

**Does Infants' Socially-guided Attention Uniquely Predict
Language Development?**

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ABSTRACT

The purpose of this study was to examine whether infants' social attention, as well as their joint attention behaviors uniquely predicted emerging language abilities. This longitudinal study examined attention regulation skills, joint attention behaviors, infants' expressive/receptive language (current), emerging communication abilities at 16- and 17-month-old (time 1); expressive/receptive language (subsequent) at 18- 19-month-old (time 2). Infants' sustained attention was measured by their attention control to a central stimulus in the presence of a distracter competing for their attention. Dynamic human face (upright, inverted) and abstract display with their matched voice tracks were used to separately measure infants' attention regulation to different types of events. Infants' sustained attention was estimated by their latencies away from central stimuli to distracters, as well as their fixation duration and gaze count on central events and distracters. It was found that infants' latency away from the abstract figure toward the distracter was the only variable that significantly negatively predicted current expressive vocabulary. Initiating joint attention was observed to significantly predict infants' abilities in current receptive vocabulary. The emerging language communication ability predicted expressive vocabulary at two times. In addition, infants' fixation and count to the upright speaker's face and eyes contributed significant amount of variance in initiating joint attestation. The fixation and gaze count on the distracter in the upright condition significantly predicted infants' emerging language skills.

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1.0 Introduction

The engagement and disengagement of attention are dynamic processes that are modulated by the control of cognitive resources. Once attention is engaged, many factors influence what infants select and attend to in the environment, how long they stay focused on any given central target, and how likely they are to disengage attention to a competing event. Some of these factors are associated with the properties of the central stimulus and peripheral distracters, whereas others are associated with infants' regulation of current state governed by the development of attention systems across the first year. All of these factors work together to determine how infants direct cognitive resources to selected activities and how effectively they resist distracters that compete for their attention and responsiveness. Interestingly, infants' engagement of attention to objects at 9 months is positively linked to their language outcomes later in development at 31 months of age (Kannass & Oakes, 2008). Likewise, 11-month-old infants' sustained attention to a dynamic female speaker in the presence of a distracter significantly predicts aspects of joint attention and vocabulary size at 18 months of age (Salley, Panneton, & Colombo, 2012). Clearly, good attention regulation in general is an important element in achieving various developmental milestones in the first postnatal year. In both cases just mentioned, some aspects of infants' attention was predictive of emerging language skill, but it is unclear whether there is a qualitative difference in the nature of attention allocation to non-social (i.e., objects) compared to social (i.e., persons) events and language. The purpose of this study is to examine whether infants' allocation and control of attention to social agents uniquely predicts emerging language capabilities (i.e., beyond the contribution of more general attention skills). In order to address this question, infants' sustained attention to social and non-social

events needs to be separately considered in order to discuss the influence of social versus non-social information in the support of language development.

1.1 Infants' Attention to Non-social Events

Many sources of information are available to infants to attend to as they are exposed to a variety of visual and auditory events in the environment. In infants' day-to-day world, non-social events can orient and shift infants' attention quickly. For instance, infants will look toward a toy truck as it drives around making a beeping noise and flashing lights, and infants will play with a complex toy longer if it consists of multiple colors and moving parts than a toy consisted of a simple structure. How does infants' visual attention to non-social events emerge in early development?

1.1.1 Infants' attention development to non-social objects. Objects varying in their complexities are effective at attracting infants' attention at different developmental stages. Before 3 months of age, infants' visual selection is largely determined by the quantity or intensity of stimulation, such as visual contrast in the stimulus pattern (Ruff & Rothbart, 1996). For example, some studies showed that newborns preferred to look at checkerboards that contained local regions of high contrast than local regions of low contrast, and infants' sensitivity to stimulus contrast increased until 2 months of age (Adams & Maurer, 1984). Therefore simple visual displays are effective at attracting infants' attention in the first few months after birth.

From about 3 to 6 months, there is a general linear decline in infants' look duration to almost all types of visual displays regardless of the features of the stimuli (simple or complex; static or dynamic) (Courage, Reynolds, & Richards, 2006). However from 6 months until the end of the first year, infants' look duration tends to diverge depending on the stimulus types: their

visual fixation to children's cartoons, such as Sesame Street, steadily increases as their responsiveness to achromatic geometric patterns continues to decline (or not change) (Courage et al., 2006; Richards & Cronise, 2000). This increased look duration to complex visual stimuli (i.e. Sesame Street) is consistent with the previous finding in toy play in which infants showed elongated examination of complex toys at 10 months (Oakes & Tellinghuisen, 1994).

Thus, infants' attention to objects does not generally decline as with age and there is a discontinuity at around 6 months of age between attention decrement to achromatic geometric patterned stimuli and attention increment to complex movie-liked stimuli. What accounts for this developmental discontinuity? In order to answer this question, it is useful to consider the process of attention regulation in infancy as one involving contribution from both exogenous (external) and endogenous (internal) influences.

1.1.2 Development of exogenous and endogenous attention. Infants' attention allocation appears to be jointly influenced by the interaction between exogenous and endogenous factors. Exogenous factors are an external source of influence, such as the physical characteristics of a target object and the features of a distracting event. In contrast, endogenous factors are related to internal self-regulatory control, such as current attentional state and the motivation of the infant to attend to the event (Kannass & Oakes, 2008; Kannass, Oakes, & Shaddy, 2006; Oakes, Kannass, & Shaddy, 2002; Oakes, Tellinghuisen, & Tjebkes, 2000).

In early and middle infancy, exogenous factors primarily impact how infants distribute their attention. What attracts and holds infants' attention to multiple competing stimuli during this earlier part of infancy are the external characteristics of the events themselves, such as color and shape, but also their relative novelty (Colombo, 2001). The exogenous control of attention is associated with advances in the orienting/investigative system emerging from 3 to 6 months,

which facilitates infants' attentive behavior to more salient and novel aspects of a visual event as well as disengaging attention from visual focus (Ruff & Rothbart, 1996). For instance, in the first few months, infants have great difficulties disengaging from salient targets even as they display a high level of distress (sometimes called "sticky fixation"; Frick, Colombo, & Saxon, 1999). By 4 months of age, infants seem less likely to become "stuck" in their visual focus and exhibit more flexible control over attention to stimuli with novel properties (Johnson, Posner, & Rothbart, 1991). The neural underpinnings of the orienting/investigative system have been found to link directly to the parietal lobe and/or tempo-parietal junction (Posner & Peterson, 1990; Tucker & Williamson, 1984).

Older (compared to younger) infants' attention allocation is more likely to be influenced by endogenous factors, such as the ability to voluntarily hold attention (Colombo, 2001). As higher levels of the attention regulating system begin to emerge (specifically from 9 to 12 months) and continue to develop, the duration of infants' specific fixations gradually decrease and more complex actions guided by the infants' goal-directed behaviors and sophisticated cognitive functioning become more prevalent (Colombo, 2001), such as better inhibitory responses (Bell & Fox, 1992; Colombo, 2001). The advance of infants' cognitive functioning is stimulated by frontal lobe maturation (Diamond & Goldman-Rakic, 1989), which has been related to changes in memory (Carver, Bauer, & Nelson, 2000). This underlying neurodevelopment in the brain allows infants to move from the orienting/investigative system to a higher ordered self-regulatory control system, through which infants are gradually motivated to actively process information.

As for what accounts for the attention discontinuity to objects at 6 months of age, Colombo, Harlan, and Mitchell (1999) suggested that this discontinuity might due to infants'

development of exogenous and endogenous attention being governed by the maturation of neural circuits. Specifically they proposed that that infants' look durations follow a triphasic course of development over the first year: the first phase starts from birth to about 3 months, during which infants' attention is primarily determined by alert or arousal systems that direct infants' attention to the exogenous factors of an event. In the second phase, infants' decreased look durations to all types of visual stimuli from 3 to 6 months is a result of the development of disengagement and shifting of attention. In the third phase, increased look duration to the complex auditory visual movie clips reflects the emergence of the endogenous aspect of attention, such as the inhibition of shifting attention away from the events that are potentially interesting. Thus infants' attention to objects over the first year reflects the developmental course of exogenous and endogenous control of attention.

1.1.3 Infants' attention modulation to non-social objects. To capture how infants stay focused on a visual event and their ability to resist distraction in the laboratory, researchers have investigated infants' attention allocation when faced with competing visual stimuli, with one stimulus in the central visual field and the other in the periphery (Lansink & Richards, 1997; Oakes & Tellinghuisen, 1994; Richards, 1997). The assumption is that if the central stimulus is interesting enough and infants are motivated to process information about it, they should resist orienting toward the peripheral distracter by means of delaying their attention shift to the distracter. What characteristics determine the length of infants' sustained attention to the central stimulus? How are these characteristics related to exogenous and endogenous attention in infants?

1.1.3.1 Influence of central stimulus and distracter characteristics on infants' engagement. The characteristics of the central stimulus and peripheral distracter contribute great

effectiveness at attracting and holding infants' attention. In the absence of competing events, stimulus novelty and complexity largely determine infants' examination duration in the first year, which is strongly dominated by the orienting/investigative system (Ruff & Rothbart, 1996). Oakes and Tellinghuisen (1994) found that infants examined novel toys more than familiar ones and complex toys more than simple ones, demonstrating the contribution of stimulus salience to infants' orienting responsiveness. When the distracter is present, varying dimensions in its characteristics have been found to have a large influence on infants' latency to disengage from a central target. Tellinghuisen and Oakes (1997) found that when infants were exploring novel toys, bimodal distracters consisting of both auditory and visual features were more effective at disengaging infants' attention (infants looked at distracter more quickly) than did unimodal distracters with only visual or auditory features. In addition, the distracters consisting of more visual and auditory content (two colored checkerboards with alternating tones) were more effective at disengaging infants than those with less visual and auditory content (one colored rectangle with single tone). Finlay and Ivinskis (1984) found that the peripheral distracter competed more for infants' attention when it rotated much faster than did the visual fixation target. When the distracter rotated at the same speed as the central target, it took infants longer to orientate to the distracter. Thus infants' latency to distracters varies as a function of the physical characteristics of the distracters, namely the brightness of color, size and movement of the distracter (Maurer & Lewis, 1991).

Taken together, in the absence of competing events, what determines infants' visual selection largely depends on whether the event presented in the center is perceptually salient. In contrast, in the presence of competing events in the periphery, the initial stimulus not only plays a role as an attention getter that recruits infants' attention to the stimulus of interest, but also a

role as an attention holder that sustains infants' fixation to the stimulus. If the peripheral distracter is more interesting, the central event will lose its competitive advantage unless it contains stronger attention-holding properties.

