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Infant Responding to Joint Attention, Executive Processes, and Self-Regulation in Preschool Children

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Abstract: Infant joint attention is related to behavioral and social outcomes, as well as language in childhood. Recent research and theory suggests that the relations between joint attention and social-behavioral outcomes may reflect the role of executive self-regulatory processes in the development of joint attention. To test this hypothesis two- studies were conducted. The first, cross-sectional study examined the development of responding to joint attention skill (RJA) in terms of increasing executive efficiency of responding between 9 and 18 months of age. The results indicated that development of RJA was characterized by a decreased latency to shift attention in following another person's gaze and head turn, as well as an increase in the proportion of correct RJA responses exhibited by older infants. The second study examined the longitudinal relations between 12-month measures of responding to joint attention (RJA) and 36-month attention regulation in a delay of gratification task. The results indicated that responding to joint attention at 12-months was significantly related to children's use of three types of self-regulation behaviors while waiting for a snack reward at 36 months of age. These observations are discussed in light of a developmental theory of attention regulation and joint attention in infancy.

Keywords: infant, joint attention, responding to joint attention, delay of gratification, self-regulation, executive function

Joint attention is a major developmental milestone of infancy (Adamson, 1995) that contributes to childhood intellectual, social-emotional, and interpersonal development (e.g., Sheinkopf, Mundy, Claussen, & Willoughby, 2004; Ulvund & Smith, 1996), as well as language development (Carpenter, Nagell, & Tomasello, 1998; Mundy, Block, Delgado, Pomares, Van Hecke, & Parlade, 2007). Impairments in early joint attention development also contribute to developmental disorders such as autism (Mundy, Sullivan, & Mastergeorge, 2009; Sigman & Ruskin, 1999), and individual differences in early joint attention predict difference in adult social competence in individuals with this disorder (Gillespie-Lynch et al., in press).

One type of joint attention involves the ability to follow the head-turn, line of visual regard, and/or pointing gesture of a social partner (see Figure 1). This ability domain was first studied by Scaife and Bruner (1975) and has been called Responding to Joint Attention or RJA (Seibert, Hogan, & Mundy, 1982). The rudiments of RJA may emerge as early as 3 months (D'Entremont, Hains, & Muir, 1997; Hood, Willen, & Driver, 1998), and the behavior is observable, at greater than chance levels, by 6–10 months of age (Brooks & Meltzoff, 2005; Butterworth & Cochran, 1980; Corkum & Moore, 1998; Morales, Mundy, & Rojas, 1998; Scaife & Bruner, 1975). Research and theory suggest that the development of RJA, along with other types of joint attention, may reflect changes in infants' executive control of attention (Dawson et al., 2002; Mundy, 2003). For example, joint attention has been associated with measures of response inhibition in a spatial reversal task (McEvoy, Rogers, & Pennington, 1993; Griffith, Pennington, Wehner, & Rogers, 1999), the integration of response inhibition, reward-based learning, and novelty discrimination in a delayed non-match to sample task (Dawson et al., 2002, Nichols, Fox, & Mundy, 2005), as well as self-awareness in a self-recognition task (Nichols et al., 2005).

Figure 1* Illustration of Responding to Joint Attention-RJA (ESCS: Mundy et al., 2003) *to be reproduced in color on the Web and in black and white in print.

Posner, Rothbart, and colleagues (e.g., Posner & Peterson, 1990; Rothbart et al., 1994) provide a plausible account of how RJA and gaze following likely develop in concert with executive abilities in the first year of life: the early developing posterior attention network. Aspects of the posterior network develop in the first four months of life and are localized to the superior parietal lobe (disengagement from a current focus), the midbrain superior colliculus (shift of attention to new stimulus), and the pulvinar and reticular nuclei of the thalamus (processing of information from the new focus) (Rothbart & Posner, 2001). This early-developing network of cortical and subcortical control may serve as the neural foundation for the behavioral mechanisms involved in RJA (Mundy et al., 2000). Thus, RJA may be regulated by an executive posterior attention system (temporal-parietal cortex) (Redcay et al., 2010) that plays a fundamental role in the capacity to disengage attention from a central stimulus in order to allocate attention to a new spatial location in a goal-directed manner (Butterworth & Jarrett, 1991; Kingstone, Friesen, & Gazzaniga, 2000; Mundy, Card, & Fox, 2000; Rothbart & Posner, 2001;Vaughan Van Hecke & Mundy, 2007).

