possible dysfunctional processes in emotionally maltreating families and help identify processes to target.

Limitations. The present study provides preliminary evidence for the adaptive nature of dyadic flexibility and its role in emotional development, as well as the differential importance of parental characteristics across different types of tasks with varying objectives. There are, however, several limitations in this study.

Sample size. One limitation was the sample size of 66 participants, or 33 parent-child dyads. The nature of the data, however, resulted in a large number of data points, which has been considered to be more essential for nonlinear dynamic systems analyses than sample size (Guastello, 2011). Previous studies applying similar dynamic systems methodology to dyadic interactions have ranged from very small (*n*=8 infants; Lewis et al., 1999), to small (*n*=24 dyads: Lewis et al., 2004; *n*=33 dyads: Granic & Lamey, 2002; *n*=38 dyads: Granic et al., 2003), to medium (*n*=55 dyads), to large (*n*=148 dyads: Granic et al., 2003; *n*=270 dyads: Hollenstein et al., 2004). Similar to the present study, Granic's clinical samples had 33 (Granic & Lamey, 2002) and 38 (Granic et al., 2007) dyads.

As the present study was interested in dyadic processes across a number of interactions, the length of the interactions and large number of data points were the focus. The shortest dyadic interaction was 1875 seconds (i.e., 31.25 mins), and the mean length for total duration of interaction for all dyads was 2650 seconds (i.e., 45 mins). Data was coded for every 15-second interval with the RPC for both child and parents, resulting in 250 data points between the dyad members for the shortest interaction, and every 20-second interval with the PWCS, resulting in 94 data points for the parent. Number of total data points for dyads for the RPC ranged from 250 to 478 with a mean of 342, and from 94 to 179 for the PWCS with a mean of 128. Thus, the total number of coded data points in the present sample was 15,528. The application of dynamic systems theory to the social sciences is relatively new; therefore, no minimum sample size has as yet been identified. Guastello (2011) discussed “the myth of the million data points” (p.63) which involves the notion that dynamic systems analyses require tens or hundreds of thousands of data points. However, by using a previously identified range of formulae by Liebovitch (1998), Guastello calculated that the formulae for a four-dimensional system would result in a vast range of hypothesized data points from 3.24 points to 3.1 million points. He argued that the next smaller estimate would be 100 observations for a four-dimensional system (Ding, Grebogi, Ott, Sauer, & Yorke, 1993). Other researchers have posited that approximately 2000 data points are sufficient to apply basic method for nonlinear data analysis, provided the system has less than four degrees of freedom (Heath, 2000; Heath et al., 2007).

Violations of normality and linearity assumptions. Three of the four flexibility variables showed significant violations of normality. The variable that exhibited a normal distribution was Total Unique Cells, or the number of grids visited at least once throughout the interaction. In essence, TUC is akin to the range of behaviours available in a dyad’s repertoire of actions and emotional states. The number of Transitions per minute and Dispersion, or measure of spread, showed negative skewness. The Average Mean Duration in each cell showed positive skewness, although higher levels of AMD indicate *less* flexibility in contrast to the other three variables; thus, it demonstrates similar skewness patterns as Transitions and Dispersion.

Negative dyadic processes (i.e., permissiveness, mutual negative engagement, parent attack) and parental hostility also demonstrated negative skewness. Inspection of the data indicates that the skewness appears to be due primarily to the relatively few negative events across the interactions, which is consistent with parent-child research indicating relatively low base rates of negative behaviours, even in samples involving children with externalizing problems (e.g., Dishion, Duncan, Eddy, Fagot, & Fetrow, 1994). Within each task type, the number of dyads that did not demonstrate a particular negative process varied from a low of 36.4% (parent attack during free play) to 90.9% (mutual negative engagement during puzzle; see Table 26). It should be noted, however, that only one dyad in each task did not display any negative processes throughout that task, and these were different dyads in each task (e.g., Dyad A showed no negative processes in free play, Dyad B showed no negative processes during clean-up).

Another limitation of the present study is the decision to run analyses with the data despite violations of normality because the variation across emotional states, particularly as tasks demands changed, was of particular interest. Variability in development is considered to represent important information in a complex, dynamic system. Van Geert and Steenbeek (2008) have discussed the difficulty of studying complex, non-linear processes with standard research methods, but these methods may capture at least a significant portion of their dynamic nature. The application of dynamic systems to developmental psychology is still in its relative infancy; thus, there is comparatively little research on individual trajectories and differences currently (van Geert & Steenbeek, 2008). The studies that have thus far examined measures of dyadic flexibility derived from state space grid methodology do not appear to have transformed

Table 26

Number of Dyads Not Exhibiting Negative Dyadic Process or Parental Characteristics within Each Task

	Free Play		Clean-Up		Puzzle		Etch		Lego	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
MutPos	7	21.2	6	18.2	7	21.2	20	64.5	10	30.3
Scaffolding	1	3	3	9.1	0	0	4	12.9	3	9.1
Permissive	17	51.5	21	63.6	23	69.7	29	93.5	20	60.6
MutNeg	23	69.7	19	57.6	30	90.9	25	80.6	24	72.7
ParAttack	12	36.4	21	63.6	20	60.6	24	77.4	18	54.5
Warmth	0	0	8	24.2	0	0	6	19.4	3	9.1
Sensitivity	0	0	0	0	0	0	2	6.5	1	3
Hostility	24	72.7	25	75.8	28	84.8	28	90.3	27	81.8

or removed flexibility variables. Other researchers have used data derived from SSGs, including dyadic processes and emotional states, in linear analyses with little change or transformation of their data (e.g., Granic et al. 2007). While the analyses in the present study can be quite robust to violations of normality and linearity, such violations may have led to issues including diminished power of statistical tests and potential skewness of the regression prediction equation (Tabachnick & Fidell, 2002). Violations of assumptions may be somewhat less of an issue in the discriminant function analysis in which classification, rather than inference, is a goal (although this may have impacted the tests of significance), as well as the principal components analysis (Tabachnick & Fidell, 2002).

Appropriate analytic approaches to dynamic systems developmental psychology are still in the process of being identified, and future research will benefit from their adoption. The present study provides a preliminary and exploratory examination of the nature of dyadic flexibility, how it relates to other dyadic and parental processes, and how these may vary according to contextual demands in young children with externalizing behaviour problems. It will be important in future developmental research using dynamic systems to examine ways of transforming non-linear data if linear analyses are used, and to investigate more complex, non-linear methods of data analysis.