1.1.3.2 Influence of attentional state on infants' engagement. The effectiveness of any particular event in attracting infants' attention not only depends on the physical properties of the central and peripheral events but also on the infants' current attentional state. Attentional state refers to the amount of resources being exerted during an entire examining period, in which orienting, engagement, and disengagement appear at different times and can be distinguished by behavioral and/or psychophysiological indicators. It has been found that in general, infants are not as easily distracted during a focused attentional state than during a casual attentional state, given that focused attention reflects active intake of information and information processing toward the initial stimulus (Casey & Richards, 1988; Richards, 1997; Oakes & Tellinghuisen, 1994). For example, in a study examining the relation between heart rate-defined and behavioral-defined attention phases in infants at 6, 9, and 12 months, Lansink and Richards (1997) manipulated the onset of a peripheral distracter during toy play, so that the distracter occurred during periods of time when both heart rate and behavioral ratings indicated that infants were in either sustained attention or attention termination. The result showed that infants displayed the longest distraction latencies during sustained attention that was defined by both heart rate and behavioral ratings; in contrast, infants showed the shortest distraction latencies during attention termination that was indicated by both measures. Therefore infants' attentional state modulates their ability to resist distraction from peripheral events that compete for their attention to central stimuli.

1.1.3.3 Interaction of central stimulus characteristics, distracter characteristics, and

attentional state on infants' engagement. If the characteristics of the orienting stimulus and distracter, along with infants' attentional state, independently contribute to holding/distracting infants' attention, do these three factors work together to jointly influence infants' attention latencies to the distracting events? Some studies have provided evidence that attentional state influences infants' sustained focus on the central target in the presence of a distracter by moderating the distracter salience perceived by the infants. Tellinghuisen, Oakes, and Tjebkes (1999) presented infants with four types of auditory-visual distracters (solid colored rectangle with single-tone or alternating-tone vs. two-colored checkerboard with single-tone or alternating-tone) when exploring objects. They found that infants who received a single-tone distracter exhibited longer latencies to disengage from the toy during focused attention than during casual attention. Building on this, Oakes et al. (2000) found a three-way interaction among characteristics of the central stimulus, characteristics of the distracter, and infants' attentional state on the function of infants' attention latencies in that infants were least likely to turn to the solid distracter (simple distracter) rather than the checkerboard (complex distracter) when engaged in focused attention to the initial complex toy rather than the simple toy. Therefore attentional state plays a mediating role in individuals' attention engagement, such that sustained attention may lead to more cognitive resources exerted toward the central stimulus. When infants are focused, their attention competition is biased toward the central stimulus in that infants' active information processing during this time holds their attention to the central target stimulus. In this case, if the central stimulus has strong attention-getting and attention-holding properties, the competing distracter needs to be more salient in order to compete infants' attention (see Tellinghuisen et al., 1999).

Infants' attention allocation is a complex resource distribution and redistribution process, which is likely to be interactively determined by exogenous factors (e.g. characteristics of the initial orienting visual event and the distracter) early on and endogenous factors (infants' current attentional state) toward the end of the first year. Although infants exhibit substantial interest in looking at non-social objects, they are social creatures and are sensitive to a variety of social cues (Morales, Mundy, & Rojas, 1998). Infants need to negotiate a message between themselves and others in order to gain knowledge about the world.

1.2 Infants' Attention to Social events

Social attention, the perception of the attentional state and encoding of aspects of other people (see Birmingham & Kingstone, 2009; Frank, Vul, & Saxe, 2012), has been studied extensively from different perspectives. With accumulated experience in the social world, infants increasingly recognize the human face more accurately, establish gaze following responses, and participate more in attention sharing behaviors with social partners. How does infants' attention to social events develop from birth? Do infants encode the referential information from others' looking behaviors?

1.2.1 Infants' attention development to social events. The human face is one of the most important social stimuli in the environment for infants. Studies investigating the development of face perception during early infancy have yielded consistent results. Human newborn infants have been found to exhibit a preference for looking at face-like stimuli rather than non face-like stimuli, in that they look longer to schematic drawings of a face arranged naturally than schematic drawings of a face arranged unnaturally (Johnson, Dziurawiec, Ellis, & Morton, 1991; Valenza, Simion, Cassia, & Umilta, 1996). As young as 4 days, infants can differentiate their mothers from other similar looking women (Pascalis & de Schonen, 1994;

Pascalis, de Schonen, Morton, Deruelle, & Fabre-Grenet, 1995). In the next few months, infants use smiles, gestures and vocalizations more in the presence of a real person rather than in the presence of an inanimate object (see Johnson, 2003) and are likely to seek eye contact and invite caretakers to participate in shared attention (Keller & Gauda, 1987). Many research findings indicate that infants gain better distinction of genders (Quinn, Yahr, Kuhn, Slater, & Pascalis, 2002) and faces of their own race (Kelly et al., 2005) over the course of several months after birth. Between 6 to 9 months of age, they increasingly establish the use of gaze following behaviors (Butterworth & Jarrett, 1991; Carpenter, Akhtar, & Tomasello, 1998; Woodward, 2003). Together, these studies suggest that human face is one of the most attractive stimuli encountered by infants.

Since infants are sensitive to the features on a human face, how exactly do they examine the face? Studies of selective attention have shown that from birth to 6 months, infants primarily fixate their attention on the eyes more than other regions of face (Haith, Bergman, & Moore, 1977). After 6 months of age, infants begin to increase their looking at the mouth (Hunnius & Geuze, 2004), and it is assumed that this preference shift from the eyes to mouth may be related to infants' growing interest and motivation in language learning (Bahrick, Lickliter, & Flom, 2004). In a recent study, Lewkowicz and Hansen-Tift (2012) eye-tracked 4- to 12-month-old native English-learning infants when watching a female who was speaking English (native) and one speaking Spanish (non-native). They found that between 4 and 8 months, there was a shift from eyes to mouth regardless of which language (native or non-native) the infants were exposed to. When infants were at 12 months of age, they shifted their attention back to the eyes when listening to their native language but not the non-native language. It is assumed that the first shift from eyes to mouth enables infants to get access to a large amount of auditory-visual speech

information, which assists infants to perceive relevant linguistic cues in their native language. The second shift from mouth to eyes reflects infants' growing expertise in their native language which frees them to distribute attention back to the eyes in the attempt to acquire more social cues. In contrast, the non-native language is more difficult for infants to perceive at 12 months of age due to its novelty. This study suggests that infant's attention allocation to the eyes and the mouth is largely determined by their demand for language learning in relation to age.

Other studies have investigated infants' face scanning pattern via presenting social stimuli with different complexities. Frank, Vul, and Saxe (2012) presented infants with real-world photographs of scenes with people and objects, and a variety of live movies with the purpose of examining infants' selective attention toward social events. A large group of infants between 3 and 30 months were eye-tracked as they watched engaging dynamic movie clips as well as the photographs. They found that human faces overall drew infants' attention more than other physical parts of human body and the surrounding social context. Specifically when given the faces only, younger infants primarily looked at eyes whereas older infants paid more attention to the mouths; when the face was talking or emotionally expressive, both younger and older infants fixated attention more on the mouth instead of eyes. This suggests when the social stimuli carried out complex actions (i.e. multiple people picking up or putting down objects), older infants distributed more attention than younger infants to the hands of the social agent who performed the actions. This developmental shift from face to the body parts demonstrates that toddlers are better able to allocate attention to the parts of the complex scenes that are most interesting, informative, and socially meaningful.

Taken together, just as infants' attention to objects is determined by the complexities of the objects and the infants' age, infants' attention distribution to social events is also determined

by the complexities of the context, demand for language learning, age, and perhaps experiences with faces and hands in their lives. Although human eyes probably contain the most salient social information, as infants develop, they gradually shift their interest from eyes to other context-sensitive cues, such as the mouth or hands, in the social environment.

1.2.2 Infant attention to both objects and social events. Given that infants are sensitive to human face at an early age, a further question is whether they are sensitive to the face in relation to some external objects or events? By the end of the first year, infants' "triadic abilities" develop, which refers to the capability of connecting an adult social partner's intentional state (e.g., eye gaze) to a target of interest (e.g., object) in the communicative context (Tomasello, Carpenter, Call, Behne, & Moll, 2005). This triadic ability of understanding the referential communication is called *joint attention*. In order to engage in joint attention, infants must be attuned to the actions of others and use the cues provided by others to modify their own behaviors.

1.2.2.1 What is joint attention? Joint attention refers to the coordination of attention between the self, others, and objects in the social context (Tomasello, 1995; Tomasello et al., 2005). The general behavior of joint attention can be divided into different categories that result in the shared attention between infants and social partners. Responding to joint attention (RJA), defined as gaze following or pointing toward an object of interest in order to share a common point of reference, is usually observed around 6 to 9 months and continues to develop through age 3 (Bakeman & Adamson, 1984; Carpenter et al., 1998; Butterworth & Jarrett, 1991; Woodward, 2003). Initiating joint attention (IJA) refers to infants' own effort to seek eye contact or use of gesture to gain the attention of others (Mundy & Newell, 2007). The goal of using IJA is to voluntarily share their interest and current feeling with the social partner. Initiating behavior

regulation (IBR) is defined as infants' ability to direct attention to a given object for the purpose of acquiring that object with the help of the partner. Responding to behavior request (RBR) refers to infants' correct behavior in response to a statement ("Give me the ball over there!") along with a gesture.

What is the relation between joint attention and attention? According to Mundy, Card and Fox (2000), joint attention is the outcome of the development of two attention regulation systems. One is the posterior orienting system that primarily controls the development of RJA during infancy, which serves a function in imitation and perceiving others' eye movements and head turn orientation. The other is the anterior orienting system associated with self-constrained allocation and volitional control of attention-related activity. These two attention systems interactively influence individuals' gaze following of others as well as the initiation of mutual gaze (Mundy & Newell, 2007).

Episodes of joint attention to objects or events in the social context provide the initial means under which infants convey a shared experience with their interactive partners. Joint attention provides infants an environment for negotiating a message between themselves and others, in the service of gaining knowledge about the social world. Specifically, joint attention serves an important function in prelinguistic development, given that most word-labeling takes place in the unstructured communicative interplay between infants and adults (see Mundy & Newell, 2007).

1.2.2.2 Impact of joint attention on infant language development. Joint attention skill has been found to distinguish infants and preschool children with atypical development (e.g. autism) from those with typical development (Bacon, Fein, Morris, Waterhouse, & Allen, 1998; Dawson, Meltzoff, Osterling, & Rinaldi, 1998), as well as linguistic and social competence in

both typical and atypical populations of children (Baldwin, 1995; Brooks & Meltzoff, 2005; Carpenter, Nagell, & Tomasello, 1998; Luyster, Kadlec, Carter, & Tager-Flusberg, 2008; Mundy & Gomes, 1998).

Well-established literature has demonstrated that infants' engagement in joint attention is related to early language acquisition, preverbal communication skills, and vocabulary size (Brooks & Meltzoff, 2005; Kristen, Sodian, Thoermer, & Perst, 2011; Mundy et al., 2007; Salley, Panneton, & Colombo, 2012). Measures varying in dimensions of joint attention (i.e. multimodal combination of vocalizing, pointing and looking) between 6 and 18 months have a predictive effect on infants' vocabulary size at 24 and 30 months (Meltzoff & Brooks, 2008; Carpenter et al., 1998; Morales et al., 2000; Mundy et al., 2007). For instance, Meltzoff and Brooks (2008) found that infants who showed longer duration of correct looking when following bids for attention of a social partner at 10 months exhibited accelerated productive vocabulary size (i.e. total number of words produced) at age 24 months, suggesting joint attention relates to subsequent language development.