Competing theories suggest that the early development and expression of RJA can be characterized by social cognitive processes (e.g., understanding of others' intentions may be indicated by following the direction of their visual gaze: Baron-Cohen, 1995; Brooks & Meltzoff, 2002; Gredeback, Fikke, & Melinder, 2010; Tomasello, Carpenter, Call, Behne, & Moll, 2005); however, the results of the above self-monitoring and self-regulation studies suggest that executive functions may be integral to the development of infant joint attention, even before social cognitive processes play a major role in the behavior domain (Mundy, 2003; Mundy et al. 2009; Vaughan Van Hecke & Mundy, 2007). The contribution of executive functions and self regulation may help to explain observations of significant relations between early joint attention and later social outcomes in typically and atypically developing children (Sheinkopf et al., 2004; Mundy & Sigman, 2006; Sigman & Ruskin, 1999; Vaughan Van Hecke et al., 2007), as well as links between joint attention, temperament, and social competence (Todd & Dixon, 2010; Vaughan Van Hecke et al., 2007). Individual differences in attention regulation constitute one of the fundamental components of temperament that has been related to the development of social-competence (Masten & Coatsworth, 1998; Posner, 1988; Posner & Rothbart, 2000; Rothbart & Posner, 2001). Individual differences in infants' tendencies to attend or look away from a rewarding or negative stimulus is one of the first and most important means by which infants learn to self-regulate their affective states and goal-related intentional behaviors directed toward people and objects (Posner & Rothbart, 2000).

Thus, the infant development of RJA skill and the posterior attention system may explain the links between joint attention and later measures of self-regulation, which in turn predict associated domains such as social competence even to adulthood (Gillespie-Lynch et al., in press). Research has begun to bear evidence for this hypothesis: Morales, Mundy, Delgado, Yale, Neal, and Schwartz (2000) observed that RJA at six months was associated with mothers' ratings of individual differences in attention regulation. Also, Morales, Mundy, Crowson, Neal, and Delgado (2005) reported that 6-month old infants who had more developed RJA skill were more likely to use active distraction strategies and wait longer for a desired object in a 24-month delay of gratification paradigm. However, it is important to note that two studies to date (Todd & Dixon, 2010; Vaughan Van Hecke et al., 2007) have also found that high levels of RJA at 11–12 months were also associated with *lower* levels of inhibitory control on temperament measures, which at first glance seems contrary to the idea that RJA might be positively related to executive process. However, the important distinction here is between concurrent and predictive relations: it may be that young infants who are less regulated or inhibited are more likely to show concurrent high rates of shifting attention; however, over development, this high rate is refined to result in fewer incorrect/extraneous shifts of attention and more frequent relevant/correct shifts of attention. Then, it is likely that, over time, the infant's ability to make necessary refinements to shifting attention would also be predictive of the child's ability to regulate behavior in other settings. In this perspective, both infants that are high in shifting attention due to less inhibition and infants who are high in shifting attention due to better initial regulation end up at a common end point: one in which more efficient shifting of attention should predict better self-regulation at a later point in development.

In summary, this executive control perspective on joint attention raises the hypothesis that the development of RJA may not only be characterized by improvements in the *ability* to shift attention in a manner that is congruent with that of social partner, but also in the *efficiency* of the execution of this type of attention coordination behavior (Mundy et al., 2009). Efficiency on RJA trials may be measured in terms of speed of responses, or the latency between infants' observation of their social partner's head and gaze shift and the execution of their own spatially correct gaze shift and head turn. That is, if changes in executive control play a role in RJA development, then we would expect to observe decreases in latency to respond on RJA trials, as well as increases in correct responses to RJA trials across ages in infancy. Additionally, if executive attention processes are involved in RJA, one would expect that individual differences in RJA skill at an early time point would predict later measures of childhood self-regulation. These hypotheses were addressed in the following two-part study: the first, cross-sectional study aimed to understand the early executive development of RJA, via examining changes in ability and efficiency of RJA skill of typically developing infants between 9- and 18-months of age; and the second, longitudinal study examined whether RJA skill at 12-months predicted self-regulation, via a delay of gratification laboratory paradigm, at 3 years of age.