Comparability and generalizability. Another limitation involves the fact that, while the present study employed methodology similar to techniques used by other developmental psychology researchers using dynamic systems theory (e.g., using SSGs to categorize each interval of dyadic interactions into positive, neutral, negative, and hostile categories), there is a limited ability for comparisons between those studies and the present study due to the lack of differentiation of hostile from other negative behaviours in the RPC. It will be of interest in future studies to differentiate hostility from other expressions of negative affect states, such as sadness, since hostility appears to be particularly detrimental to child development (Rutter & Quinton, 1984). Another potential limitation involves the generalizability of the results. Developmental psychology researchers have traditionally relied on parent ratings or general observer ratings for relatively large periods of time as compared to 15-second intervals. One corollary of examining a single interaction in-depth is that results are applicable for a narrow period of time. Nevertheless, as the primary focus in the present study was deconstructing the dyadic interaction as it unfolds and because different types of tasks were included, the viability of examining SSGs and dyadic flexibility was demonstrated and could be applied to future longitudinal research.

The lack of comparison group in the present study precludes the identification of dyadic processes that are unique to parent-child dyads involving children with externalizing behaviour problems. For example, the finding that permissiveness and parent attack predicted flexibility in certain tasks may be unique to children with externalizing difficulties, or it may reflect the increased variability in the parent-child interaction during a transitional period between early childhood and school entry. It will be essential for future studies to examine predictors of flexibility in preschool-aged children without significant behaviour problems.

Finally, while the young age range of the children and clinical nature of the sample expand upon previous research, they also limit generalizability to other populations. The young childhood age range was of interest as it is a period of tremendous cognitive and emotional development in which children spend the majority of their time with their primary caregiver. This age range has been studied relatively less by other psychology researchers using a dynamic systems approach. However, as can be seen with the discrepant results between the externalizing subgroups in the present study and in Granic and Lamey's (2002) study, the nature of what constitutes adaptive and maladaptive parent-child processes may differ as children develop and increasingly interact with peers and other external figures. Over time, behavioural tendencies may become more entrenched, and dyads have developed methods of interacting which can be solidified by a longer history and more stable expectations. Studying the younger age group is essential for targeting early intervention and prevention programs for at-risk youth.

Children with clinical-level behaviour problems were particularly of interest in the present study as the majority of previous psychology studies studying the dynamic nature of parent-child interactions have examined community samples. The fact that the children in the present study had already been referred at a young age to a tertiary children's mental health agency speaks to the severity of the sample. Inclusion criteria in the program also included a high-risk status of the family, such as maternal depression or low socioeconomic status. Therefore, the children and parents in the present sample may show more maladaptive processes and related difficulties than even other clinical populations; however, high-risk families comprise a relatively large proportion of the children's mental health system. It is essential to identify maladaptive processes to target in prevention and intervention programs with high-risk populations to prevent the entrenchment of such families in the mental health system.

Clinical Implications

Several treatment programs exist that have demonstrated efficacy for young children with externalizing behaviour problems. For example, Eyberg, Nelson, and Boggs (2008) have identified PMT as a well-established treatment and the Triple P – Positive Parenting Program (Sanders, 1999; Sanders, Cann, & Markie-Dadds, 2003) and Parent-Child Interaction Therapy (PCIT; Brinkmeyer & Eyberg, 2003; Hembree-Kigin & McNeil, 1995) as probably efficacious, among others. The PCIT in particular focuses in-depth on the parent-child interaction as it unfolds in real-time, and was tentatively considered a well-established treatment as a result of a meta-analysis (Thomas & Zimmer-Gembeck, 2007). There remain, however, a significant proportion of families that terminate treatment prematurely or fail to show immediate and/or long-lasting improvements, particularly for youth with aggressive behaviours and/or high-risk families (e.g., socioeconomic disadvantage, high parental stress; Kazdin, 1997, 2001). The positive results of both PCIT and Triple P found in a recent meta-analysis were also tempered by the lack of certainty on whether they generalise to low-income or high-risk families, particularly the Triple P, which has been primarily studied in families who have self-referred to the program (Thomas & Zimmer-Gembeck, 2007). Thus, Kazdin (2001) advocated for a focus on studying the mechanisms of change in treatment.

A primary focus of existing treatment protocols for children with behaviour problems is increasing the proportion of positive reinforcement for appropriate behaviours and disengaging from negative child behaviours. In relation to dyadic flexibility, increasing the ratio of positive and neutral emotional states relative to negative behaviours in families with existing negative dyadic processes may be adaptive as a form of "conflict repair". That is, families that would be appropriate for such protocols often show maladaptive or coercive parent-child processes. The increased focus on positive and neutral states in such families may help to increase flexibility, whereas families with few clinical difficulties are likely to already exhibit lower proportions of negative processes and may not need more variation in their emotional states. This hypothesis is in line with Lunkenheimer et al.'s (2011) speculation that flexibility can be adaptive in families exhibiting higher levels of negative affect as compared to the conceivably adaptive processes in 'healthy' families that may already transition primarily between positive and neutral states. In summary, the idea that dyadic flexibility (i.e., experiencing a range of positive and negative states) can be adaptive does not appear to contradict the central tenets of existing treatment protocols, at least not in families already experiencing maladaptive modes of interaction.

It would be of interest in future research to assess whether positive outcomes in PCIT, Triple P, and PMT are associated with greater flexibility, as was found in Granic and Lamey's (2002) finding of increased flexibility after families completed PMT and CBT, but greater rigidity in treatment completers who failed to improve. If research reveals an increase in flexibility in families who improve with intervention, this may indicate a potential benefit in increasing a focus on increasing flexibility in parent-child dyads who demonstrate low levels of flexibility pre-treatment and show a relative lack of progress mid-treatment.

The results of the present study do suggest that it may be beneficial for clinicians to target flexibility and expectations in parents of young children with externalizing behaviour problems. Clinicians may temper their expectations of treatment progress accordingly if they expect greater variability in dyadic responding, less consistency in children's behaviours as they negotiate new skills and interpersonal interactions, and possible difficulties in parents' adjustment to their children's behaviours during the preschool period. Psychoeducation could help caregivers to prepare for what appears to be increased inconsistency in dyadic processes during this phase transition. It would also be beneficial for parents, particularly those with high levels of parenting stress, to learn coping strategies, basic psychoeducation about normative child development, and what they may realistically expect from their children during this developmental period.