Although composite measures of joint attention have been adopted by many studies, RJA is widely used in a large body of research in the assessment of verbal skill and early forms of social communication (Mundy et al., 2007; Presmanes et al., 2007; Stone, & Yoder, 2007). Compared to other components of joint attention, RJA has most often been theoretically and empirically associated with receptive and expressive language development (Morales et al., 2000; Mundy et al., 2007; Mundy & Gomes, 1998; Mundy & Rojas, 1998). A recent study by Salley et al. (2012) revealed unique contributions of RJA to the development of older infants' lexicon, in that RJA at 14 months accounted for 48% amount of the variance in productive

vocabulary size reported by parents at 18 months, after controlling the baseline of infants' communicative skill.

Infants' attention to social events paves the way for their emerging language capabilities because social cues help infants select appropriate information in the environment and inform infants what to learn. If we want to build a big picture of how infants acquire language and apply the linguistic information they learned to the real social communication with their partners, we need to consider infant language learning from a more broad perspective. Indeed, human language is fundamentally social (Snow, 1999; Tamis-LeMonda, Bornstein, Baumwell, Kahan-Kalman, & Cyphers, 1998), thus the context in which infants are linguistically entrenched has to be considered in order to discuss the effect of social factors on infant language learning.

1.2.2.3. Effects of social factors on language learning. Infants are bathed in a variety of social information in the environment, such as the eye contact, informative gaze, word vocalizing, gesture pointing, and the like. The relatedness between infants and social partners is shaped by the "shared timing" between their social behaviors, and this infant-partner relationship captures the concurrent, sequential, and organized ongoing style of the context (see Feldman, 2007). Social responsiveness and verbal contingency provided by the partners may play a role in facilitating infants' attention to speech, resulting in a form of reinforcement for infant vocal learning (Goldstein & West, 1999; Goldstein et al., 2003). For example, Goldstein and Schwade (2008) provided evidence for the role of parental social interaction in vocal development. In this study, half mothers were instructed to respond to their infants' babbling contingently, and half mothers were instructed to respond to infants based on the response schedules of the mothers in the contingent group. The result showed that infants who received the contingent feedbacks increased their proportion of structured syllables than did infants who received the non-

contingent feedbacks, suggesting the role of contingency on infants' phonological learning. Likewise, participation and response on the part of infants may also modulate the dynamic social exchange between the infants and the social partners, leading to positive aspects in language learning. For example, a number of data have suggested that infants' awareness of the communicative intent from the social partners, their sensitivity and engagement with a live person in joint attention, and their desire to imitate the vocal and social behaviors assist infants' language acquisition (Baldwin, 1995; Brooks & Meltzoff, 2005; Tomasello, 2003).

Indeed, the social environment for a language-learning infant is a source of rich structure that can help infants focus their attention on relevant aspects of the speech signals. Kuhl (2007) proposed that social factors "gate" infant language acquisition. More importantly the real-time social interaction with a person is necessary for natural speech learning during the language exposure. Her assumption was inspired by a study that demonstrated a powerful effect of social context on foreign language learning (Kuhl, Liu, & Tsao, 2003). In this study, American infants of 10-12 months were exposed to Chinese in three different contexts: infants interacted with a native Chinese speaker who read books, played toys and directed to infants with natural infant-directed speech; infants learned language through watching TV; infants learned language through listening to the sounds only. The results showed that only infants who were exposed to the real-time social interaction with the person showed remarkable learning in Chinese, suggesting the critical meaning of the presence of a human being in language facilitation.

In sum, in infants' day-to-day world, social and non-social information co-occur in many learning situations, potentially dividing infants' attention between the social and non-social types. A growing number of findings have indicated that infants' emerging understanding of language, such as speech perception and vocabulary growth, is related to measures of sustained

attention (Salley et al., 2012). However, the nature of attention required for language learning remains unclear. Although the role of social context has long been considered relevant for linguistic outcomes, the separable influence of social versus non-social information in the support of language development is unknown. Additionally, language studies investigating the combined predictive effect of infants' social attention and joint attention on their linguistic development are limited in the literature.

The purpose of this study was to examine whether infants' allocation and control of attention to social events, as well as their individual difference in joint attention, uniquely predict emerging language capabilities. In order to examine this, infants' sustained attention to social and non-social events at 16 and 17 months was separately measured by their ability to stay focused in the presence of a peripheral distracter. If infants who are less distractible when looking at social events show better language outcomes later on, this indicates the effectiveness of social attention in the prediction of infant language development. Infants' RJA and IJA responses in joint attention were measured in a face-to-face interaction with an adult female partner and the predictive utility of infants' joint attention behaviors on their linguistic outcomes was assessed. Additionally a screening instrument of emerging communication skills was completed for infants by their primary caregivers, which was used as a measure of infants' baseline level of initial communication capability. Receptive vocabulary, expressive language were assessed at two waves: first at the time of the laboratory visit and second, two months after the visit when infants were at 18 and 19 months of age, using a parent-report measure of language development.

It was hypothesized that sustained attention to social events and the RJA and IJA responses in joint attention would each predict and account for unique variance in receptive

vocabulary and expressive vocabulary. That is, infants who display a high level of sustained social attention reflected by less distractibility when looking at social information in the presence of competing events, and more frequent response to the tester's bids as well as more frequent initiations in joint attention are expected to have better receptive and expressive vocabularies. It was expected that most infants would be moderate to high in social attention and joint attention, but that more variance would be seen in patterns of attention to non-social events.

2.0 Method

2.1 Participants

Twenty-eight infants (15 girls) aged between 16 and 17 months (when infants are capable of displaying reliable gaze following behaviors and differential sustained attention) were recruited from the New River Valley areas to participate in this study. Due to the fussiness/high activity of the infants and equipment failure (i.e., eye tracker lost calibration), only 20 successful infants [$M=505$ (in days), $SD=25.73$] were included in the current study. All infants were healthy and had no history of any medical problems (determined by parental report) at the time of the test.

Infants were recruited from a participant database maintained at the Developmental Research Suite in the Department of Psychology. Potential participants were obtained from commercial mailing lists; advertisements placed through flyers at the day care centers, preschools, and university list-serves. Parents of infants were invited via letters and follow-up telephone calls (if possible) to participate in this study, and those who were interested in the current study were scheduled for a one-time appointment at their convenience. Regardless if infants successfully completed the study, they received a colorful infant certificate and \$10 compensation fee by way of thanking them for their participation.

2.2 Procedure

The current study was a longitudinal project and consisted of two parts. The first part was a laboratory visit involving infants and their parents, in which infants finished two tasks (“distractibility task” and “joint attention task”). The second part of this study was a parental assessment of infants’ language development, which took place two months after the laboratory visit. Parents received the MacArthur-Bates Communicative Development Inventory (MCDI) and Vineland Adaptive Behavior Scales-II Parent/Caregiver Rating Forms (will be discussed specifically in the “language outcome measures” section below) in the mail after their laboratory visit. They were instructed to fill out these two questionnaires and returned them back to the lab via a stamped and self-addressed envelope as soon as possible.

When parents arrived at the Lab, they were first guided into an infant-friendly waiting room, where they completed a short survey, which included the Ages and Stages Questionnaire (ASQ, see Appendix A and Appendix B), a demographic questionnaire (see Appendix C), and a contact information sheet (see Appendix D). Parents additionally signed two copies of informed consent (see Appendix E) to authorize their infants’ participation, with one copy for their record, and the other copy filed in the laboratory’s records. While parents worked on the surveys and questionnaires in the waiting room, research assistants interacted with the infants, allowing infants to have a “warm up” period so that their arousal/comfort was at an optimal level prior to testing.

2.2.1 Emerging communication skill. The ASQ is a measurement of parental perception of emerging communication skill and language readiness. This questionnaire is usually used as a means of screening the developmental performance of infants in verbal communication, gross/fine motor skills, problem solving, personal-social skills, and overall development during

infancy. Due to the purpose of this study, only the communication domain was of interest (e.g. Does your child point to, pat, or try to pick up pictures in a book? When your child wants something, does he tell you by pointing to it?). The items on the scale collectively prospect the readiness for language, such that the verbal communication skills infants should be able to perform at this age.

2.2.2 Language outcome measures. Infants' language outcomes in this longitudinal study were measured twice, at the time of the laboratory visit (time 1) and two months after the visit (time 2). Infants' expressive (language production) vocabulary was measured with the MCDI (see Appendix F) (Fenson et al., 1993; 2007), which was a reliable and valid parental survey for assessing language development and communicative skills from 8 to 30 months in both typical (Farrar & Maag, 2002; Feldman et al., 2003) and clinical populations. In this study, the infant MCDI (short form vocabulary checklist) was completed by the parents of infants. Infants' receptive vocabulary (language comprehension) was quantified by the Vineland Scales (see Appendix G), in which the individuals' adaptive behavior composites in terms of communication, daily living skills, socialization, and motor skills were provided. This scale was widely used in educational and clinical diagnostic evaluations of the developmental delays and developmental evaluations of infants and young children. In this study, only the communication section of the Vineland Scale was finished by the parents. Different from the MCDI, the communication section in Vineland scale is not a vocabulary checklist; in contrast, it is diagnosis or evaluation of infants' listening and understanding impairments (e.g., looks toward parent or caregiver when hearing parent's or caregiver's voice; listens to story for at least 5 minutes) based on the answers of parents. This communication subscale is usually considered as a measurement of infants' early receptive language.

When the infants were at 18 and 19 months (time 2) ($M=572$, $SD=27.99$, $n=20$), their language outcomes (expressive and receptive vocabulary) were acquired by the parental report of the MCDI and Vineland scales (language sections only) in the mail, in which the simple instructions about how to fill out the questionnaires were given. The parents were instructed to return these two time-sensitive questionnaires as soon as possible. The average and standard deviation of the time elapsed from the assessment at time 1 to time 2 during the study were 68 (in days) and 11.90 respectively.

2.2.3 Eye-tracking procedure. After giving informed consent, infants and parents were guided into an eye-tracking room to complete the “distractibility task”. The eye-tracking procedure assessed infants’ attention regulation to social and non-social events in the presence of a distracter. The apparatus used for this experiment was a Tobii T60 binocular corneal reflection eye-tracking system, which measured eye movements through the use of near infrared illumination (Tobii Handbook). The Tobii T60 Eye Tracker consisted of a built-in TET monitor that controlled the presentation of events to the viewer and a Dell Optiplex 755 desktop computer and monitor connected to the TET monitor. The TET monitor recorded dual eye movements on the screen via a two-camera system regardless of any head movements. When the task started, the light in the room was dimmed. In addition, black curtains and a 6’ x 6’ dividing screen blocked the rest of the room and computer equipment from the infants’ view, so that infants could maximally focus their attention on the screen. During the “distractibility task”, infants were seated in a high-chair approximately 70 cm away from the eye-tracker. The monitor was mounted on an ergonomic arm that could be adjusted to the height and angle of the infants.