1. Study 1: Latency and the Development of RJA Information Processing Efficiency

1.1 Method

1.1.1 Participants

Infants in this study were drawn from a larger sample of urban children participating in a 9 to 36 month longitudinal study of typical social development (see Mundy et al., 2007 & Vaughan Van Hecke et al., 2007 for further details). Infants were recruited if they met the following criteria: five-minute APGAR scores greater than or equal to seven, and no history of major medical, neurological, sensory, congenital, and/or chromosomal abnormalities at intake. Seventeen 9-month-old-infants (9 boys, 8 girls) and 17 18-month-olds (8 boys, 9 girls) were included in this study.

The mean Bayley Scales Infant Mental Developmental Index (MDI: Bayley, 1993) scores for the 9-month group was 91.82 (SD = 14.4) and for the 18-month group was 95.6 (SD = 11.7). Average birth weight for the 9-month group was 6.13 lbs (SD = 1.57) and for the 18-month group was 6.87 lbs (SD = 1.35). Respectively, the average gestational ages for the 9- and 18-month groups were 38.1 weeks (SD = 2.2; 18) and 38.6 weeks (SD = 1.9). Estimates of the mothers' level of education were 87% with some college or more and 83% with some college or more for the 9- and 18-month groups, respectively. 97% of mothers of infants in this study indicated that they were Caucasian.

1.1.2 Measures

Parents identified whether English or Spanish was the preferred language for all infants in this study, and testers who were fluent, native speakers in the preferred language administered all measures. Infants were assessed in a child-friendly, carpeted laboratory room decorated with posters, a couch, a testing table, an intercom, and several chairs. All assessments were videotaped through a one-way mirror.

Early Social Communication Scales (ESCS: Mundy, Delgado, Block, Venezia, Hogan, & Seibert, 2003)

The ESCS is a 20-minute structured interaction designed to assess infants' tendencies to initiate and respond to joint attention bids in standardized social interactions with a tester. In this paradigm, the experimenter and child were seated facing each other at a small table, with the infant seated on a caregiver's lap. A set of toys, which was visible to the child, was placed to the right of the experimenter, but out of reach of the infant. Posters were placed on the walls 90 degrees to the child's right and left, and 170 degrees to the right and left behind the face-forward position of the child.

Along with the other standardized ESCS tasks, the children were presented with two sets of four RJA trials in a standardized sequence, such that: on Trial 1 testers looked and pointed the poster to the child's right side, on Trial 2 testers looked and pointed to the poster behind and to the right side of the child, on Trial 3 testers looked and pointed to poster to the child's left, and on Trial 4 the tester looked and pointed to the poster behind and to the left of the child. Prior to the presentation of each trial, the tester attracted the child's attention to her face by calling the child's name and/or tapping the table and touching the child lightly. On each trial, the tester turned toward or fixated on a poster to the left, right, or behind the child (left or right side) and called the child's name three times with increasing emphasis. The tester did not look back to the child during the trial, and each trial lasted 5 seconds to provide an ample opportunity for the child to respond. On all trials, testers kept their elbows close to their bodies while pointing in order to minimize arm movements that could serve to direct the attention of the infants. On left and right trials, testers maintained an upright posture so that body inclination to the right or left was minimized. On behind trials, however, testers leaned forward and inclined their heads slightly to "look behind" the infants' right or left shoulder. Once initiated, a complete set of RJA trials was administered without interruption. The first set of the RJA trials was administered at approximately at the mid-point of the ESCS, and the second set was administered at about the end of the assessment.

