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The Effects of Socio-Economic Status on Infant Attention

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The development of visual attention is a key component of cognitive functioning in infancy and childhood. By the time children in poverty reach school, deficits in attention are readily apparent; however, when these attention delays manifest is unknown. The current study tested attention longitudinally at 6, 9 and 12 months in infants from high-socio-economic status (SES) and low-SES families. Infants were tested in a free play attention task in both simple and complex conditions, and two measures each of attention and inattention were scored. High-SES infants showed greater attention overall and greater increases in attention when the stimuli were more complex. Low-SES infants showed higher inattention than their high-SES peers at all ages and were less likely to modulate their attention on the basis of stimulus complexity. Thus, by 6 months of age, low-income infants already show deficits in attention. Results are discussed in terms of adaptability, implications for social development and attention interventions.

Key words: attention; infancy; poverty; SES

Attention allows for selective focus on the environment and facilitates learning and active information intake (e.g. Ruff, Lawson, Parrinello, & Weissberg, 1990; Ruff & Rothbart, 1996). Attention is a fundamental building block from which learning, cognition and socio-emotional functioning can develop. Attention is also predictive of future academic success, and problems with attention are predictive of specific deficits in some high-risk populations (Duncan et al., 2007; Horn & Packard, 1985; NICHD, 2003). In particular, children growing up in poverty show deficits in school achievement that have been linked to attention (e.g. Howse, Lange, Farran, & Boyles, 2003; Smith, Brooks-Gunn, & Klebanov, 1997), but little is known about when these problems begin. The current study seeks to identify and track the onset of attention delays in low-socio-economic status (SES) infants.

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Even by age 2, poverty is negatively associated with cognitive functioning (e.g. Klebanov, Brooks-Gunn, McCarton, & McCormick, 1998). Two-year-old children living below the poverty line score lower than high-SES children on the Bayley Scales of Infant Development (Smith et al., 1997). This correlation remains stable, as family income is a powerful predictor of IQ at age 5 (Duncan, Brooks-Gunn, & Klebanov, 1994). The longer the duration of children's exposure to poverty, the lower their scores on vocabulary, reading recognition and mathematics assessments (Smith et al., 1997).

Though low-SES children perform worse overall than their high-SES peers on a battery of cognitive tests, the cognitive deficits are not uniform across neuro-cognitive systems. Low-SES children show specific deficits in cognitive control and working memory (Farah et al., 2006; Noble, McCandliss, & Farah, 2007). Cognitive control, or the ability to filter distractors and focus selectively, is a key component of attention. Indeed, in kindergarten, economically at-risk children show deficiencies not only in the attainment of attentional states but also in the maintenance of attention (Howse et al., 2003).

Event-related brain potential data indicate that there may be processing differences in high-SES versus low-SES children's selective attention (D'Angiulli, Herdman, Stapells, & Hertzman, 2008; Stevens, Lauinger, & Neville, 2009). D'Angiulli et al. (2008) presented high-SES and low-SES children in sixth through ninth grade with an auditory selective attention task in which participants were instructed to attend to two types of tones (the relevant information) while ignoring two other tones (the irrelevant information). Both groups performed similarly on accuracies and false alarms; however, event-related brain potential data showed that the low-SES children attended to irrelevant information significantly more than the high-SES children (D'Angiulli et al., 2008). Similar results were reported for 3- to 8-year-old children in a similar task (Stevens et al., 2009). Both studies suggested that higher-SES children may use early selection when filtering distractors, meaning that they filter the irrelevant stimuli at the sensory level rather than later in auditory information processing. Low-SES children, on the other hand, may not filter irrelevant stimuli early in mental processing but instead use late selection, a process that requires more cognitive exertion and resources.

Although the negative effects of poverty on attention in school aged children are well known, research regarding attention is limited to studies of children age 3 and older (Stevens et al., 2009). Therefore, it is possible that attention differences arise even earlier than has previously been studied. Here, we investigate attention in high-SES and low-SES infants across the first year of life.

The development of attention is well documented (e.g. Colombo, 2001; Oakes & Tellinghuisen, 1994; Ruff, 1986). According to Colombo (2001), there are four key components of infant attention that develop at different rates over the first year of life. The first component is state of alertness, which increases gradually over the first 12 weeks with increased regulation of waking and sleep cycles (Berg & Berg, 1979). The second component is spatial orienting (the 'where' system), which involves the ability to engage, disengage and switch focus of attention as well as visually follow a target smoothly. The development of this system is well established by 6 months (Colombo, 2001). Third, attention to the features of an object involves processes that lead to object recognition and identification (the 'what' system). For example, infants can perceive colour, pattern and form in a multidimensional compound at 3 to 5 months (Bushnell & Roder, 1985; Dannemiller & Braun, 1988; Mundy, 1988). The final component of infant attention is the development of endogenous control, or the will to focus on something and sustain attention while simultaneously inhibiting attention to irrelevant stimuli. This kind of control becomes stronger and cohesive

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around 3–6 months of age. Early organization of these states is important because it relates to later cognitive functioning in infancy (Colombo, Moss, & Horowitz, 1989; Moss, Colombo, Mitchell, & Horowitz, 1988). These four components of attention allow infants to concentrate and acquire knowledge regarding the objects and people in their environment.