Specifically, after providing psychoeducation, treatment could include the videotaping of the parent-child dyad interacting during an unstructured, low-stress task. The clinician could then watch the interaction recording with the parent while addressing parents' interpretations of the child's behaviours and generate alternative strategies for dealing with conflict. Parents could also be provided with coping strategies to use when becoming distressed, such as relaxation training and cognitive restructuring. As parents show improvement with unstructured tasks, the process could be repeated with increasingly structured tasks that gradually incorporates greater demands on the child and potential for conflict.

Future Directions

Various theories exist for how externalizing behaviour problems develop and are maintained in children. What dynamic systems theory can add is the idea that emotion and behavioural regulation difficulties may develop and be maintained throughout frequent interactions, which become stable attractor states, or default patterns of action, that are difficult to disrupt. Howe (2004) has described the aggregation of externalizing behaviours wherein each episode of social interaction is seen as incrementally reinforcing the propensity of the child to act in disruptive ways in a broader range of contexts, with a result that this behavioural propensity is progressively built up over time. In parallel fashion, the propensity for using prosocial behaviour is eroded over developmental time (Howe, 2004). As these patterns repeat hundreds of times, they produce and strengthen default modes of interaction, therefore constraining the type of real-time interactions in which the child and dyad will engage in the future (i.e., stabilizing the developmental trajectory; Granic, 2005). A key question then emerges: how does one destabilize an entrenched system (i.e., with very stable attractors)?

A number of empirically-supported treatments exist for children with behaviour problems; however, significant numbers of children and families do not complete treatment or show improvement. Granic (2006) has surmised that intervention research and practice might benefit from remembering the importance of measuring self-stabilizing and amplifying processes as they occur in real-time rather than focusing exclusively on measuring developmental outcomes. A central assumption of DST approaches is that change is a result of reciprocal interactions repeatedly occurring over time (Lewis, 2004). Shifting the dynamics of a system in terms of its structure, or its degree of rigidity versus flexibility, is a critical parameter for social developmental change (Lewis, 2004; Patterson, DeGarmo, & Forgatch, 2004; Snyder, Prichard, Schrepferman, & Patrick, 2004). Dynamic systems theory has posited that a system's level of variability increases as it approaches a phase transition, or shifts to a new organization. Thus, phase transitions may be an optimal time to target treatment, as attractors may become less stable and allow access to and manipulation of the mechanisms underlying change (Granic, 2005). It has been suggested that, in order for improvements to occur, treatment must trigger a reorganization of affective, cognitive, and behavioural systems (e.g., Caspar, Rothenfluh, & Segal, 1992; Greenberg, Rice, & Elliott, 1996; Mahoney, 1991).

The present study applied a measure of dyadic flexibility that appears to hold promise as an adaptive psychological and interpersonal process to a preschool-age, clinical sample. The ability to 'step back' and change emotional and behavioural responding in response to contextual demands increasingly appears to be associated with improved functioning. Flexibility does not preclude the expression of negative emotions; rather, flexibility includes the ability to express negative emotions appropriately and be responsive to other people's negative emotions. The present study illustrated that dyadic flexibility can vary with respect to the demands of the task at hand, and that parents may need to adjust their responses to children, maintaining flexibility in re-examining and adapting their responses as demands change. It will be of interest in future research to examine larger samples, compare dyadic processes and relations to flexibility in different populations (e.g., internalizing difficulties, no psychopathology), and perform longitudinal studies to assess how interaction processes change over time and whether they become very stable by a particular developmental stage. Dynamic systems theory provides a conceptual framework and tools with which to examine how parent-child interactions organize and stabilize both in-the-moment and over time. The importance of maintaining flexibility throughout interactions and examining how dyadic processes evolve adds to the literature on parent-child relationships in general, and children with externalizing behaviour problems in particular.

References

Abidin, R.R. (1995). Parenting Stress Index, Third Edition: Professional Manual. Odessa, FL: Psychological Assessment Resources, Inc.

Achenbach, T.M. (1991). *Integrative guide for the 1991 CBCL/4-18, YSR, and TRF profiles*. Burlington, VT: University of Vermont, Department of Psychiatry.

Achenbach, T.M., & Rescorla, L.A. (2001). *Manual for ASEBA School-Age Forms & Profiles*. Burlington, VT: University of Vermont, Research Center for Children, Youth, & Families.

Allen, J.P., & Land, D. (1999). Attachment in adolescence. In: J. Cassidy, & P.R. Shaver (Eds), *Handbook of attachment: Theory, research, and clinical applications. (pp. 319-335).* New York: Guilford Press.

Ambrosini, P.J., Metz, C., Bianchi, M.D., Rabinovich, H., & Undie, A. (1991). Concurrent validity and psychometric properties of the Beck Depression Inventory in outpatient adolescents. *Journal of the American Academy of Child and Adolescent Psychiatry, 30*, 51-57.

Azar, S.T. (2002). Parenting and child maltreatment. In: M.H. Bornstein (Ed.), *Handbook of parenting (2/e): Volume 4, Social conditions and applied parenting*, (pp.361-388). Mahwah, NJ, US: Lawrence Erlbaum Associates Inc.

Barrett, P.M., Rapee, R.M., Dadds, M.R., & Ryan, S.M. (1996). Family enhancement of cognitive style in anxious and aggressive children. *Journal of Abnormal Child Psychology*, *37*, 187–203.

Beck, A. T., & Steer, R. A. (1987). *Manual for the Beck Depression Inventory*. San Antonio, TX: The Psychological Corporation.

Beck, A. T., Steer, R. A., & Brown, G. K. (1996). *Beck Depression Inventory—Second Edition manual*. San Antonio: The Psychological Corporation.

Beck, A.T., Steer, R.A., Ball, R., & Ranieri, W. (1996). Comparison of Beck Depression Inventories -IA and -II in psychiatric outpatients. *Journal of Personality Assessment, 67*, 588–597.

Bégin, P. (2004). Voices from the field: Public policies and the prevention of early childhood aggression. In: R.E. Tremblay, R.G. Barr, & R.DeV. Peters (Eds.), *Encyclopedia on Early Childhood Development* [online], (pp.1-5). Montreal, Quebec: Centre of Excellence for Early Childhood Development. Available at: http://www.child-encyclopedia.com/documents/BeginANGps.pdf.