Several variables were obtained from the eight RJA trials in this study. The percent correct responses across the combined left-right trials and combined behind trials were computed for each child. These measures have been used to examine the development of RJA responding in previous research (e.g. Delgado, Mundy, Crowson, Markus, Yale, & Schwartz, 2002). A correct response on an RJA trial was scored if the infant shifted their gaze (with or without a head turn) to look in the direction indicated by the tester's gaze, head-turn and pointing gesture. On left and right trials, a correct response was scored if the infant shifted their gaze in the direction of the testers gaze and point *and* were rated as looking beyond the tester's pointing index finger. That is, infants needed to demonstrate they were not just following the body or hand motion of the tester but were looking beyond the tester in the appropriate direction. On behind trials a correct response was scored if the infant looked beyond the line of their shoulders or greater than 90% from mid-line in the correct direction of the tester's gaze and pointing gesture. Two coders independently rated data from 10 children in this study (30%) and the intra-class correlation estimate of their reliability on this variable was .96, $p < .001$.

The frequency of children who displayed a correct response on each trial was also scored. The independent ratings of 2 coders for children in this study yielded an intraclass correlation estimate of their reliability that was significant, .97, $p < .001$.

Finally, the latency to respond on RJA trials was also coded using on screen vertical interval time code (VITC) and frame-by-frame analyses of video data. The first frame in which raters observed that the tester began to turn and extend their index figure to the right or left of the child indicated the beginning of a left or right RJA trial. The behind trial was marked on the first frame in which the tester began to lean forward and extend her index figure to point over the right or left shoulder of the infant. Latency of the infant's response on RJA trials was obtained by noting the time code associated with the video frame on which the infant first began the correct gaze shift/head turn and then subtracting this from the time code associated with the initiation of the tester's behavior on that same trial. The inter-rater reliability estimate for the latency scores using these methods was acceptable (average of 1st set of trials = .92; average of 2nd set of trials = .96; average of all trials = .95; all *p*s < .001.

1.2 Results

1.2.1 Preliminary Analyses

The 9-month group displayed a mean percent correct of 52% (SD = 37%, SE = 9%) on left-right trials and a mean of 2% on behind trials (SD = 6%, SE = 2%). Comparable data for the 18-month group were 85% (SD = 21%, SE = 5%) for left-right trials and 52% (SD = 33%, SE = 8%) for behind trials. The RJA data were submitted to arcsine transformations (due to restricted range of the percentage scale) and analyzed in a 2 between (Age Group) X 2 within (Trial Type, left-right or behind) ANOVA. This yielded an effect for Trial Type ($F(1,32) = 57.36$, $p < .001$) such that both groups were significantly better on left-right trials than behind trials performance (post-hoc t-tests, *p*s < .002 for both Age Groups). This analysis also revealed an age effect ($F(1,32) = 23.40$, $p < .001$), such that the 18-month group displayed significantly better performance on both left right and behind trials (post-hoc t-tests *p*s < .005 for both Trial Types).

1.2.2 Latency Data

To evaluate if increases in information processing efficiency as well as numbers of correct responses characterize RJA development, the latency to turn on RJA trials was analyzed across the age groups. However, significantly more of the 18-month-old than 9-month-old children displayed correct responses on their first left and right side RJA trials as well as all behind trials (Fischer's Exact Test *p*s < .01, see Table 1). Therefore, analyses were limited to data from children who displayed correct responses on a given trial (see Tables 1 & 2) in order to control for differences in latency in RJA information processing across the age groups that may have been due to incorrect responses.

Table 1
Study 1: Frequency of children with correct RJA response by trials and age groups.

RJA trials	9-month group		18-month group	
	Correct	Fail	Correct	Fail
1st right-side trial	7	10	16	1**
1st left-side trial	7	10	16	1**
1st behind-right trial	1	16	12	5**
1st behind-left trial	0	17	10	7**
2nd right-side trial	12	5	15	2
2nd left-side trial	9	8	11	6
2nd behind-right trial	0	17	7	10*
2nd behind-left trial	0	17	6	11*

* Age Group difference $p < .01$.
** Age Group difference $p < .005$.

Table 2
Study 1: Latency in seconds of correct responses on the RJA trials for the 9- and 18-month age groups.