Infants demonstrate attention to objects in their environment very early in life (Ruff, 1986). Patterns of infant attention and inattention to objects have been measured extensively using free play tasks because they allow infants to interact independently and spontaneously with toys (e.g. Ruff, 1986; Ruff et al., 1990; Ruff & Capozzoli, 2003; Ruff, Capozzoli, & Saltarelli, 1996; Lawson & Ruff, 2004a, 2004b). How long infants spend closely concentrating and examining toys is indicative of information uptake and active learning (Ruff, 1986). The amount of time infants spend distracted and unfocused is indicative of inattention, which is linked to later attention deficits (Ruff et al., 1990).

Infants as young as 7–10 months are able to focus intently and ignore distractions (Ruff et al., 1996; Oakes & Tellinghuisen, 1994). When engaged in focused attention, 10-month-old infants were less distractible than when casually attending to objects (Ruff et al., 1996). In a related study, 7- and 10-month-old infants were less likely to be distracted by a video screen when actively examining a toy than when engaged in non-examining behaviour (Oakes & Tellinghuisen, 1994). This effect was evident in infants at least through 3.5 years of age (Ruff & Capozzoli, 2003).

Focused attention is stable throughout infancy and up to 5 years of age (e.g. Lawson & Ruff, 2004a, 2004b). Many studies have reported that early visual fixation on objects is predictive of later attention (e.g. Kannass, Oakes, & Shaddy, 2006; Ruff et al., 1990; Tamis-LeMonda & Bornstein, 1993), exploratory competence (Tamis-LeMonda & Bornstein, 1993) and language use (Kannass & Oakes, 2008). Visual attention to objects is even predictive for at-risk infants. For example, in a longitudinal study of premature, at-risk infants, measures of inattention at 1 year were predictive of hyperactivity and maternal ratings of behaviour at 3.5 years (Ruff et al., 1990). Thus, visual attention as measured through free play tasks is an excellent predictor of later attention.

During the typical free play attention task, attention is measured by how long infants spend examining the toy, and inattention is measured as the time spent not examining the toy. But because infants participate in this task with a parent, infants have the option of looking at that parent instead of the toy. Although this looking is not classic focused attention, we believe that it does reflect a kind of attentional control and is therefore worth measuring. Indeed, infant attention to faces dramatically increases between 3 and 9 months of age (Frank, Vul, & Johnson, 2009). At 3 months, infants' gazes scatter across a display of images, but by 6 and 9 months, attention to faces becomes more narrowly focused. One possible explanation for this shift is that infants become increasingly aware of the socially relevant information available through faces and have a higher motivation to attend to those stimuli. Another factor in increased attention to faces may be the development of the mechanism governing attentional control. It is possible that younger infants also prefer faces but lack the attentional control to attend to them while simultaneously suppressing distracting stimuli (Frank et al., 2009). The ability to filter relevant information and disregard interfering stimuli is a necessary skill for the development of selective attention (Amso & Johnson, 2006).

Comparisons between the frequencies of attention to faces versus objects have been mixed. Infants look at faces more frequently than objects in a complex display depicting both faces and objects (Gliga, Elsabbagh, Andravizou, & Johnson, 2009) and when the faces are dynamic compared with static displays (Courage, Reynolds,

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& Richards, 2006). However, many studies provide evidence of greater visual attention to objects (Ellsworth, Muir & Hains, 1993; Field, 1979; Klein & Jennings, 1979). In these cases, attention to objects was more prevalent even though the infants showed greater communicative behaviour for people than objects (Ellsworth et al., 1993) and experienced elevated heart rate while visually attending to their mother (Field, 1979). But if attentional control reflects basic cognitive processing, then attention to faces in infancy may also be impacted by poverty.

The purpose of the present study was to investigate early attention and inattention in both low and high income infants. We longitudinally tracked high-SES and low-SES infants at 6, 9 and 12 months of age, and measured their attention to objects and people. We predicted that low-SES infants would show lower levels of focused attention and higher levels of inattention to toys compared with their high-SES peers and that these differences would be stable over time. We further predicted that low-SES infants would show lower levels of attention to people than high-SES infants.