There has been great enthusiasm of using the eye-tracking technology in the study of infants, including both typical and atypical populations (Karatekin, 2007), and research

examining infants' early development with the eye tracking has been involved in wide developmental domains (Frank et al., 2012; Navab, Gillespie Lynch, Johnson, Sigman, & Hutman, 2011; Hunnis & Geuze, 2004; Johnson, Slemmer, & Amso, 2004). The utility of an eye-tracking procedure is not only in providing great precision in determining where and how long infants look but also quantifying the latency and frequency of the reactive gaze saccade to the visual distracter (Gredebäck, Johnson, & von Hofsten, 2010), which is substantially important for studying infants' attention allocation in the competing context (Amso & Johnson, 2005; 2009).

2.2.3.1 Calibration. Calibration was a procedure that allowed for the measurement of unique characteristics of each individual participant's point of gaze and motion of eyes before initiating the eye-tracking procedure. The five-point calibration routine with a moving target with infant-appropriate sound track from the Tobii eye-tracker was carried out before presenting infants the task movies using Tobii Studio (the Tobii eye-tracker's proprietary software). The background of the calibration screen matched the one from the events used in the test so as to provide the best quality of calibration. When infants fixated on the moving target on the screen, then the right arrow on the keyboard was pressed to present another calibration target. This sequence was repeated until all five points had been shown. If the calibration results were either incomplete (i.e., one of the targets was not fixated) and/or a substantial amount of visual splatter on a target was seen (shown as error vectors on the screen to the experimenter), calibration of those particular targets were repeated until all five points show good verifiability.

2.2.4 Distractibility Task. Dynamic auditory and visual movies were constructed to test infants' attention to social and non-social events. During the trials, a target of interest appeared in the central visual field followed by a distracter (checkerboard) in the visual periphery that

competed for infants' attention. The dynamic videos consisted of: (1) an upright female speaker with her voice tracks, (2) the same but *inverted* female speaker with filtered (cutoff of 400Hz) voice tracks. The low-pass filtered voice effectively removed all phonetic information but preserved other acoustic information (e.g., pitch and duration) of the sound, and (3) an abstract moving image with modulating sine waves. This abstract stimulus was derived from the digital video of the same female speaker (used in condition 1 and 2) by carrying out a number of transformations with Adobe Premier Pro, such that the image no longer resembled a human face (see Hunnius & Geuze, 2004). During the transformation, the image of the speaker was rotated 90 degrees to the right, distorted, and scrambled, so that the social features, such as eyes and mouth, were not recognizable. The modulating sine waves in this video were the low-pass filtered voices (used in condition 2) *in reverse*, which helped eliminate human voice characteristics. This procedure ensured that the movies across the three conditions were comparable, since there was no change with regard to color (central displays and background), size (central figures), and luminance. The examples of each type of the visual stimuli are presented in Figure 1. All the central figures were presented against a grey background. If differential attention distractibility was observed in the conditions, this should be attributable to the types of the central stimuli (upright, inverted, and abstract), instead of other irrelevant factors. Overall, three stories generated by the female speakers were used for this study.

The purpose of using the three types of visual displays as the central events was to compare infants' attention regulation and distractibility from looking at the extreme social events to the extreme non-social events, in which the upright, inverted, and abstract "faces" represented an event continuum from being very social to being very non-social. Although a great number of studies have examined the impact of social factors on early developmental outcomes in infancy,

the definition of what social is was very vague in the literature. For instance, the social factor was usually determined by having human being involved or human face presented in contrast to objects during the study (Kuhl et al., 2007; Oakes, 1996). Thus in the current study, besides the presentation of a normal human face (right face) and a non-human display (abstract display), another condition (inverted human face) was introduced as to understand how infants' sustained attention was regulated by the nature of the visual displays arranged as a continuum.

In all the conditions, a flashing black and white checkerboard was used as a distracter that competed for infants' attention from the central events. The peripheral distracters were randomly presented adjacent to the central figures to gauge infants' sustained attention as a function of the movie types. Each infant received a total of 12 trials (5 upright, 5 inverted, and 2 abstract), in which each trial lasted for about 11 seconds. Thus, infants had 2 sec within which to respond to the distracter (which was 2 sec in length) regardless of which movie type they were viewing. After the central events had been played for at least 5 consecutive seconds, a checkerboard was randomly presented in the periphery of the screen (either left or right at midline relative to the central figures, see Figure 1) and stayed on for 2 seconds and then disappeared. During each trial, the onset of the distracter was randomized (at 5, 7, and 9 sec), so that infants were not able to predict when and where the distracters would appear. Across all the test trials, each distracter onset (5, 7, and 9 sec) was represented in all the three movie types (upright, inverted, and abstract). With this, infants had an equal chance to see all the randomized distracters in movies, regardless of the movie type.

In order to quantify the locations of gaze saccade, three areas of interest (AOIs) on each type of central display were drawn, which divided the central figures into upper, middle, and lower regions (see figure 2). The AOI size across the three conditions was kept the same.

Although the AOIs on the abstract figure divided it into the upper, middle, and lower regions which were the same as the ones from the upright and inverted condition, these regions were not in correspondence with forehead, eyes, and mouth, in that the social features were not recognizable in the abstract display. In addition to the AOIs of the central stimuli, an AOI on the distracter was also drawn, which was about .75 inch bigger on each side than the real size of the distracter. The reason was that many infants were observed (from the replay of Tobii Studio) to be not able to accurately target the area within the checkerboards although they were distracted by the presence of them (i.e., shifting gaze more than half the distance between the central displays and distracters). In total, four AOIs (3 for the central displays, and 1 for the distracter) in the test movies across all the conditions were made to acquire the statistics of latency, gaze fixation, and gaze count. Eventually, some trials from the infant participants were eliminated from the participants' data analysis to calculate accurate latencies, because infants were either not attending to the screen during the movie watching or the eye-tracker lost the calibration. The criterion of trial elimination was that infants had to have a chance to see the distracters in the trials. For instance, if infants looked away from the screen before the appearance of the distracter and re-attended to the screen after the distracter went away in a trial, this trial was excluded to calculate their gaze latency to distracters. This trial elimination ensures that all infants were attending to the screen when the distracter was active.

Also, a series of attention-getting movies (a baby giggling at the infant participants) were played before the start of each test trial, and a cartoon clip (3 total) was presented after every three test trials were completed. These additional movies were used to reinforce infants' attention to the eye-tracker during the test. Infants' sustained attention to the three types of events was measured by the latency it took them to shift the gaze away from the central displays to the

distracters, as well as the overall fixation duration and gaze count on the central events and distracters during the test.

Similar distractibility paradigms had been used in previous studies in measuring infants' attention regulation (e.g., Kannass et al., 2006; Lansink & Richards, 1997; Oakes & Tellinghuisen, 1994; Richards, 1997; Richards & Turner, 2001). The rationale behind this procedure was that if the central target event differentially engaged infants' attention as a function of its nature, infants' disengagement from the central target as reflected in their likelihood of shifting attention to the distracter should be low (operationalized as either longer latency to gaze shift and/or no gaze shift).

2.2.5 Joint attention task. After the “distractibility task” was complete, infants and parents were instructed to go to another testing room to participate in the “joint attention task”. During this task, infants were administered a version of the Early Social Communication Scales (ESCS, Mundy et al., 2003), a 5-8 min structured observation that had been used to measure the individual difference in nonverbal social communication behaviors in infants. In this task, a trained female experimenter was seated across a table with the infants. If infants were not focused on the experimenter initially, she tapped the table in front of the infant, then tapped her nose while saying the infant's name enthusiastically.

The experimenter pointed and visually fixated on four posters (placed on the walls 90° to the infants' left and right, and 175° behind the infants to the left and right) and four active toys (within infants' view but out of their reach) one at a time without direct verbal communication (i.e. “look at there!”). The posters were “Tinker Bell” (L1), “Toy story” (L2), “Princesses in Castle” (R1), “Snow White” (R2) and the toys were small plastic wind-up toys that were able to walk across the table from left to right or right to left. Infants were presented with a sequence of

posters (L1, L2, R1, R2), toy1 (L, R), toy2 (R, L), posters (R1, R2, L1, L2), toy3 (R, L), and toy4 (L, R). Three statements for each poster (i.e. “She has on a pretty green dress!”) and toy (i.e. “That tiger is silly!”) were made by the experimenter during the test. After making the statement for each poster, the experimenter maintained her gaze and point on the poster; while after making the statement for each toy, the experimenter looked from the toy to the infant at least once.

Infants’ response to joint attention (RJA) and initiating joint attention (IJA) were the interest of the study, given that both RJA and IJA had been reported in a large body of research to be related to infants’ and children’s vocabulary in the first and second years of life (Morales et al., 2000, 2007; Morales, Mundy, & Rojas, 1998; Mundy & Gomes, 1998; Salley et al., 2012) and were also correlated with later language ability (Morales, Mundy, Delgado, Yale, Messinger, Neal, & Schwartz, 2000; Toth et al., 2006; Ulvund & Smith, 1996). The experimenter-infant interplay was videotaped with a Panasonic digital video camera, and the infants’ RJA and IJA behaviors were coded off-line. During both tasks (distractibility task and joint attention task), the parents of infants were seated aside the infants, out of the view of both the eye-tracker and the camera, and were instructed not to verbally communicate or influence the behaviors of the infants during the experimental sessions.

2.2.5.1 Coding. Videotapes of the joint attention performance were converted to digital format. Two trained joint attention coders who were blind to the data collection and research hypotheses coded the behaviors of infants. RJA was coded as the number of times infants turned their gaze or head in the direction of the experimenter’s gaze and point. The coding criterion was determined as infants shift the gaze approximately 45° off midline if the posters were 90° to the infants, and they shift the gaze more than 90° off midline if the posters were 175° behind the infants. In comparison, IJA was coded as alternating the eye contact between the toys and the

experimenter (see Van Hecke et., 2007). If the infants made the eye contact with the experimenter but did not shift their attention from the toys to her, this behavior was not considered as IJA, given that it failed to demonstrate the meaning of attention alternation (i.e., infants was showing or pointing other distal objects in the testing room and immediately made the eye contact with the experimenter without looking at the toys). The result of joint attention coding showed that the inter-rater reliability in RJA and IJA between the coders was .99 and .99 based on intra-class correlation coefficients, which was one of the most commonly used statistics for assessing the inter-rater reliability for ordinal, interval, and ratio variables (Haidet, Tate, Divirgilio-Thomas, Kolanowski, & Happ, 2009; Hallgren, 2012).