Brestan, E. V., & Eyberg, S. M. (1998). Effective psychosocial treatments of conduct-disordered children and adolescents: 29 years, 82 studies, and 5,272 kids. *Journal of Clinical Child Psychology*, 27, 180–189.

Brinkmeyer, M., & Eyberg, S.M. (2003). Parent-child interaction therapy for oppositional children. In A.E. Kazdin & J.R. Weisz (Eds.). *Evidence-based psychotherapies for children and adolescents*, (pp. 204-223). New York: Guilford.

Calkins, S.D., & Johnson, M.C. (1998). Toddler regulation of distress to frustrating events: Temperamental and maternal correlates. *Infant Behavior and Development, 21*, 379-395.

Campbell, S. B. (2002). *Behavior problems in preschool children: Clinical and developmental issues* (2nd ed.). New York: Guilford Press.

Campbell, S.B., Shaw, D.S., Gilliom, M. (2000). Early externalizing behavior problems: Toddlers and preschoolers at risk for later maladjustment. *Development and Psychopathology, 12*, 467–488.

Case, R., Marra, K., Bleiker, C., & Okamoto, Y. (1996). Central spatial structures and their development. In R. Case & Y. Okamoto (Eds.), The role of central conceptual structures in the development of children's thought. *Monographs of the Society for Research in Child Development, 61 (1-2*, Serial No. 246), 103-130.

Caspar, F., Rothenfluh, T., & Segal, Z. (1992). The appeal of connectionism for clinical psychology. *Clinical Psychology Review, 12*, 719–762.

Cassidy, J. (1994). Emotion regulation: Influences of attachment relationships. In: N.A. Fox (Ed.), The development of emotion regulation and dysregulation: Biological and behavioural aspects. *Monographs of the Society for Research in Child Development, 59(2-3, Serial No 240)*, 228-249.

Chambless, D.L., & Hollon, S.D. (1998). Defining empirically supported therapies. *Journal of Consulting and Clinical Psychology*, *66*, 7-18.

Cole, P.M., Armstrong, L.M., & Pemberton, C.K. (2010). The role of language in the development of emotion regulation. In S. Calkins and M. Bell (Eds), *Child development at the intersection of emotion and cognition: Human brain development, (pp. 59-77).* Washington DC, US: American Psychological Association.

Collins, W.A., Maccoby, E.E., Steinberg, L., Hetherington, E.M., & Bornstein, M.H. (2000). Contemporary research on parenting: The case for nature and nurture. *American Psychologist, 55*, 218-232.

Corbetta, D., & Thelen, E. (1996). The developmental origins of two-handed coordination: A dynamic perspective. *Journal of Experimental Psychology: Human Perception and Performance, 22*, 502-522.

Cramer, E. M., & Nicewander, W. A. (1979). Some symmetric, invariant measures of multivariate association. *Psychometrika, 44*, 43-54.

Crick, N.R., & Dodge, K.A. (1994). A review and reformulation of social information-processing mechanisms in children's social adjustment. *Psychological Bulletin*, *115*, 74–101.

Crowell, J.A., O'Connor, E., Wollmers, G., Sprafkin, J., & Rao, U. (1991). Mothers' conceptualizations of parent-child relationships: Relation to mother-child interaction and child behaviour problems. *Development and Psychopathology, 3*, 431-444.

Davidov, M., & Grusec, J.E. (2006). Untangling the links of parental responsiveness to distress and warmth to child outcomes. *Child Development, 77*, 44-58.

de Weerth, C., van Geert, P., & Hoijtink, H. (1999). Intraindividual variability in infant behavior. *Developmental Psychology*, *35*, 1102–1112.

Demos, V. (1986). Crying in early infancy: An illustration of the motivational function of affect. In: T.B. Brazelton & M.W. Yogman (Eds.), *Affective development in infancy* (pp. 39–73). Norwood, NJ: Ablex.

Denham, S.A., Workman, E., Cole, P.M., Weissbrod, C., Kendziora, K.T., & Zahn-Waxler, C. (2000). Prediction of externalizing behavior problems from early to middle childhood: The role of parental socialization and emotional expression. *Development and Psychopathology, 12,* 23–45.

Ding, M., Grebogi, C., Ott, E., Sauer, T., & Yorke, J. A. (1993). Plateau onset for correlation dimension: When does it occur?" *Phys Rev Lett, 70*, 3872-3875.

Dishion, T. J., Duncan, T. E., Eddy, J. M., Fagot, B. I., & Fetrow, R. A. (1994). The world of parents and peers: Coercive exchanges and children's social adaption. *Social Development, 3,* 255-268.

Dishion, T., Rivera, E. K., Verberkmoes, S., Jones, L., & Patras, J.M. (2002). *Relationship Process Code training manua : A system for coding relationship interactions*. University of Oregon: Child and Family Center.

Dumas, J. E. (1989). Treating antisocial behavior in children: Child family approaches. *Clinical Psychology Review, 9,* 197-222.

Dunn, J., & Brown, J. (1994). Affect expression in the family, children's understanding of emotions, and their interactions with others. *Merrill-Palmer Quarterly, 40*, 120-137.

Eisenberg, N., & Fabes, R. (1998). Prosocial development. In N. Eisenberg & W. Damon (Eds.), *Social, emotional, and personality development: Vol. 3. Handbook of child psychology* (5th ed., pp. 701–778). New York: Wiley.

Eron, L. D. (1990). Understanding aggression. *Bulletin of the International Society for Research on Aggression, 12*, 5–9.

Eyberg, S.M., Nelson, M. M., & Boggs, S.R. (2008). Evidence-based treatments for child and adolescent disruptive behavior disorders. *Journal of Clinical Child and Adolescent Psychology, 37*, 213-235.

Fabrigar, L. R., Wegener, D. T., MacCallum, R. C., & Strahan, E. J. (1999). Evaluating the use of exploratory factor analysis in psychological research. *Psychological Methods*, *4*, 272-299.

Feldman, R. (2007). Parent-infant synchrony and the construction of shared timing; physiological precursors, developmental outcomes, and risk conditions. *J Child Psychol Psychiatry, 48(3-4),* 329-54.

Feldman, R., Greenbaum, C.W., & Yirmiya, N. (1999). Mother-infant affect synchrony as an antecedent of the emergence of self-control. *Developmental Psychology, 35*, 223-231.

Fischer, M., Barkley, R., Smallish, L., & Fletcher, K. (2005). Executive functioning in hyperactive children as young adults: Attention, inhibition, response perseveration, and the impact of comorbidity. *Developmental Neuropsychology, 27*, 107–133.