RJA trials	9-month group Latency (*N*, SD, SE)	18-month group Latency (*N*, SD, SE)
1st right-side trial	2.29 (7, 1.4, .52)	.88 (16, .89, .22)*
1st left-side trial	1.86 (7, 1.1, .40)	.88 (16, .88, .22)*
2nd right-side trial	1.75 (12, 1.4, .39)	.87 (15, 1.1, .27)**
2nd left-side trial	1.33 (9, 1.2, .41)	.82 (11, .87, .26)

* Age Group difference $p < .05$.
** Age Group difference $p < .075$.

Since very few, if any, of the 9-month old children provided evidence of correct behind responding on RJA trials, the latency analyses were also limited to data from the two sets of left and right side RJA trials. These analyses indicated that the 9-month group of infants had significantly longer latencies before demonstrating a correct RJA response to the tester on the 1st right side RJA trial (t (variance corrected) = 2.49, $p < .04$) and on the 1st left side RJA trial ($t = 2.30$, $p < .04$) compared to the 18-month group. A marginally significant age effect was observed for the 2nd right side RJA trial ($t = 1.9$, $p < .075$), but no age effect was observed for the 2nd left side RJA trial (t = 1.01, $p > .10$). The data in Table 2 also suggested indicate that Age Group differences in latency diminished between the first and second set of trials because the 9-month olds become faster on RJA (displayed shorter latencies on trial 2 than on trial 1). However, none of the 1st trial versus 2nd trial comparisons was significant when based only on data from infants with correct responses. However, t-tests of the combined left-right trial 1 versus trial 2 data for the seven 9-month-olds who passed the second RJA trials revealed a one-tailed effect that approached a conventional level of significance (1st trials = 2.78 seconds (1.41); 2nd trials = 1.52 (.93); $p < .075$).

1.3 Discussion

The results of this study indicated that RJA development in the 9- to 18-month period may be characterized by a significant *increase in the efficiency of the execution* of correct infant RJA responses, as well as by an increase in the *consistency of correct* infant responses to referential signals of a social partner. This developmental change in latency may reflect functional improvement in the posterior attention system and especially an improved capacity to disengage from a focal stimulus in infancy between 9 to 18 months (Morales et al., 2005; Rothbart & Posner, 2001;Vaughan Van Hecke & Mundy, 2007). Alternatively, it is also possible that developmental shifts in latency of RJA may reflect changes in speed of social information processing, or how rapidly infants may perceive and process the meaning of the gaze shift and head turn of the social partner. Such an account would be consistent with the observation that changes in the speed of visual information processing is a general and fundamental feature of infant cognitive development (Case, 1987; Rose, Feldman, & Jankowski, 2003).

Other aspects of the data were also noteworthy. Across RJA trials, the 9-month group displayed some evidence of improved responding in terms of both the latency of correct responses and the numbers of infants who displayed correct responses. This may have reflected practice based learning and improvement in RJA execution even within the brief 20-minute interval of the ESCS. Previous data provides some support of the former possibility. Corkum and Moore (1998) observed that 8-month-olds are on the cusp of consolidating left-right RJA skill and display improved RJA skill when provided with even minimal practice and operant rewards. Indeed, the testers in this study often provided positive social reward when children looked in the correct direction on RJA trials (e.g. stating "good looking" with positive affect). It is possible that the improvement in RJA displayed by 9-month-olds in this study reflected a similar effect of practice and reward. On the other hand, a non-specific effect, such as decreased behavioral inhibition as the result of acclimation to the novel tester and the novel interactive situation, may have led to improved RJA performance in the 9-month-olds. However, given that children showed an increased executive facility in RJA over time, it will be important to discern, in Study 2, whether this honing of RJA skill is in isolation or is predictive of later forms of self-regulation.

2. Study 2: Delay of Gratification and Self-Regulation Related Processes in RJA

2.1 Method

2.1.1. Participants

Participants were drawn from the same larger study as Study 1. Inclusion criteria also included complete RJA and delay of gratification data at 12- and 36-months. This yielded an initial sample of 34 infants. Analyses were also limited to those children with 24-month Bayley Mental Development Index (MDI) scores of greater than 70 (mean MDI = 102.37, *SD* = 11.34). The addition of this criterion reduced the sample available for this study to 29 children. Excluded infants did not significantly differ from included infants on the basis of gender, birth weight, gestation, maternal age, maternal education, or maternal race.