3.0 Results

Available data for all 20 successful participants were included. Descriptive statistics for all the tasks and measures are presented in Table 1. Infants' latency to the distracters across the three conditions was measured as a mean across similar trials in each condition (due to the different numbers of trials in the upright, inverted, and abstract movies). The RJA and IJA data were also calculated as infants' average frequency of following and initiating the tester's joint attention respectively in each trial (due to missing data). Tests of normality showed that the latency data in the three movie types all followed the normal distributions, and no outliers were detected (no latency scores were found to be above or below 3 standard deviations of the mean).

3.1 Correlations between attention predictors and language outcomes

Pearson correlations among the attention predictors (latency and joint attention) and language outcomes are presented in Table 2. Contrary to the predicted relationships, infants' latency in the upright condition did not significantly correlate with the joint attention measures (RJA, IJA), or with language outcomes. However distracter latency in the abstract condition

evidenced a significant *negative* correlation with expressive vocabulary size at time one ($r = -.49$). IJA was significantly positively correlated with infants' receptive vocabulary size at time one ($r = .47$), but not at time two (Vineland-II). In addition, infants' ASQ communication score was significantly positively correlated with their time one and time two expressive vocabulary size ($r_{MCDI-I} = .59$; $r_{MCDI-II} = .55$). Finally, both infants' time one expressive/receptive language positively correlated with their time two expressive/receptive language ($r_{MCDI-I,II} = .76$; $r_{Vineland-I,II} = .66$).

3.2 Regression analyses of latency on language outcomes

The predictive effect of infants' attention distractibility (upright_latency, inverted_latency, and abstract_latency) and their joint attention performance (RJA and IJA) on their expressive (MCDI) and receptive (Vineland scale) language outcomes was analyzed separately using multiple regressions. Before conducting the regression analyses, the difference among the distracter latency across the three conditions was compared. The result from a repeated analysis of variance (ANOVA) with Movie Type (upright, inverted, abstract) as a within-subject variable showed that there was a significant main effect [$F_{(2,32)} = 3.37, p < .05$]. A paired t-test showed that infants' average latency to the distracter during the upright movie was significantly longer compared to the inverted [$t(19) = 2.45, p < .05$] and abstract movies [$t(16) = 2.34, p < .05$], but there was no significant difference in the latency between the inverted and abstract conditions [$t(16) = 1.23, p > .05$]. Also given that the average latencies among all three movie types were intercorrelated (see Table 2), multicollinearity existed among these predictors, leading to inflated standard errors. In order to test the multicollinearity, a tolerance statistic for the latency variables (upright_latency, inverted_latency, and abstract_latency) was performed. The result showed that the tolerance for upright_latency, inverted_latency, and

abstract_latency was .42, .43, and .70 respectively, which indicated acceptable intercorrelations among these variables (tolerance values smaller than .10 are usually indications of serious multicollinearity, see Cohen, Cohen, West, & Aiken, 2003).

3.2.1 Expressive language –Time One. First, the regression analysis with one single predictor (abstract_latency) was performed to test whether non-social attention was significantly related to infants' current expressive language. The result showed that abstract latency negatively predicted a significant amount of variance in the MCDI-I [$F_{(1,15)}=4.78, p< .05, R^2= .24, \beta= -.49$]. That is, infants who shifted their attention from the abstract form toward the distracter more quickly showed higher expressive vocabularies.

Next, regression was calculated with the three predictors (abstract_latency, up_latency, and inverted_latency) in the model to test the effect of social and non-social attention on language outcome. The average latencies to the distracters in both upright and inverted conditions did not account for any significant unique variance in MCDI-I [$F_{(3,13)}=1.84, p> .05, R^2 \text{ change}= .30$]. Due to the high intercorrelation ($r = .70, p < .01$) between the latency in the upright and inverted condition (although serious multicollinearity was not detected by the tolerance statistics) and the hypothesis of the study [infants' latency to the distracters on the social trials (upright) would account for unique variance in language outcomes above their latency to distracters on non-social trials (abstract)], inverted_latency was dropped out of the model. Again, the regression analysis showed that infants' distracter latency in the upright condition did not contribute significant amount of unique variance in expressive language [$F_{(2,14)}=2.87, p> .05, R^2 \text{ change}= .29$].

Another regression model was developed using abstract_latency, RJA and IJA as the predictors to test how non-social attention and joint attention had an effect on language outcome.

The result showed that RJA and IJA did not make any significant contribution in predicting the MCDI at time one [$F_{(3,12)}=1.34, p> .05, R^2 \text{ change}= .25$].

3.2.2 Receptive language –Time One. The logic for testing the variance explained in receptive language by the task measures (e.g. latency variables and joint attention variables) was the same as the logic presented above when testing the variance explained in expressive language. First, the regression analysis was performed using abstract_latency as the predictor to test its effect on receptive vocabulary. The result did not support its predictive effect on receptive language [$F_{(1,14)}=2.41, p> .05, R^2= .15$]. Next, upright_latency and inverted_latency were used as the predictors to test the effect of attention to social events on receptive language outcome. These two predictors together did not predict any variance in receptive language [$F_{(2,16)}=.38, p> .05, R^2 = .05$]. Finally, the regression analysis was conducted with only one predictor (upright_latency) in the model, and upright_latency still did not show any effect in predicting receptive vocabulary [$F_{(1,17)}=.68, p> .05, R^2= .04$].

Next, the regression model was developed using RJA and IJA as the predictors to test how joint attention affected language outcome. The result showed that RJA and IJA together did not make any significant contribution in predicting the Vineland scale at time one [$F_{(2,15)}=2.14, p> .05, R^2 = .25$]. RJA and IJA were also entered separately as predictors in a univariate regression analysis to predict variance in receptive language. The result showed that IJA was the only variable ($\beta= .47, p = .05$) that significantly accounted for variance in time 1 receptive language [$F_{(1,16)}=4.46, p=.05, R^2= .22$]. In contrast, RJA did not predict the Vineland score at time one [$F_{(1,16)}=.28, p >.05, R^2= .02$].

3.2.3 Expressive language –Time Two. First, the regression model with a single non-social predictor (abstract_latency) did not significantly predict any variance in MCDI at time two [$F_{(1,15)}=.76, p > .05, R^2= .05$]. Next, the latency variables in the upright and inverted conditions, excluding the abstract_latency, were put into the model to test the effect of social attention on language outcome. The result showed that the upright and inverted latency did not predict any significant variance in the MCDI-II [$F_{(2,17)}=.06, p > .05, R^2= .01$]. Furthermore, inverted_latency was dropped out of the model to test how attention to the upright face was related to the MCDI-II. However, upright_latency alone did significantly predict the MCDI at time two [$F_{(1,18)}=.06, p > .05, R^2= .003$].

Next, joint attention measures (RJA, IJA) were introduced into the regression model to test their effects on the MCDI at time two. The result indicated that RJA and IJA together did not show any significant effect in predicting the MCDI-II [$F_{(2,16)}=.16, p > .05, R^2= .02$]. In addition, RJA [$F_{(1,17)}=.32, p > .05, R^2= .02$] and IJA [$F_{(1,17)}=.02, p > .05, R^2= .001$] did not significantly predict any variance in the MCDI at time two, based on two univariate simple regression analyses.

3.2.4 Receptive language –Time Two. In the first step, the regression analysis was performed with abstract_latency only in the model, but this factor did not significantly account for variance in the Vineland-II [$F_{(1,15)}=3.86, p =.07, R^2= .20$]. Next, upright_latency and inverted_latency were entered into the model to test the effect of attention to social events on receptive language. However, they did not significantly predict any variance in receptive vocabulary at time two [$=.83, F_{(2,17)} p > .05, R^2= .09$]. Finally, upright_latency alone in the model still did not predict the Vineland-II score [$F_{(1,18)}=1.25, p > .05, R^2= .07$].

3.2.5 Effect of Attention latency on Language Composite

Due to multiple measures of language outcomes and large numbers of regression analyses, a composite language outcome measure from the infant participants was made by aggregating the scores of language production (MCDI) and language comprehension (Vineland Scale) at two times. The language composite score was computed by averaging the normalized scores (Z-scores) of MCDI-I, MCDI-II, Vineland-I, and Vineland-II. Correlations between the test measures and language composite are shown in Table 3. Nothing changed in the pattern of results. Abstract_latency ($r = -.54, p < .05$) and the ASQ score ($r = .49, p < .05$) still significantly correlated with the language composite. However, the significant correlation between IJA and the language composite was no longer observed. The regression analysis showed that abstract_latency [$F_{(1,14)} = 5.83, p < .05, R^2 = .29$] and the ASQ communication [$F_{(1,17)} = 5.31, p < .05, R^2 = .24$] each significantly predicted variance in the language composite score. Different from what was observed before, IJA no longer predicted infants' combined language abilities.

3.3 Infants' Scanning Patterns to Social and Non-Social Movies

In order to explore ways in which infants attended to the various movies, infants' scanning of areas of interest on the faces, abstract figure, and the distracter were analyzed in two ways.

3.3.1 Fixation Duration Data

First, fixation duration (total amount of dwell time) on various regions of interest (AOI) was calculated by designating three areas on each central form (upper, middle, lower), the entire central display (upper+middle+lower), and the distracters. The upper, middle, and lower AOIs corresponded to social features in the following ways: for the upright movie, upper = forehead, middle=eye area, lower=mouth area; for the inverted movie, upper=mouth area, middle = eye

area, lower = forehead; for the abstract, the upper, middle, and lower areas correspond to similar areas on the upright face, but have no social meaning. A 3×3 repeated ANOVA with Movie Type (upright, inverted, and abstract) and AOI (upper, middle, lower) as the within-subject variables showed a significant main effect for Movie Type [$F_{(2,38)}=8.02, p < .01$]. A paired sample t-test evidenced that infants showed significantly longer average fixations to the upright face ($M=5.94, SD=2.58$) than the inverted face [$M=5.08, SD=1.86, t(19)= -2.43, p < .05$] and the abstract figure [$M=4.09, SD=2.52, t(19)= -3.47, p < .05$]. However there was no significant difference in attention fixation between the inverted and abstract conditions [$t(19)= -2.05, p > .05$]. There was also a significant main effect for AOI [$F_{(2,38)}=8.80, p < .01$]: infants showed significantly longer average fixations on the eyes and mouth regions regardless of the movie type. However, this main effect was superseded by a significant Movie Type x AOI interaction [$F_{(4,76)}=24.16, p < .01$]. Although infants did not show statistically different fixation duration to the eyes ($M_{Upright} = 2.79, M_{Upright} = 2.43; M_{Inverted} = 2.37, SD_{Inverted} = 1.06$) and mouth ($M_{Upright} = 3.13, M_{Upright} = 2.41; M_{Inverted} = 2.69, SD_{Inverted} = 1.66$) in the upright and inverted movies based on a series of paired sample t-tests, they looked longer at the lower region during the abstract movie [$t(19)=3.84, p < .01$]. In addition, a one-way repeated ANOVA comparing fixation duration on the distracter AOI across the three movie types (upright, inverted, and abstract) as the within-subject variable showed no significant main effect [$F_{(2,38)}=.95, p > .05$].