Ford, D. H., & Lerner, R. M. (1992). *Developmental systems theory: An integrative approach.* Newbury Park, CA: Sage.

Forman, D.R., & Kochanska, G. (2001). Viewing imitation as child responsiveness: A link between teaching and discipline contexts of socialization. *Developmental Psychology, 37,* 198-206.

Foster, E.M., Jones, D.E., & the Conduct Problems Prevention Research Group. (2005). The high costs of aggression: Public expenditures resulting from conduct disorder. *American Journal of Public Health, 95*, 1767-1772.

Gianino A., & Tronick, E. (1988). The mutual regulation model: The infant's self and interactive regulation and coping and defensive capacities. In: T. Field, P.

McCabe, & N. Schneiderman (Eds.), *Stress and coping (Vol. 2, pp.47-68)*. Hillsdale, NJ, US: Erlbaum.

Gleason, T. C. (1976). On redundancy in canonical analysis. *Psychological Bulletin, 83*, 1004-1006.

Gottschalk, A., Bauer, M.S., & Whybrow, P.C. (1995). Evidence of chaotic mood variation in bipolar disorder. *Arch Gen Psychiatry, 52*, 947-959.

Granic, I. (2006). Timing is everything: Developmental psychopathology from a dynamic systems perspective. *Developmental Review, 25*, 386-407.

Granic, I., & Lamey, A.V. (2002). Combining dynamic systems and multivariate analyses to compare the mother-child interactions of externalizing subtypes. *Journal of Abnormal Child Psychology, 30*, 265-283.

Granic, I., Hollenstein, T., Dishion, T.J., & Patterson, G.R. (2003). Longitudinal analysis of flexibility and reorganization in early adolescence: A dynamics systems study of family interactions. *Developmental Psychology, 39*, 606-617.

Granic, I., O'Hara, A., Pepler, D., & Lewis, M.D. (2007). A dynamic systems analysis of parent-child changes associated with successful "real-world" interventions for aggressive children. *Journal of Abnormal Child Psychology, 35*, 845-857.

Granic, I. & Patterson, G.R. (2006). Toward a comprehensive model of antisocial development: A dynamic systems approach. *Psychological Review, 113*, 101-131.

Greenberg, L. S., Rice, L. N., & Elliott, R.K. (1996). *Facilitating emotional change: The moment-by-moment process*. New York, NY, USA: Guilford Press.

Guadagnoli, E., & Velicer, W. F. (1988). Relation of sample size to the stability of component patterns. *Psychological Bulletin, 103*, 265-275.

Guastello, S. J. (2011). Frequency, distributions, and error functions. In: S.J. Guastello & R.A.M. Gregson (Eds.), *Nonlinear dynamical systems analysis for the behavioral sciences using real data, (pp.)*. Boca Raton, FL: CRC Press/Taylor & Francis.

Guastello, S. J., & Liebovitch, L. (2009). Introduction to nonlinear dynamics and complexity. In: S.J. Guastello, M. Koopmans, & Pincus, D. (Eds.), *Chaos and complexity in psychology: The theory of nonlinear dynamical systems*, *(pp.1-40).* Cambridge: Cambridge University.

Harris, R. J. (1975). *A primer of multivariate statistics*. New York: Academic Press.

Harris, R. J. (1985). *A primer of multivariate statistics (2/e)*. New York: Academic Press.

Haskett, M.E., Ahern, L.S., Ward, C.S., & Allaire, J.C. (2006). Factor structure and validity of the Parenting Stress Index-Short Form. *Journal of Clinical Child and Adolescent Psychology, 35,* 302-312.

Heath, R. (2000). Nonlinear dynamics: Techniques and applications in psychology. Mahwah, NJ: Lawrence Erlbaum.

Heath, R., Heiby, E. M. & Pagano, I. (2007). Complex dynamics in depression: An application to long-term, mood-rating time series. In: R.W.J. Neufeld (Ed.), *Advances in Clinical Cognitive Science, (pp. 263-291).* Washington, D.C.: American Psychological Association.

Heiby, E.M., Pagano, I., Blaine, D., Nelson, K., & Heath, R. A. (2003). Modeling unipolar depression as a chaotic process. Psychological Assessment, 15, 426-434.

Hembree-Kigin, T., & McNeil, C. (1995). *Parent-Child Interaction Therapy*. New York: Plenum.

Hollenstein, T., Granic, I., Stoolmiller, M., & Snyder, J. (2004). Rigidity in parent-child interactions and the development of externalizing and internalizing behavior in early childhood. *Journal of Abnormal Child Psychology, 32*, 595-607.

Hollenstein, T., & Lewis, M.D. (2006). A state space analysis of emotion and flexibility in parent-child interactions. *Emotion, 6*, 656-662.

Howe, G. W. (2004). Studying the dynamics of problem behavior across multiple time scales: Prospects and challenges. *Journal of Abnormal Child Psychology, 32*, 673-678.

Hughes, C., & Dunn, J. (1998). Understanding mind and emotion understanding: Longitudinal associations with mental state talk between young friends. *Developmental Psychology, 34,* 1026-1037.

Ireton, H. (1992). *The Child Development Inventory Manual*. Minneapolis, MN: Behavior Science Systems.

Israels, A. Z. (1984). Redundancy analysis of qualitative variables. *Psychometrika, 49*, 331-346.

Johansson, J.K. (1981). An extension of Wollenberg's redundancy analysis. *Psychometrika, 46*, 93-103.

Kaiser, H.F. (1958). The varimax criterion for analytic rotation in factor analysis. *Psychometrika, 23,* 187-200.

Kazdin, A. E. (1997). Practitioner review: Psychosocial treatments for conduct disorder in children. *J. Child Psychol. Psychial., 38*, 161-178.

Kazdin, A. E. (2001). *Behavior modification in applied settings (6th ed.).* Belmont, CA: Wadsworth.

Kazdin, A. E., & Kendall, P. C. (1998). Current progress and future plans for developing effective treatments: Comments and perspectives. *Journal of Clinical Child Psychology, 27*, 217–226.

Kazdin, A.E., Siegal, T., & Bass, D.(1992). Cognitive problem solving skills training and parent management training in the treatment of antisocial behavior in children. *Journal of Consulting and Clinical Psychology, 60,* 733-747.