Eighteen (62%) of these infants were female, and 11 (38%) were male. Mean infant birth weight was 6.66 pounds (*SD* = 1.24) and mean gestation was 38 weeks (*SD* = 2.2). 90% of mothers in this study had some college education. 97% of mothers of infants in this study indicated that they were Caucasian.

2.1.2 Measures

Early Social Communication Scales (ESCS: Mundy et al., 2003)

The ESCS (see Study 1 for details) was administered to infants at 12 months of age. The intra-class correlation coefficient for RJA among four independent coders for 10 sets of ESCS data from children in this specific study was .91 ($p < .05$).

Delay of Gratification Assessment

The delay of gratification assessment for this study consisted of the "Snack Delay" portion of the Laboratory Temperament Assessment Battery- Preschool Version 0.5 (Lab-Tab: Goldsmith, Reilly, Lemery, Longley, & Prescott, 1999), conducted at 36-months. In this assessment, the experimenter and child were seated across from each other at a child-sized table, with no parents present. The experimenter showed the child a bag of fruit snacks, a clear plastic cup, and a bell, and told the child that the experimenter would put a fruit snack under the cup, and when the experimenter rang the bell, the child could have the snack. Children were presented with 6 trials, with the delay time between placement of the cup and ringing of the bell varying as follows: 5 seconds, 10 seconds, 0 seconds, 20 seconds, 0 seconds, and 30 seconds. Zero-second trials were not coded. All children were presented with all trials regardless of whether or not they rang the bell or retrieved the snack prematurely on a trial (s).

Codes for the trials were as follows: Prompts, Delay, Anticipation, and Distraction (see Table 3 for variable descriptions). High scores on Delay and Distraction would be expected to relate to higher self-regulation; whereas high scores for Prompts and Anticipation would be indicative of lower self-regulation. The intra-class correlation coefficients among three independent coders for 7 sets of delay of gratification data from children in this study were as follows: Prompts = .97, Delay = .99, Anticipation = .95, and Distraction = .97 (all *p*'s < .05).

Table 3
Study 2: Description of snack delay of gratification variables (Lab-Tab: Goldsmith et al., 1999).

Variable	Description
1. Prompts	Average number of times the child touched or reached for the bell, touched the experimenter, or said "Ring it," "I'm ready, "Now," or "Ok," during all trials
2. Delay	Total number of seconds, summed over all trials, that the child waited before retrieving the snack
3. Anticipation	Average of the following codes for all trials: 0 = no anticipation; 1 = briefly looks at cup, snack, or bell (<three seconds for each look); 2 = looks at cup, snack, or bell (≥three seconds for each look), or holds cup; and 3 = picks up cup, or plays with cup or snack
4. Distraction	Average of the following codes for all trials: 0 = child performs no alternative activities during trial; 1 = child briefly (<3 s) glances at table, one-way mirror, couch, or walls, or makes one or two snack-unrelated comments to experimenter; 2 = child looks around the room, looks at the one-way mirror, or makes faces in the one-way mirror (≥3 s); and 3 = child makes extensive snack-unrelated comments or never looks at snack the entire trial

2.2 Results

Descriptive statistics for all measures in this study are presented in Table 4. Primary analyses involved computing Pearson correlations between 12-month infant RJA and 36-month delay of gratification measures. Examination of distributions revealed that the Delay variable was significantly negatively skewed; thus, Spearman correlation coefficients are reported for the Delay variable.

Table 4
Study 2: Descriptive statistics.

Variable	Mean	Standard deviation
1. 12-month responding to joint attention percentage (RJA)	58.92	24.60
2. 36-month snack delay average prompts	1.48	1.64
3. 36-month snack delay seconds delayed to retrieve snack	60.10	9.27
4. 36-month snack delay average anticipation behaviors	1.82	.47
5. 36-month snack delay average distraction behaviors	.83	.56

Note: $N = 29$.
RJA was scored from the Early Social Communication Scales (ESCS: Mundy et al., 2003) completed when infants were 12 months of age. RJA Percentage score reflects the percentage of all trials in which the infant responded correctly by following the point and gaze of the tester. Snack Delay measures were scored from the Snack Delay assessment in the Preschool Laboratory Temperament Assessment Battery (Lab-Tab: Goldsmith et al., 1999) at 36 months of age.