METHODS

Participants

Thirty-two infants with a mean age of 6.29 months at the first visit, 9.16 months at the second visit and 12.15 months at the third visit participated. Seventeen of the infants (8 males and 9 females) came from families of middle SES to high SES and 15 (10 males and 5 females) from families of low SES. Of the high-SES group, 14 infants were Caucasian and 3 Hispanic. The low-SES cohort included 10 Caucasian infants and 5 Hispanic infants. Two low-SES infants missed the 12-month session, but there was no other attrition. Socio-economic status was evaluated using maternal education as a proxy for SES, with some college or more (meaning 2 years or more) designating high SES and less than 1 year of college designating low SES (Noble et al., 2007; Stevens et al., 2009). This proxy was used because parents generally report their education levels more accurately than income and because maternal education is strongly correlated with both income and SES (Noble et al., 2007; Stevens et al., 2009). To confirm SES, the caregivers were also asked to complete a needs assessment survey, rating their ability to meet the family's financial needs, including rent, food and health care. Participants were recruited from newspaper ads recruiting 6-month-old infants (with no mention of SES in the ad), local programmes for mothers and families, flyers and a programme run by the Washington State Migrant Council. Families were compensated with gift cards and books.

Apparatus

For the one-toy condition, the same toy was used for every trial: a commercially bought colourful rattle with interesting shapes and features. In the six-toy condition, experimenters chose randomly from eight commercially available toys of varying shapes, colours and textures, including teething rings, small stuffed animals and rattles. A digital JVC hard disk camcorder (by JVC Kenwood Group, Kanagawa Japan), model GZ-MG130, was used to record the infants' behaviour.

Procedure

Observations were made during home visits (29 infants) or visits to the lab (by parent request; three infants: two high SES and one low SES). There were no differences

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between the data from these participants and those tested in the home. During the experiment, the infant was seated on the caregiver's lap at a table while the experimenter sat kitty-corner to the dyad. A second researcher was present to record the session and time each task.

The tasks exactly followed the free play tasks in Ruff's studies on infant attention (Ruff et al., 1990). In the first task, the infant was presented with a single toy and given 2 min to examine and play with the toy. If the infant dropped or threw the toy, it was picked up and returned to the table. After a few seconds break between tasks, six toys were presented simultaneously for another 2 min. This time, if toys were dropped or thrown, they were not picked up unless there were no toys remaining. The order of the task was always the same (with the single toy presented before the six-toy condition). Mothers were instructed to allow their infant to interact with the toy freely and to talk to their infant if desired.

Dependent Measures

All data were coded using recordings of the sessions. There were two measures of attention (focused attention to toys and attention to people) and two measures of inattention (quiet disengagement and inattention), all measured in seconds. Focused attention to toys was taken directly from Ruff et al. (1990), defined as the duration of visual attention towards the toy, including intent facial expressions and examining behaviour. Attention to people was adapted from the aforementioned definition of attention to toys and was designed to capture the number of seconds that infants were not engaging in focused attention but were focused instead on the people in the room. Thus, we defined attention to people as visual focus towards a person (mother or experimenter), often including a serious facial expression or smiling on the part of the infant. The first measure of inattention, called quiet disengagement, was defined as the duration of time an infant spent physically touching the toy, but not looking at it or otherwise exploring it. The infant could have been looking anywhere in the room. This measure reflects time that the infant was looking off task but still potentially taking in some information about the toy through touch. Because infants do explore objects haptically as a sort of information intake (e.g. Ruff, 1984), this seemed importantly different than inattention. The final measure, inattention, was adapted from Ruff et al. (1990), and was defined as time spent looking off task and not touching the toy.

All sessions were coded by a single researcher, and a second coder, blind to the hypotheses, coded 20% of the data (seven infants were randomly selected for each age tested, and reliability was calculated across both conditions, for an $n = 42$). The coders were highly reliable ($r = 0.999$ for focused attention, $r = 0.999$ for attention to people, $r = 0.999$ for quiet disengagement and $r = 0.999$ for inattention, respectively, all $ps < .001$; the percentage of scores within 1 s of each other was 72.73%, 86.36%, 84.09% and 88.64% for focused attention to toys, attention to people, quiet disengagement and inattention, respectively).

RESULTS

The data were analysed with a series of 3-way repeated measures ANOVAs. The independent variables were SES (high or low), condition (one and six toys) and age (6, 9, and 12 months). The dependent variables were time (in seconds) engaging in focused attention, attention to people, quiet disengagement and inattention.

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For focused attention, there was a significant 3-way interaction (F(2, 58) = 4.073, $p < .05$, $\eta^2 = .042$; Figure 1). At 6 and 9 months, both high-SES and low-SES infants showed more focused attention in the six-toy condition compared with the one-toy condition. However, at 12 months, only the high-SES infants look longer at six toys ($t(16) = 6.61$, $p < .01$), whereas there are no condition differences for the low-SES 12-month-olds ($t(13) = 1.46$, n.s.). There were also significant main effects for SES ($F(1, 29) = 6.244$, $p < .05$, $\eta^2 = .215$, with high-SES infants looking longer overall than low-SES infants), for condition ($F(1, 29) = 76.51$, $p < .001$, $\eta^2 = .536$, with infants looking more at six toys than one) and a significant effect of age ($F(2, 29) = 4.52$, $p < .05$, $\eta^2 = .098$, with infants looking more over time).