Kobak, R.R., Cole, H.E., Ferenz-Gillies, R., Fleming, W.S., et al. (1993). Attachment and emotion regulation during mother-teen problem solving: A control theory analysis. *Child Development, 64*, 231-245.

Kopp, C.B. (1989). Regulation of distress and negative emotions: A developmental view. *Developmental Psychology, 25*, 343-354.

Laible, D. J., & Thompson, R. A. (1998). Attachment and emotional understanding in preschool children. *Developmental Psychology*, *34*, 1038-1045.

Lamey, A., Hollenstein, T., Lewis, M.D., & Granic, I. (2004). GridWare (Version 1.1). [Computer software]. http://www.statespacegrids.org.

Lee, V. & Hoaken, P. N. S. (2007). Cognition, emotion, and neurobiological development: Mediating the relation between maltreatment and aggression. *Child Maltreatment, 12*, 281-298.

Lewis, M. D. (2000). The promise of dynamic systems approaches for an integrated account of human development. *Child Development, 71,* 36-43.

Lewis, M. D. (2000). Emotional self-organization at three time scales. In: M.D. Lewis & I. Granic (Eds.), *Emotion, development, and self-organization: Dynamic systems* *approaches to emotional development*, (pp.37-69). Cambridge, UK: Cambridge University Press.

Lewis, M. D. (2004). Trouble ahead: Predicting antisocial trajectories with dynamic systems concepts and methods. *Journal of Abnormal Child Psychology, 32*, 665-671

Lewis, M. D., Lamey, A.V., & Douglas, L. (1999). A new dynamic systems method for the analysis of early socioemotional development. *Developmental Science, 2*, 457-475.

Lewis, M. D., Zimmerman, S., Hollenstein, T., & Lamey, A. V. (2004). Reorganization of coping behavior at 1 1/2 years: Dynamic systems and normative change. *Developmental Science, 7,* 56-73.

Lichtwarck-Aschoff, A., Kunnen, S.E., & van Geert, P.L.C. (2009). Here we go again: A dynamic systems perspective on emotional rigidity across parent-adolescent conflicts. *Developmental Psychology, 45*, 1364-1375.

Liebovitch, L. S. (1998). *Fractals and Chaos Simplified for the Life Sciences.* Oxford University Press, New York.

Lindsey, E. W., Cremeens, P.R., Colwell, M.J., & Caldera, Y.M. (2009). The structure of parent–child dyadic synchrony in toddlerhood and children's communication competence and self-control. *Social Development, 18,* 375-396.

Lindsey, E. W., Mize, J., & Pettit, G.S. (1997). Mutuality in parent-child play: Consequences for children's peer competence. *Journal of Social and Personal Relationships, 14*, 523-538.

Lugo-Gil, J., & Tamis-LeMonda, C.S. (2008). Family resources and parenting quality: Links to children's cognitive development across the first 3 years. *Child Development, 79*, 1065-1085.

Lunkenheimer, E. S., Olson, S. L., Hollenstein, T., Sameroff, A. J., & Winter, C. (2011). Dyadic flexibility and positive affect in parent-child coregulation and the development of child behavior problems. *Development and Psychopathology, 23*, 577-591.

Lunkenheimer, E.S., Shields, A. M., & Cortina, K. S. (2007). Parental coaching and dismissing of children's emotions in family interactions. *Social Development, 16*, 232-248.

Luthar, S.S., & Zelazo, L.B. (2003). Research on resilience: An integrative review. In: S.S. Luthar (Ed.), *Resilience and vulnerability: Adaptation in the context of childhood adversities,* (pp.510-549). New York: Cambridge University Press.

MacDonald, K. B. (1992). Warmth as a developmental construct: An evolutionary analysis. *Child Development, 63*, 753–773.

Mahoney, M.J. (1991). *Human change processes: The scientific foundations of psychotherapy*. New York, NY: Basic Books.

Matthys, W., van Goozen, S. H., de Vries, H., Cohen-Kettenis, P. T., & van Engeland, H. (1998). The dominance of behavioural activation over behavioural inhibition in conduct disordered boys with or without attention-deficit hyperactivity disorder. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 39,* 643–651.

McFayden-Ketchum, S.A., Bates, J.E., Dodge, K.A., & Pettit, G.S. (1996). Patterns of change in early childhood aggressive-disruptive behavior: Gender differences in predictions from early coercive and affectionate mother–child interactions. *Child Development*, *67*, 2417–2433.

Mize, J., & Pettit, G. (1997). Mothers' social coaching, mother–child relationship style, and children's peer competence: Is the medium the message? *Child Development*, *68*, 312–332.

Moorman, E. A., & Pomerantz, E. M. (2008). Mothers' cognitions about children's self-control: Implications for mothers' responses to children's helplessness. *Social Development, 14*, 960-979.

Neufeld, R. W. J. (1977). *Clinical quantitative methods* New York: Grune & Stratton.

Neufeld, R. W. J. (1999). Dynamic differentials of stress and coping. *Psychological. Review, 106*, 385-397.

Neufeld, R. W. J., & Gardner, R. C. (1990). Data aggregation in evaluating psychological constructs: Multivariate and logical deductive considerations. *Journal of Mathematical Psychology, 34*, 276-296.

O'Connor, B. P. (2000). SPSS and SAS programs for determining the number of components using parallel analysis and Velicer's MAP test. *Behavior Research Methods, Instruments, & Computers, 32*, 396-402.

Olson, C. L. (1976). On choosing a test statistic in multivariate analysis of variance. *Psychological Bulletin, 83*, 579-586.

Olson, C. L. (1979). Practical considerations in choosing a MANOVA test statistic: A rejoinder to Stevens. *Psychological Bulletin, 86,*1350-1352.

Olson, S.L., Sameroff, A.J., Kerr, D.C.R., Lopez, N.L., & Wellman, H.M. (2005). Developmental foundations of externalizing problems in young children: The role of effortful control. *Developmental Psychopathology, 17,* 25–45.

Pagano, I. S., Barkhoff, H., Heiby, E. M., & Schlicht, W. (2006). Dynamical modeling of the relations between leisure activities and health indicators in a cross-national sample. *Journal of Leisure Research, 38*, 61-77.

Patterson, G.R. (2002). Etiology and treatment of child and adolescent antisocial behavior. *The Behavior Analyst Today, 3,* 133 -143.

Patterson, G.R., DeGarmo, D., & Forgatch, M.S. (2004). Systematic changes in families following prevention trials. *Journal of Abnormal Child Psychology, 32*, 621-633.