RJA at 12 months was significantly correlated with 3-year-old children's ability to regulate their attention in the delay of gratification paradigm. Specifically, children who were more successful in following the gazes and pointing behavior of social partners at 12 months were significantly less likely to prompt an adult (r (27) = −.39, $p < .05$) or show high levels of anticipation behaviors (r (27) = −.52, $p < .01$) when waiting for a snack at 3 years. In addition, children with higher 12-month RJA scores were significantly more likely to divert their attention from the snack by using more complex distraction behaviors (r (27) = .41, $p < .03$). The significant relations of RJA to the Prompts, Anticipation, and Distraction variables remained even when controlling for potential effects of MDI using partial correlations (for Prompts, Anticipation, and Distraction, respectively: r (24) = −.40, $p < .05$; r (24) = −.51, $p < .01$; r (24) = .40, $p < .05$). The relation between RJA and amount of time delayed in retrieving a snack (Delay) was not significant (r (27) = .19, *ns*).

2.3 Discussion

The results of this study indicated that infant responding to joint attention at 12 months predicted children's performance on a 36-month delay of gratification task. Thus, there are now three independent observations that infant joint attention is associated with the development of preschool self-regulation (Morales et al., 2005; Raver, 1996). It was not clear, though, why RJA did not display the expected path of association with the overall measure of children's ability to delay gratification- seconds waited before eating a snack. Two post-hoc hypotheses may help to explain this null finding. First, it may be that RJA was more related to the *strategies and behaviors* children exhibit when waiting for a desired item, rather than inhibition processes involved in the actual act of *delaying* behavior responses. This hypothesis could be addressed in future research on the role of strategies versus behavioral inhibition in delay of gratification. However, a major limitation of this study was small sample size. So, it is also possible that the sample of this study was inadequate to detect potential relations between RJA and seconds waited in a delay of gratification paradigm.

3. Integrative Discussion

At a minimum, RJA involves three functions: a) processing the information provided by the social partner, then b) disengaging attention from the social partner, and c) re-orienting visual attention in a goal directed, socially-anchored and spatially correct fashion (cf. Butterworth & Jarrett, 1991). Hence, it is not surprising that RJA at six months is associated with mothers' ratings of individual differences in attention regulation skills among infants (Morales et al., 2000). RJA development has also been related to temporal and parietal components of the "social brain" responsible for monitoring direction of gaze of others (Emery, 2000; Vaughan Van Hecke & Mundy, 2007) as well as the overlapping "posterior attention system" (Posner & Peterson, 1990) responsible for attention disengagement and the flexible deployment of attention in response to external stimuli (Mundy, 2003; Vaughan Van Hecke & Mundy, 2007).

The results of these two studies illustrate the need to better understand the roles of executive functions, joint attention, and the development of self-regulation and competence in childhood. For example, understanding executive functions that are integrated into social attention coordination may help to explain the relations that have been observed between infant joint attention and later intellectual and self-regulatory development (Morales et al., 2005; Ulvund & Smith, 1996; Vaughan, Mundy, Block, Delgado, Gomez, Neal et al., 2003). While the existence of an association between infant RJA and later self-regulation in Study 2 and in other studies (Morales et al., 2005; Raver, 1996) reflects a clearly replicable phenomenon, the exact nature of the processes involved needs to be determined. The development of joint attention is sensitive to early social cognition (e.g., Brooks & Meltzoff, 2002). However, social-cognitive processes have not typically been ascribed to delay of gratification performance. It is possible, though, that children's use of representational thinking, and perhaps even their mental representations of the intent of the tester, contributed to delay related behaviors in Study 2. This hypothesis could partially account for the fact that the strategies children used in the delay paradigm were related to the amount of time that they delayed. Specifically, children who prompted an adult less and who showed fewer anticipation behaviors waited longer in the delay task. These children may have been able to incur the mental representation that, to receive a snack, they must modify their behavior in accordance with the task and the desires of the adult. However, the nature of being able to modify one's own behavior and the results from Study 1 lead to another explanation: the fact that executive processes may have contributed to both infant joint attention performance and the development of self-regulation exhibited by children in this study (Mundy, 2003; Sheinkopf et al., 2004; Vaughan Van Hecke et al., 2007).