In terms of relationships between scanning patterns and language measures, fixation duration to the upright face and upright eyes were significantly positively correlated with the Vineland-I ($r_{face} = .53, p < .05; r_{eyes} = .49, p < .05$). Also, infants' fixation duration to the eyes in the upright movie was significantly positively correlated with their IJA ($r = .60, p < .01$). In contrast, the fixation duration to the distracter in the upright ($r = -.49, p < .05$) condition was

significantly negatively correlated with ASQ (addressed in the ASQ section below). However, fixation duration to the overall central displays, fixation duration to the upper, middle, and lower areas of the central displays, as well as on the distracters, did not significantly predict MCDI at time one. In contrast, infants' fixation duration to the upright face ($\beta=.53, p <.05$) and to upright eyes ($\beta=.29, p <.05$) significantly predicted variance in receptive vocabulary size at time 1 [$F_{(1,17)}=6.78, p <.05, R^2=.29$ and $F_{(1,17)}=5.24, p <.05, R^2=.24$, respectively]. Surprisingly, fixation duration patterns did not significantly predict any variance in the MCDI and Vineland scales at time two.

3.3.2 Fixation Count Data

The results of analyses with fixation count (frequency of individual saccades) data were highly similar to those with fixation duration. The result from a repeated 3x3 ANOVA with Movie Type (upright, inverted, and abstract) and AOI (upper, middle, lower) as the within-subject variables showed that: first, there was a significant main effect for Movie Type [$F_{(2,38)}=17.90, p <.01$]. The paired sample t-tests indicated that infants showed more frequent count to the upright [$M=13.58, SD=4.34; t(19)=-5.23, p <.01$] and inverted faces ($M=11.83, SD=3.08; t(19)=-4.86, p <.01$) than to the abstract display ($M=8.55, SD=3.74$), but there was no significant difference in count between the upright and inverted conditions [$t(19)=-1.96, p=.07$]. Second, there was a main effect for AOIs [$F_{(2,38)}=18.44, p <.01$]: infants showed more frequent count to the eyes and mouth regions regardless of the movie type. Finally, there was a significant movie type x AOI interaction [$F_{(4,76)}=37.03, p <.01$]. Although infants did not show any distinguished count difference to the eyes ($M_{Upright}=6.88, SD_{Upright}=4.13; M_{Inverted}=6.54, SD_{Inverted}=2.66$) and mouth ($M_{Upright}=6.61, SD_{Upright}=4.08; M_{Inverted}=5.14, SD_{Inverted}=1.88$) in the upright and inverted movies (based on a series of paired sample t-tests), they displayed more count at the lower AOI

in the abstract movies [$t(19)=3.97, p < .01$]. Additionally, a repeated ANOVA with the distracter count as the within-subject variable showed that there was no significant difference regarding distracter count as a function of condition [$F_{(2,38)}=.21, p > .05$].

The correlation data showed that infants' count to the upright face and upright eyes were significantly correlated with their Vineland-I ($r_{face} = .55, p < .05$; $r_{eyes} = .47, p < .05$); the count on the upright eyes was significantly correlated with IJA ($r = .47, p < .05$). Also, the distracter count in the upright condition demonstrated a significantly negative correlation with the ASQ ($r = -.50, p < .05$) (addressed in the ASQ section below). However, none of the count data in the current study significantly predicted the MCDI at time one. In contrast, infants' count to the upright face ($\beta=.55, p < .05$) significantly predicted 30% variance in their current receptive vocabulary size [$F_{(1,17)}=7.41, p < .05, R^2=.30$]; their count to the upright eyes ($\beta=.46, p = .05$) also predicted 21% variance in the current receptive language [$F_{(1,17)}=4.46, p = .05, R^2=.21$]. Likewise, the variance predicted by the count on the upright face and eyes was the shared variance. None of the count data in the currently study made any significant prediction in the MCDI and Vineland scale at time two.

3.3.3 ASQ communication skill

Infants' emerging communication skill was also assessed by the ASQ at the time of test (time one). It was found that infants' ASQ score significantly predicted expressive vocabulary at both time one [$F_{(1,17)}=9.10, p < .01, R^2=.35, \beta=.59$] and time two [$F_{(1,17)}=7.45, p < .05, R^2=.31, \beta=.55$]. Given the predictive effect of ASQ on the MCDI, the sample of infants was subdivided according to this measure in order to explore whether individual difference in the ASQ score were differentially related to latency patterns in the scanning task as well as joint attention.

3.3.3.1 Individual difference in ASQ score. Infants were split into two groups, in which the high-ASQ group was determined by those who had ASQ scores above 40 ($n=8$; median=40); whereas those who had scores below 40 ($n=7$) were grouped together in a low-ASQ group. Four infants were left out because they had ASQ scores at the median. A 2×3 ANOVA with ASQ Group (high, low) as a between-subject variable and Latency to Distracter across Movie Type (upright, inverted, abstract) as a within-subject variable showed that there was no significant difference with regard to distracter latencies across conditions [$F_{(1,11)}=.46, p >.05$]. Another two t-tests indicated that there was also no significant difference regarding RJA [$t(12)=-.03, p >.05$] and IJA behaviors [$t(12)=-.37, p >.05$] between the high and low ASQ groups. Thus no significant individual difference in latency patterns and joint attention performance was observed in the current study.

3.3.3.2 Predictive effect of the task measures on ASQ score. Although the high and low ASQ groups did not statistically differ in distractibility in general and joint attention behaviors, it would be still interesting to look at what task measures designed in this study might predict the ASQ communication in infancy. Based on all the fixation, count, and latency data, it was found that fixation and count on distracters in the upright condition, as well as fixation duration to distracters in the inverted condition, were the only test measures that significantly predicted the ASQ communication score (based on three simple regression analyses with one predictor each). Specifically, the distracter fixation [$F_{(1,17)}=5.34, p <.05, R^2=.24, \beta=-.49$] and count [$F_{(1,17)}=5.63, p <.05, R^2=.25, \beta=-.50$] when looking at the upright trials negatively predicted 24% and 25% variance respectively in the ASQ score, and the fixation duration to the distracter [$F_{(1,17)}=5.60, p <.05, R^2=.25, \beta=-.50$] when looking at the inverted trials negatively predicted 25% variance in the ASQ score. Likewise, all the variance mentioned above was the shared variance.

4.0 Discussion

The purpose of this study was to examine whether infants' allocation and control of attention to social agents uniquely predicted emerging language capabilities over and beyond the contribution made by more general attention skills. The combined contribution of infants' sustained attention to social and non-social events and their responsiveness to joint attention were measured to predict their effects on infants' current (16 and 17 months) and subsequent (18 and 19 months) language skills. It was hypothesized that sustained attention to social events and the RJA and IJA responses would each predict and account for unique variance in expressive and receptive vocabulary size.

4.1 Contribution of distractibility

It was predicted that infants' latency to disengage from a talking female to a peripheral distracter on the social trials (upright) would account for unique variance in language outcomes above their latency to distracters on non-social trials (abstract). Contrary to this prediction, distracter latency in the social condition was not significantly correlated with any joint attention measures (RJA, IJA), and it did not correlate or predict unique variance in language outcomes (expressive, receptive vocabulary).

However, infants' average latency to distracters on the abstract trials predicted a significant amount of variance in infants' current expressive language. Among the predicting variables computed in the study, only attention to the abstract figure was a measure of infants' general attention regulation skills, in that the upright and inverted conditions both involved dynamic human faces and voice tracks (although in different orientations), which specifically captured the social aspect of attention comparing to attention to the abstract figure. Given that abstract latency was the only variable that significantly explained variance in expressive

language at time one, the hypothesis that attention to social events predicting unique variance above and beyond the general attention skills was not supported. Thus, the development of expressive vocabulary in infancy may require more general attention skills instead of attention to social events.

Importantly, the predictive effect of abstract latency on expressive language was negative. That is, infants who displayed longer latencies to the distracter when the non-social figure was presented as the central stimulus showed lower expressive vocabulary size than those who displayed shorter latency to the distracter. Thus, infants who did not quickly disengage attention from a non-meaningful event were also reported by parents as producing fewer words at 16 and 17 months of age. This negative relationship can be explained by the significance and complexity of the visual/auditory events to which infants were exposed. The most social event generated by the study was the combination of an upright female face and her voice in infant directed speech. This combination contained a great amount of intersensory redundancy (e.g., information presented redundantly and in temporal synchrony across multiple senses), leading to substantial perceptual salience (Bahrick & Lickliter, 2000; 2003; Flom & Bahrick, 2007). Another audiovisual stimulus made in the study was an inverted female face and her filtered voice track, which was not considered fully social or non-social. The most non-social event developed in the study was a comparable abstract figure consisted of fewer visual details accompanied by the female speaker's filtered voice track played in reverse – the least “speech-like” sound track of the three event types. Among the three types of stimuli, the abstract figure and its matched sound track should be the one that consisted of the least complexity. Therefore, the non-social event, a stimulus with reduced complexity in both visual and auditory aspects, should lead to more rapid encoding and thereby faster attention processing speed. However,

those infants' who required longer to shift attention away from this abstract event may have difficulty disengaging attention from events that are not meaningful and important, leading to poor language skills reported by the parents. As a result, better attention skills with respect to language learning may not only require longer sustained attention, but also greater facility at disengaging attention (Colombo, 1993; Freseman, Colombo, & Coldren, 1993; Frick, Columbo, & Saxon, 1999).

4.2 Contribution of joint attention

Initiating joint attention was the only measure observed in joint attention that yielded a unique predictive contribution to infants' current receptive vocabulary at 16 and 17 months. This was in line with considerable literature on the relationship between the IJA abilities and language acquisition in the first and second years of life (Morales et al., 1998; Mundy & Gomes, 1998). However, the relationship between IJA and infants' expressive and receptive language was not consistently reported in the previous studies. Some studies supported the predictive effect of IJA on infants' expressive language growth (Mundy et al., 2007), whereas others demonstrated the effect of IJA on receptive language development (Mundy et al., 2007; Ulvund & Smith, 1996).

It has been suggested that IJA may reflect enthusiasm for social engagement and the purpose of sharing attention and experience with others (Mundy & Sigman, 2006, see Mundy, 2007), which are regulated by the activation of frontal systems (Caplan et al., 1993; Henderson, Yoder, Yale, & McDuffieal, 2002). This high social motivation and deep understanding in self and others may be associated with increased competence in social information processing, which facilitates social problem solving skills and better cognitive abilities, such as greater frontal functioning (Mundy et al., 1993; Mundy, Fox, & Card, 2003; Mundy & Sigman, 2006; Tomasello, 1995).