Pellegrini, A.D., & Smith, P.K. (1998). Physical activity play: The nature and function of a neglected aspect of play. *Child Development, 69*, 577-598.

Pepler, D.J. (2003). Supporting young children and their families in the reduction of aggression. Comments on Webster-Stratton, Domitrovich and Greenberg, and Lochman. In: R.E. Tremblay, R.G. Barr, R.DeV. Peters (Eds.), *Encyclopedia on Early Childhood Development* [online]. Montreal, Quebec: Centre of Excellence for Early Childhood Development; 2003:1-5. Available at: http://www.childencyclopedia.com/documents/PeplerANGxp.pdf

Peterson, J.B., & Flanders, J.L. (2005). Play and the regulation of aggression. In: R.E. Tremblay, W.W. Hartup, & J. Archer (Eds.), *Developmental origins of aggression*, (pp.133-157). New York: The Guilford Press.

Pettit, G. S., Laird, R. D., Dodge, K. A., Bates, J. E., & Cross, M. M. (2001). Antecedents and behavior-problem outcomes of parental monitoring and psychological control in early adolescence. *Child Development, 72,* 583–598.

Reitman, D., Currier, R.O., & Stickle, T.R. (2002). A critical evaluation of the Parenting Stress Index-Short Form (PSI-SF) in a Head Start population. *Journal of Clinical Child & Adolesccent Psychology, 31*, 384-92.

Roberts, W. L., & Strayer, J. (1987). Parents' responses to the emotional distress of their children: Relations with children's competence. *Developmental Psychology, 23*, 415-422.

Roggman, L. A. (1991). Assessing social interactions of mothers and infants through play. In. C. E. Schaefer, K. Gitlin, and A. Sandgrund (Eds.), *Play diagnosis and assessment* (pp. 427–462). New York: Wiley.

Rubin, K. H., & McKinnon, J. (1994). The *Parental Warmth and Control Scale*. Unpublished coding manual, University of Waterloo, Waterloo, Ontario, Canada.

Rutter, M. & Quinton, D. (1984). Parental psychiatric disorder: Effects on children. *Psychological Medicine*, *14*, 853-880.

Sanders, M. R. (1999). Triple P-Positive Parenting Program: Towards an empirically validated multilevel parenting and family support strategy for the prevention of behavioural and emotional problems in children. *Clinical Child and Family Psychology Review*, *2*, 71-90.

Sanders, M. R., Cann, W., & Markie-Dadds, C. (2003). Why a universal population-level approach to the prevention of child abuse is essential. *Child Abuse Review, 12*, 155-171.

Schore, A. N. (1994). *Affect regulation and the origin of the self: The neurobiology of emotional development.* Hillsdale NJ: Lawrence Erlbaum.

Schore, A. N. (2000). The self-organization of the right brain and the neurobiology of emotional development. In M.D. Lewis & I. Granic (Eds.), *Emotion, Development, and Self-Organization, (pp. 155-185).* New York: Cambridge University Press.

Séguin, J.R., & Zelazo, P.D. (2005). Executive function in early physical aggression. In: R.E. Tremblay, W.W. Hartup, & J. Archer (Eds.), *Developmental origins of aggression, (pp.307-329)*. New York: The Guilford Press.

Seja, A. L., & Russ, S. W. (1999). Children's fantasy play and emotional understanding. *Journal of Clinical Child Psychology, 28*, 269–277.

Shinbrot, T., Grebogi, C., Yorke, J.A., & Ott, E. (1993). Using small perturbations to control chaos. *Nature, 363*, 411 – 417.

Shortt, A.L., Barrett, P.M., Dadds, M.R., & Fox, T.L. (2001). The influence of family and experimental context on cognition in anxious children. *Journal of Abnormal Child Psychology*, *29*, 585–596.

Sidak, Z. (1967). Rectangular confidence regions for the means of multivariate normal distributions. *American Statistical Association, 62,* 626-633.

Snyder, J., Prichard, J., Schrepferman, L., & Patrick, M.R. (2004). Child impulsiveness-inattention, early peer experiences and the development of early onset conduct problems. *Journal of Abnormal Child Psychology, 32*, 579-594.

Spencer, J. P., Simmering, V. R., Schutte, A. R., & Schöner, G. (2007). What does theoretical neuroscience have to offer the study of behavioral development?

Insights from a dynamic field theory of spatial cognition. In J. M. Plumert & J. P. Spencer (Eds.), *Emerging landscapes of mind: Mapping the nature of change in spatial cognitive development.* New York, NY: Oxford University Press.

Sroufe, L.A. (1996). *Emotional development: The organization of emotional life in the early years.* New York: Cambridge University Press.

Staddon, J. E. (1984). Social learning theory and the dynamics of interaction. *Psychological Review, 91*, 502-507.

Steenbeek, H. W., & van Geert, P. L. C. (2008). The empirical validation of a dynamic systems model of interaction: Do children of different sociometric statuses differ in their dyadic play interactions? *Developmental Science, 11*, 253–281.

Stewart, D., & Love, W. A. (1968). A general canonical correlation index. *Psychological Bulletin, 70*, 160-163.

Tabachnick, B.G., & Fidell, L.S. (2001). *Using multivariate statistics* (4th Edition). Boston, MA: Allyn & Bacon.

Tamis-LeMonda, C. S., Užgiris, I.C., & Bornstein, M.H. (2002). Play in parent-child interactions. In: M.H. Bornstein (Ed.), *Handbook of parenting (2/e): Volume 5, Practical issues in parenting*, (pp.221-242). Mahwah, NJ, US: Lawrence Erlbaum Associates Inc.

Thelen, E., & Smith, L.B. (1994). *A dynamic systems approach to the development of cognition and action*. Cambridge, MA: The Massachusetts Institute of Technology Press.

Thelen, E., & Ulrich, B. D. (1991). Hidden skills: A dynamic systems analysis of treadmill stepping during the first year. *Monographs of the Society for Research in Child Development, 56*(1, Serial No. 223).

Thomas, R., & Zimmer-Gembeck, M. J. (2007). Behavioral outcomes of Parent-Child Interaction Therapy and Triple P – Positive Parenting Program: A review and meta-analysis. *Journal of Abnormal Child Psychology, 35*, 475-495.