Understanding the executive parameters of joint attention may also contribute to a more comprehensive understanding of development of social cognition. We have recently described the development of joint attention in relation to social cognition in terms of "learning to" and "learning from" phases of development (Mundy, Sigman, & Kasari, 1993; Mundy & Sigman, 2006; Vaughan Van Hecke & Mundy, 2007). In this model, infants first integrate basic information processing abilities to "learn to" engage in joint attention behaviors. This "learning to" state is characterized by: 1) an increase in the efficiency in the execution of joint attention behaviors in social interactions and, 2) a concomitant reduction in the cognitive resources infants must allocate to the execution and management of the motor, spatial, attention, and representation/memory skills that are thought to be integral to learning to engage in joint attention. As joint attention behaviors become more routine and efficient they develop into a type of social executive skill (Mundy, 2003; Mundy & Sheinkopf, 1998). The results from Study 1 provide support for this theoretical phase of joint attention development.

Successful negotiation of the "learning to" state, in turn, frees sufficient cognitive and executive resources to enable infants to enter the "learning from" phase of joint attention development. In the "learning from" phase, infants have sufficient cognitive and executive resources to rapidly process information about self and others. As such, interactive joint attention experiences provide an important platform for simulation and the acquisition of comparative information about commonalities in perception and intentions between self and others (see Mundy et al., 1993; Mundy & Sigman, 2006; Vaughan Van Hecke & Mundy, 2007). This type of social comparative information can only be gleaned by way of rapid information processing and contributes information necessary to human social cognitive development (Mundy et al., 1993; Mundy, 2003).

Adopting an executive function perspective on joint attention may also contribute to a better understanding of developmental impairments in joint attention among children with autism (Mundy, 2003). Young children with autism display deficits in joint attention development (e.g. Mundy et al., 1993) and also problems with the disengagement of attention from visual stimuli (Landry & Bryson, 2004). In addition, research has found that children with autism who have more facility with disengaging or regulating attention also show increased levels of joint attention (Dawson et al., 2002). In this context, the results of these studies raise the hypothesis that impairments in the capacity for attention disengagement and self-regulation may play a role in some forms of joint attention disturbance in autism.

In summary, these studies illustrated that RJA may be related to executive attention regulation processes, replicating previous findings (Morales et al., 2005; Raver, 1996), and confirming that there is an association between the development of responding to joint attention, executive attention regulation, and self-regulation in childhood. As previously noted, attention regulation skill has been viewed as a foundation for the development of social-competence (Masten &

Coatsworth, 1998; Posner & Rothbart, 2000) in typical and atypical development. It may be that aspects of joint attention reflect the early development of social applications of executive attention skills ("social executive functions," Mundy, 2003), and that these processes, in addition to or beyond social cognition, play a role in significant associations between individual differences in infant joint attention and subsequent differences in childhood social and emotional behaviors (Mundy & Sigman, 2006; Sheinkopf et al., 2004; Vaughan Van Hecke et al., 2005). Thus, social attention and responsivity in infancy may be linked to control of behavior and social competence in toddlerhood, which could have implications for how we understand the development of these domains in typical and atypical development, including disorders such as autism and attention deficit/hyperactivity disorder. Indeed, clarifying how aspects of general attention and joint attention processes in infancy dynamically exert influence over later self-regulatory capacities will be an important challenge for future studies, and will deepen our understanding of the nature of social competence in typical and atypical development.

Highlights

1. Infant joint attention predicts behavior, language, & social competence in childhood
2. Executive self-regulation in responding to joint attention (RJA) may explain these links
3. Increase of efficiency in RJA and relations between RJA and self-regulation were examined
4. Infants showed an increase in executive efficiency of RJA between 9 and 18 months of age
5. 12-month RJA was related to 36- month self-regulation skill via a delay of gratification paradigm

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Footnotes

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