Given the association between IJA and infants' receptive language, it would be interesting to look at what might predict the individual difference in infants' IJA behaviors. It was found that IJA was significantly correlated with infants' fixation duration and count to the upright human face, especially the eye region. This provided evidence that IJA, the deep understanding of attention sharing, had a close relationship with attention to human eyes as well as the orientation of human face, given that the relationship between IJA and attention (fixation and count) to the eyes in the inverted face was observed to be weak in the study. Thus eyes alone may not be critical for the development of IJA skills. What was important was the eyes being located in right place on a human face. However, the position of human eyes was only one factor that was associated with infants' attention sharing reflected by IJA. The auditory tracks accompanied with the visual events also participated in regulating infants' IJA behaviors. The dynamic upright face combined with the speaker's engaging infant directed speech in synchrony were powerful social stimuli (Bahrick & Lickliter, 2000; 2003), from which (especially eyes) infants acquired sufficient social cues, and which provided benefits in the development of their IJA skills.

Responding to joint attention was found to be neither correlated with IJA nor with the language outcome measures (expressive and receptive), which were unexpected. In fact, RJA response was not significantly correlated with any measures used in the study. Possibly, this was due to the small variability observed in the infants' RJA responses. The participants recruited for this study were typical developing infants, who generally showed more interest and motivation to look at human faces than non-human figures. This assumption was supported by the observation of longer fixation and more frequent fixation count toward the upright face than to the abstract display, as well as longer latencies away from the upright face than from the abstract figure to

the distracter. As a result, these infants showed moderate to high attention to social events, as well as high joint attention skills. Therefore there was constrained variability in infants' RJA performance.

4.3 Contribution of ASQ communication

The aim of using the ASQ communication score in the study was to gather more information about infants' language skills prior to the measurement of their subsequent language outcomes. Consistent with the prediction, 16- and 17-month-olds' ASQ communication score was significantly positively correlated with both their current and subsequent expressive vocabulary size at 18- and 19-month-old, and yielded significantly predictive variance in expressive vocabulary at two times. This direct effect of the ASQ score on infants' language outcomes demonstrated good predictive validity of the ASQ communication on the evaluation of infants' language production. The prediction on expressive vocabulary might be due to the consistency of the language measurement in the study, given that all of the language outcomes were reported by the same caregivers for individual infants over time (Kane & Case, 2004).

However it is still possible that the ASQ communication domain contains special components that meaningfully explain the individual difference in expressive language and predict significant variance in it. ASQ communication, as a general screening measure in verbal communication, queries infants' language readiness, such as appropriate language skills infants should be able to perform at this age. If looking at the items in the communication section (for 16-month-olds), most questions (4 out of 6) reflect infants' communication intention (Does your child point to, pat, or try to pick up pictures in a book?; when your child wants something, does she tell your by pointing to it?) and responsiveness (When you ask your child to, does he go into another room to find a familiar toy or object? You may ask, "where is your ball", or say, "Bring

me your coat”, or “Go get your blanket”; does your child imitate a two-word sentence? For example, when you say a two-word phrase, such as “Mama eat” “Daddy play”, “Go home”, or “What’s this”, does your child say both words back to you?). Possibly, this communication intention and responsiveness are important indicators of infants’ abilities in language production.

Given the predictive effect of the ASQ score on language skills, it was assumed that the individual difference in the ASQ communication might affect infants’ behavior performance in distractibility and joint attention. Contrary to the prediction, the high and low ASQ group did not differ in latency patterns in the social and non-social conditions, and they also did not differ in the RJA and IJA behaviors. However, it was observed that infants’ average fixation duration and count on distracters in the upright condition negatively predicted their ASQ communication score. That is, longer gaze fixation and more frequent count on distracters in the presence of an upright speaking human face resulted in infants’ lower ASQ communication perceived by parents. Although latency to distracters has been suggested as a good measure of distractibility, increased fixation duration and count on peripheral distracters also reasonably reflect low sustained attention to the central stimulus. Therefore infants’ relatively low sustained attention to social events was predictive of their low ASQ communication, which eventually led to poor expressive vocabulary. With this, the part of attention might also have an indirect effect on infants’ language abilities.

5.0 Summary

Current theory holds that infants’ engagement of attention is regulated by their capacity for endogenous control of attention as well as the salience of the targeted events to elicit and maintain attention, which is usually measured by the presence of distracters in peripheral space competing for their attention to the central events (Colombo, 2001). Some studies have provided

evidence that attention regulation skills play an important role in language capabilities early in development (Salley et al., 2012). However it is still unclear if better language achievement is due to a qualitative difference in the nature of attention allocation to social events (social attention) or events in general (global attention).

The current study did not support the predication that social attention accounts for unique variance above and beyond that contributed by general attention control with respect to language outcomes. On the contrary, the global attention regulation skills were observed to be predictive of infants' current expressive language. More importantly, advanced language production ability requires not only sustained attention in general, but also flexibility in attention disengagement from events that were not meaningful. Initiating joint attention, as one measure in joint attention, significantly predicted infants' current receptive language, indicating the unique contribution of IJA behaviors to infants' language outcomes, which supports the hypothesis that IJA would make unique contributions to infants' language outcomes.

Taken together, both visual attention in general and social aspect of attention contribute to infants' language skills. The distractibility task designed in the study demonstrates the importance of general attention regulation skills in the prediction of infants' expressive language. In contrast, joint attention performance measured in the study reflects the role of social attention in receptive language, given that IJA behaviors in joint attention are significantly correlated with infants' fixation and gaze count on the upright speaking face (especially within eyes), which is the event that contains the most salient social cues comparing to the other two stimuli (inverted and abstract). Hence, both attention in general and the social part of attention affect language abilities early in development, but they are separately associated with different language dimensions.

6.0 Limitations and future directions

The participants recruited for this study were typical developing infants. As it was mentioned above, constrained variability in infants' distracter latency in the social conditions and joint attention performance was observed, because these infants as a group were more interested in social events. If atypical developing infants, such as infants with autism, were recruited, more variability in the social aspect of attention might have been observed. Future studies need to examine how social attention and the general attention regulation abilities affect atypical developing children's language skills, so that it might provide insight into understanding the relationship between attention regulation and language abilities.

It is also possible that the design of the current study contributed to the low variability in infants' latency away from the upright speaking face to the distracter. The dynamic speaking face with different orientations possibly did not sufficiently capture infants' social part of attention, so that infants did not show differential latencies to distracters when the face was presented. Future studies need to consider using other types of central stimuli to measure infants' attention regulation abilities to social events. For instance, a face-to-face interaction might be more powerful than dynamic movies in orienting and sustaining infants' attention to the central stimuli, because real social interaction could provide contingent social response from the partner with regard to infants' behaviors and vice versa (Goldstein, King, & West, 2003; Gros-Louis, Goldstein, & King, 2006).

Then the question arises as to what constitutes a social agent? Although many studies have examined how infants' use of social cues (i.e., eyes; Baldwin, 1995) affects their developmental outcomes, the definition of what social is has been very vague. According to Kuhl (2007), social interaction, contingency, and reciprocity are what a social agent could be for

infants, which have been found to be critical for infants' language learning (Liu et al., 2003). The movies designed in this study lack all of the components mentioned above, and maybe this is the reason for the low variability in infants' distractibility in the social conditions. It is important for future studies to explore the meaning for "social agent", and develop measurements that would address each social component that constitutes the social agent, and answer the question about how each social component is associated with different aspects of language outcomes. As such, it provides more insight into the how infants' use of social cues affect their language development.

It should be noted that the purpose of using an inverted face accompanied with a filtered voice track was to introduce an event that was not fully social or non-social so as to understand how infants view social meaning. This inverted condition developed in the study was to compare infants' attention regulation from looking at the extreme social events to the extreme non-social events, in which the upright, inverted, and abstract "faces" with their appropriate sound tracks represented an event continuum from being very social to being very non-social. This condition was designed to understand how infants' sustained attention was regulated by the nature of the visual displays arranged as a continuum. Infants' attention to this inverted speaking face (i.e., latency, fixation, and count) was found to be highly correlated with their attention to the upright speaking face, although both the visual and auditory stimuli were modified. Since both the auditory and visual stimuli in the inverted condition were different from those in the upright condition, it is unclear that which modality (auditory or visual) plays more important role in determining the meaning of social for infants. It would be important for the future studies to examine how visual image and auditory sound differentially affect the social meaning of an event.

None of the test measures developed in the study could predict infants' *subsequent* language outcomes. Future studies need to consider more diverse measurements beyond language production and comprehension to investigate the influence of attention on various language outcomes. Ultimately, this work will shed light on understanding language development in both typical and atypical developing children.

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Table 1

Task and Measure Descriptive Statistics

	Min	Max	Mean	SD
Distractibility Task (milliseconds per trial)				
Upright Latency	1206	2000	1628.04	234.51
Inverted Latency	576	2000	1468.26	400.00
Abstract Latency	283	2000	1295.26	585.59
RJA Mean (frequency per trial)	.25	1.00	.62	.18
IJA Mean (frequency per trial)	.00	3.50	1.58	.86
ASQ (communication)	25	60	42.11	11.22
MCDI – I (Expressive Vocabulary)	4	28	12.15	6.46
MCDI – II	9	54	24.60	12.05
Vineland Scale – I (Receptive Vocabulary)	8	14	12.05	1.35
Vineland Scale – II	10	14	13.10	1.17

Table 2

Correlations among Predictors and Language Outcomes

	1	2	3	4	5	6	7	8	9
1. Upright Distracter Latency									
2. Inverted Distracter Latency	.70**								
3. Abstract Distracter Latency	.54*	.50*							
4. RJA	-.11	-.13	-.10						
5. IJA	-.39	-.21	-.15	.02					
6. ASQ	.42	.46*	.09	.13	.06				
7. MCDI – I	.16	-.10	-.49*	.13	.05	.59**			
8. MCDI – II	.06	-.01	-.22	.14	.04	.55*	.76**		
9. Vineland – I	-.20	-.09	-.38	.13	.47*	.03	.06	.02	
10. Vineland – II	-.26	-.06	-.45	.01	.21	.18	.16	.24	.66**

Note. * $p < .05$, ** $p < .01$.

Table 3

Correlations among Predictors and Language Composite

	1	2	3	4	5	6
1. Upright Distracter Latency						
2. Inverted Distracter Latency	.70**					
3. Abstract Distracter Latency	.54*	.50*				
4. RJA	-.11	-.13	-.10			
5. IJA	-.39	-.21	-.15	.02		
6. ASQ	.42	.46*	.09	.13	.06	
7. Language Composite	-.05	-.09	-.54*	.21	.23	.49*

Note. * $p < .05$, ** $p < .01$.