Thompson, R. A., & Meyer, S. (2007). Socialization of emotion regulation in the family. In: J.J. Gross, James J. (Ed), *Handbook of emotion regulation, (pp. 249-268).* New York, NY, US: Guilford Press.

Tonyan, H. A. (2005). Coregulating distress: Mother-child interactions around children's distress from 14 to 24 months. *International Journal of Behavioral Development, 29*, 433-444.

Tremblay, R. E. & LeMarquand, D. (2001). Individual risk and protective factors. In R. Loeber & D. P. Farrington (Eds.), *Child delinquents: Development, intervention, and service needs, (pp.137-164)*. Thousand Oaks, CA: Sage.

Valentino, K., Cicchetti, D., Toth, S.L., & Rogosch, F.A. (2006). Mother-child play and emerging social behaviors among infants from maltreatment families. *Developmental Psychology, 42*, 474-485.

van Geert, P. (2003). Dynamic systems approaches and modeling of developmental process. In J. Valsiner & K. J. Conolly (Eds.), *Handbook of developmental psychology, (pp.640–672).* London: Sage.

Van Geert, P. & Steenbeek, H. (2008). A complexity and dynamic systems approach to developmental assessment, modeling and research. In: A. M. Battro, K. W.

Fischer & P. Léna (Eds.), The educated brain: essays in neuro-education. Cambridge U.K.: Cambridge University Press (pp. 71-94).

Velicer, W. F., & Fava, J.L. (1998). The effects of variable and subject sampling on factor pattern recovery. *Psychological Methods, 3*, 231-251.

Wainer, H. (1976). Estimating coefficients in linear models: It don't make no never mind. *Psychological Bulletin, 83*, 213-217.

Wainer, H. (1978). On the sensitivity of regression and regressors. *Psychological Bulletin, 85*, 267-273.

Webster-Stratton C. (2003, 2005). Aggression in young children: services proven to be effective in reducing aggression. Rev ed. In: R.E. Tremblay, R.G. Barr, R.DeV. Peters (Eds.), *Encyclopedia on Early Childhood Development* [online]. Montreal, Quebec: Centre of Excellence for Early Childhood Development; 1-6. Available at: http://www.child-encyclopedia.com/documents/Webster-StrattonANGxp_rev.pdf.

Webster-Stratton, C., & Hammond, M. (1998). Conduct problems and level of social competence in Head Start children: Prevalence, pervasiveness and associated risk factors. *Clinical Child Psychology and Family Psychology Review, 1,* 101–124.

Webster-Stratton, C., Mihalic, S., Fagan, A., Arnold, D., Taylor, T. & Tingley, C. (2001). *Blueprints for violence prevention. Book 11: The incredible years: Parent, teacher and child training series*. Boulder, CO: Center for the Study and Prevention of Violence.

Weiss, B., Dodge, K.A., Bates, J., & Pettit, G. (1992). Some consequences of early harsh discipline and a maladaptive social information processing style. *Child Development*, *63*, 1321–1335.

Woodward, J. A., & Overall, J. E. (1975). Multivariate analysis of variance by multiple regression methods. *Psychological Bulletin, 82*, 21-32.

Wright, K. (1991). *Vision and separation: Between mother and baby.* Northvale, NJ: Jason Aronson.

Zwick, W.R., & Velicer, W. F. (1986). Factor influencing five rules for determining the number of components to retain. *Psychological Bulletin, 99*, 432-442.

Ethics Approval

Western

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Use of Human Subjects - Ethics Approval Notice

Principal Investigator: Dr. P.N.S. Hoaken
Review Number: 12627S **Review Date:** September 8, 2006 **Revision Number:**
Protocol Title: Maltreatment and Aggression: Cognition and Emotion as Mediating Variables
Department and Institution: Psychology, University of Western Ontario
Sponsor:
Ethics Approval Date: October 13, 2006 **Expiry Date:** August 31, 2008
Documents Reviewed and Approved: UWO protocol, letters (2) of information and consent: primary caregiver, legal guardian/CAS (Dated: September 20, 2006), Assent form
Documents Received for Information:

This is to notify you that The University of Western Ontario Research Ethics Board for Health Sciences Research Involving Human Subjects (HSREB) which is organized and operates according to the Tri-Council Policy Statement and the Health Canada/ICH Good Clinical Practice Practices: Consolidated Guidelines; and the applicable laws and regulations of Ontario has reviewed and granted expedited approval to the above named research study on the approval date noted above. The membership of this REB also complies with the membership requirements for REB's as defined in Division 5 of the Food and Drug Regulations.

This approval shall remain valid until the expiry date noted above assuming timely and acceptable responses to the HSREB's periodic requests for surveillance and monitoring information. If you require an updated approval notice prior to that time you must request it using the UWO Updated Approval Request Form.

During the course of the research, no deviations from, or changes to, the protocol or consent form may be initiated without prior written approval from the HSREB except when necessary to eliminate immediate hazards to the subject or when the change(s) involve only logistical or administrative aspects of the study (e.g. change of monitor, telephone number). Expedited review of minor change(s) in ongoing studies will be considered. Subjects must receive a copy of the signed information/consent documentation.

Investigators must promptly also report to the HSREB:
a) changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
b) all adverse and unexpected experiences or events that are both serious and unexpected;
c) new information that may adversely affect the safety of the subjects or the conduct of the study.

If these changes/adverse events require a change to the information/consent documentation, and/or recruitment advertisement, the newly revised information/consent documentation, and/or advertisement, must be submitted to this office for approval.

Members of the HSREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the HSREB.

Chair of HSREB: Dr. John W. McDonald
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Davidge, K.M., Atkinson, L., Douglas, L., Lee, V., Shapiro, S., Kennedy, J.L., & Beitchman, J.H. (2004). Association of the serotonin transporter and 5HT1D-beta receptor genes with extreme, persistent, and pervasive aggressive behavior in children. *Psychiatric Genetics, 14*, 143-146.

Beitchman, J.H., Davidge, K.M., Kennedy, J.L., Atkinson, L., Lee, V., Shapiro, S., & Douglas, L. (2003). The serotonin transporter gene in aggressive children with and without ADHD and nonaggressive matched controls. *Annals of the New York Academy of Sciences, 1008:248-51.*

Wolfe, D.A., Crooks, C.V., Lee, V., McIntyre-Smith, A., & Jaffe, P.G. (2003). The effects of children's exposure to domestic violence: A meta-analysis and critique. *Clinical Child and Family Psychology Review*, *6*, 171-187.