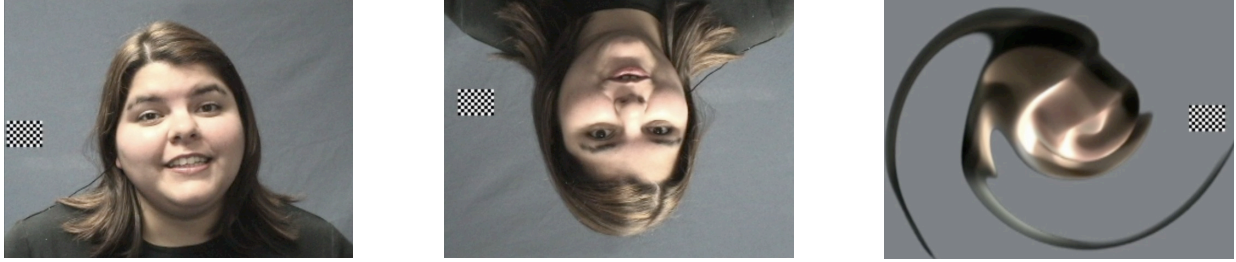


Figure 1. Central Displays with Peripheral Distracters. These three pictures represented the three conditions: upright, inverted, and abstract in the study. Small flashing black-and-white checkerboards were randomly presented for 2 sec in each trial in the visual periphery at the midline either on the left or right on the screen.

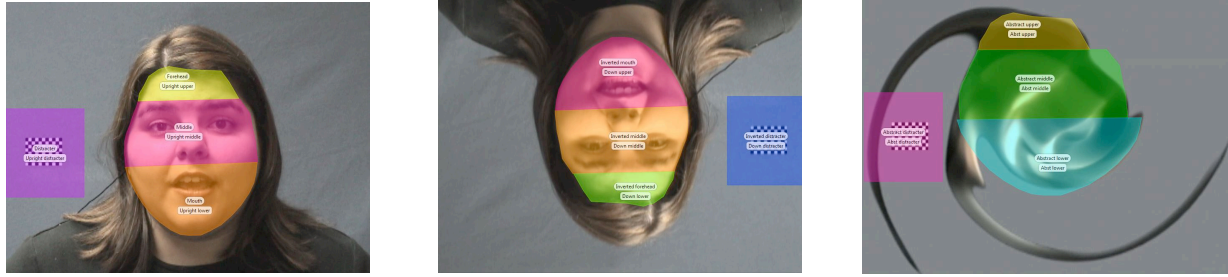


Figure 2. Area of Interests (AOIs) of Central Stimuli and Distracter. Area of interest (AOI) was calculated by designating three areas on each central form (upper, middle, lower), the entire central display (upper+middle+lower), and the distracters. The upper, middle, and lower AOIs corresponded to social features in the following ways: for the upright movie, upper = forehead, middle=eye area, lower=mouth area; for the inverted movie, upper=mouth area, middle = eye area, lower = forehead; for the abstract, the upper, middle, and lower areas correspond to similar areas on the upright face, but have no social meaning.

Appendix A

Ages and Stages Questionnaire (15 months 0 days through 16 months 30 days)

At this age, many toddlers may not be cooperative when asked to do things. You may need to try the following activities with your child more than one time. If possible, try the activities when your child is cooperative. If your child can do the activity but refuses, score "yes" for the item.

COMMUNICATION	<i>Be sure to try each activity with your child.</i>	YES	SOMETIMES	NOT YET	___
1.	Does your child point to, pat, or try to pick up pictures in a book?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	___
2.	Does your child say four or more words in addition to "Mama" and "Dada"?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	___
3.	When your child wants something, does he tell you by <i>pointing</i> to it?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	___
4.	When you ask her to, does your child go into another room to find a familiar toy or object? (You might ask, "Where is your ball?" or say, "Bring me your coat" or "Go get your blanket.")	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	___
5.	Does your child imitate a two-word sentence? For example, when you say a two-word phrase, such as "Mama eat," "Daddy play," "Go home," or "What's this?" does your child say both words back to you? (Check "yes" even if his words are difficult to understand.)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	___
6.	Does your child say eight or more words in addition to "Mama" and "Dada"?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	___
COMMUNICATION TOTAL					___

GROSS MOTOR	<i>Be sure to try each activity with your child.</i>	YES	SOMETIMES	NOT YET	___
1.	Does your child stand up in the middle of the floor by herself and take several steps forward?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	___
2.	Does your child climb onto furniture?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	___
3.	Does your child bend over or squat to pick up an object from the floor and then stand up again without any support?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	___
4.	Does your child move around by walking, rather than crawling on his hands and knees?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	___
5.	Does your child walk well and seldom fall?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	___
6.	Does your child climb on an object such as a chair to reach something she wants?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	___
GROSS MOTOR TOTAL					___

FINE MOTOR	<i>Be sure to try each activity with your child.</i>	YES	SOMETIMES	NOT YET	___
1.	Does your child help turn the pages of a book? (You may lift the pages for him to grasp.)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	___
2.	Does your child throw a small ball with a forward arm motion? (If she simply drops the ball, check "not yet" for this item.)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	___



Appendix B

Ages and Stages Questionnaire (17 months 0 days through 18 months 30 days)

At this age, many toddlers may not be cooperative when asked to do things. You may need to try the following activities with your child more than one time. If possible, try the activities when your child is cooperative. If your child can do the activity but refuses, score "yes" for the item.

	YES	SOMETIMES	NOT YET	
COMMUNICATION <i>Be sure to try each activity with your child.</i>				
1. When your child wants something, does she tell you by <i>pointing</i> to it?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	___
2. When you ask him to, does your child go into another room to find a familiar toy or object? (You might ask, "Where is your ball?" or say, "Bring me your coat" or "Go get your blanket.")	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	___
3. Does your child say eight or more words in addition to "Mama" and "Dada"?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	___
4. Does your child imitate a two-word sentence? For example, when you say a two-word phrase, such as "Mama eat," "Daddy play," "Go home," or "What's this?" does your child say both words back to you? (Check "yes" even if her words are difficult to understand.)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	___
5. Without showing him first, does your child <i>point</i> to the correct picture when you say, "Show me the kitty" or ask, "Where is the dog?" (He needs to identify only one picture correctly.)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	___
6. Does your child say two or three words that represent different ideas together, such as "See dog," "Mommy come home," or "Kitty gone"? (Don't count word combinations that express one idea, such as "Bye-bye," "All gone," "All right," and "What's that?")	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	___
Please give an example of your child's word combinations: _____				
COMMUNICATION TOTAL				___
 GROSS MOTOR <i>Be sure to try each activity with your child.</i>				
1. Does your child bend over or squat to pick up an object from the floor and then stand up again without any support?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	___
2. Does your child move around by walking, rather than by crawling on her hands and knees?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	___
3. Does your child walk well and seldom fall?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	___
4. Does your child climb on an object such as a chair to reach something he wants?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	___
5. Does your child walk down stairs if you hold onto one of her hands? (You can look for this at a store, on a playground, or at home.)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	___
6. When you show him how to kick a large ball, does your child try to kick the ball by moving his leg forward or by walking into it? (If your child already kicks a ball, check "yes" for this item.)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	___
GROSS MOTOR TOTAL				___



Appendix D
Contact Information

iLEAP Laboratory
Contact Information Sheet
(All information is strictly confidential)

Parent's Name: _____

Street Address: _____

City: _____ State: _____ Zip: _____

Phone Number: _____ Cell Phone Number: _____

Email Address: _____

Child's Name: _____

Date of Birth: _____

Appendix E

Informed Consent

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Informed Consent for Participants of Investigative Projects

Title of Project: Infants' Social Attention and Language Development

Principle Investigators:

Dr. Robin Panneton

Qiong (Joy) Wu

I. Purpose of Research Project

The purpose of this project is to investigate infants' attention to social and non-social information and how this relates to their language and social development. During the visit, first we will measure infants' attention to a talking face and a moving object during distraction. Second, we will measure infants' nonverbal social communication skills by means of interacting with an experimenter. Two months later following this visit, we will mail brief questionnaires (to be completed by a primary caregiver), which will measure infants' language and social development.

II. Procedure

Your infant will be tested for approximately 30 minutes, provided that he/she is awake, alert, and quiet. First, the baby will be seated in a high chair and faces a monitor of an eye-tracker on which movies will appear. Before the movies start, the infant will see a simple screen with moving dots so that we can calibrate his/her eye positions. Then the infant will watch a series of movie clips of either a dynamic female telling an engaging story or a moving object making a sound, in the presence of a flashing black-and-white checkerboard in the infant's visual periphery. The infant's latency and frequency of attention shift to the distracter will be recorded by the eye-tracker as

indicators of your infants' sustained attention to the social and non-social information. Second, the infant will be engaged in play with an adult female experimenter for approximately 5-10 minutes. The infant will be presented with several wind-up toys and animated movie posters during the interaction, in order to measure the infant's nonverbal social communication behaviors. Throughout the session, each baby will be videotaped during his/her session for subsequent coding of visual attention and behavior. If for any reason, your infant cries or falls asleep, testing will be discontinued.

Approximately 2 months after your visit, you will receive a packet of short questionnaires about your infant's language and social development. This should be completed by a primary caregiver, and returned by mail (self-address, stamped envelope provided).

III. Risks

There are no apparent risks to your infant or to yourself for participation in this study. Sound levels for all auditory stimuli will be verified prior to the testing of each infant.

IV. Benefits

Although there are no direct benefits to the participants in this study, your baby's participation benefits the field of infant language and social development, and will help us better understand the development of infants' attention to the language acquisition.

V. Extent of Anonymity and Confidentiality

All of the information gathered in this study will be kept confidential and the results will not be released without your consent. The information that your baby provides will be identified by a session number only, not a name. Your informed consent will be kept separate from your infant’s information. The results of this study may be presented at scientific meetings, and/or published in a scientific journal. If you would like, you will be sent a summary of this work when this project is completed. All digital recordings

of the sessions will be destroyed 5 years after the completion of this study.

VI. Freedom to Withdraw

You have the right to terminate your infant’s involvement at any point in time and for any reason should you choose to do so.

VII. Approval of Research

This project has been approved by the Human Subjects Committee of the Department of Psychology and the Institutional Review Board of Virginia Tech.

VIII. Participant’s Responsibilities

I voluntarily agree to have my infant participate in this study

IX. Subject’s Permission

I have read and understand the informed consent and conditions of this project. I have been given an opportunity to ask further questions about this procedure and I understand I have the right to end this session for any reason if I so choose. If I have any questions regarding this research and its conduct, I should contact one of the persons named below. Given these procedures and conditions, I give permission to Dr. Panneton, and her undergraduate students, and their co-workers to use their measurements of my infant’s visual attention in their research.

- Dr. Robin Panneton, Principle Investigator 231-5938
- Dr. David Harrison, Chair, Human Subjects Committee 231-4422
- Qiong (Joy) Wu, M.S. 231-9174
- David M. Moore, DVM, Assistant Vice Provost for Research Compliance 231-4991

Signature of Parent: _____

Date: _____

Name of infant: _____

I would like to be contacted by phone regarding future studies: Yes No

Appendix G

Vineland Adaptive Behavior Scales-II Parent/Caregiver Rating Forms Communication Subscale

Sparrow, S.S., Balla, D.A., & Cicchetti, D. (2005). Vineland Adaptive Behavior Scales (Vineland-II). Pearson Assessments, Bloomington, MN.