We ran an additional set of analyses to explore the trajectory of focused attention separate by condition (one toy or six toys). To test this, we ran an additional series of 2 (SES) × 3 (age) repeated measures ANOVAs on each condition separately, which did indeed reveal different developmental trajectories. In the one-toy condition, there

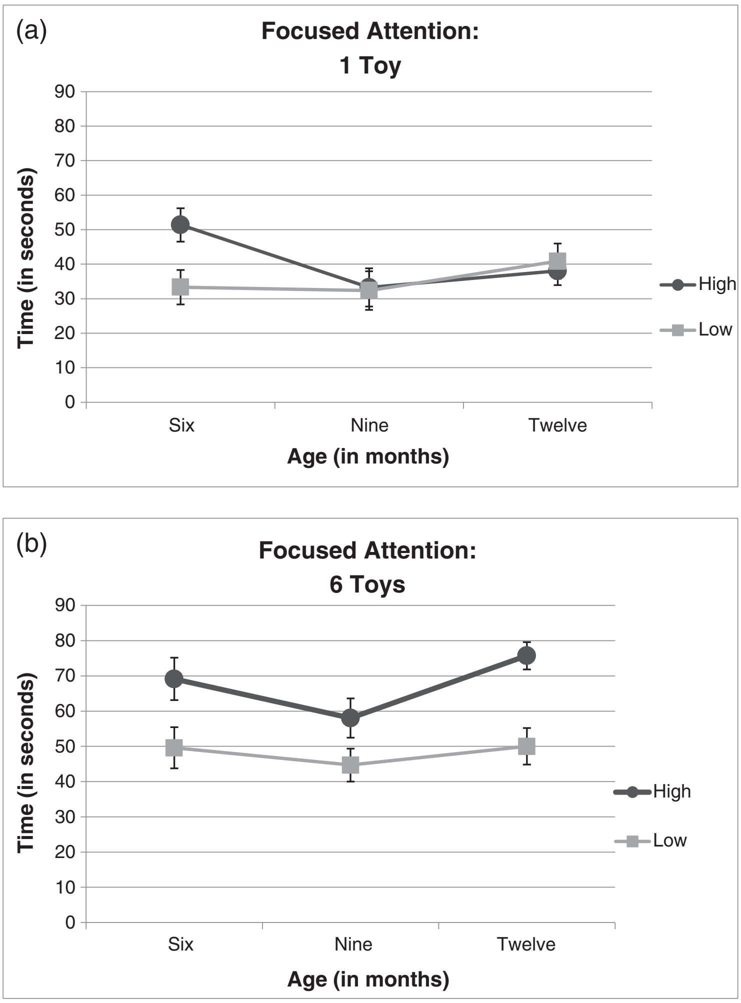

Figure 1. Attention to toys by high-socio-economic status and low-socio-economic status infants in the one-toy (a) and six-toy (b) conditions.

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was a significant interaction, $F(2, 2) = 4.29$, $p < .01$, $\eta^2 = .089$. The high-SES infants decreased their focused attention between 6 and 9 months, and it remained low at 12 months. In contrast, the low-SES infants showed no change at all across sessions. In the six-toy condition, there was a main effect of SES ($F(1, 29) = 13.67$, $p < .001$, $\eta^2 = .471$), with high-SES infants showing more focused attention, and a main effect of age ($F(2, 29) = 3.41$, $p < .05$, $\eta^2 = .115$), with focused attention increasing over time but no significant interaction ($F(2, 2) = .937$, $p = .39$, $\eta^2 = .032$).

For attention to people, there was a significant condition × SES interaction ($F(1, 29) = 7.12$, $p < .05$, $\eta^2 = 001$; Figure 2). In the six-toy condition, there were no SES differences in attention to people, $t(30) = 0.56$, n.s.; however, in the one-toy condition, high-SES infants looked significantly longer at people than low-SES infants, $t(30) = 12.24$, $p < .05$. There were also main effects for age ($F(2, 29) = 2.165$, $p < .001$, $\eta^2 = .264$) and condition ($F(1, 29) = 133.81$, $p < .001$, $\eta^2 = .748$). Again, we ran an additional series of 2 (SES) × 3 (age) repeated measures ANOVAs on each condition separately, which revealed similar developmental trajectories. The analysis of the one-toy condition attention to people showed a main effect of age ($F(2, 29) = 8.94$,

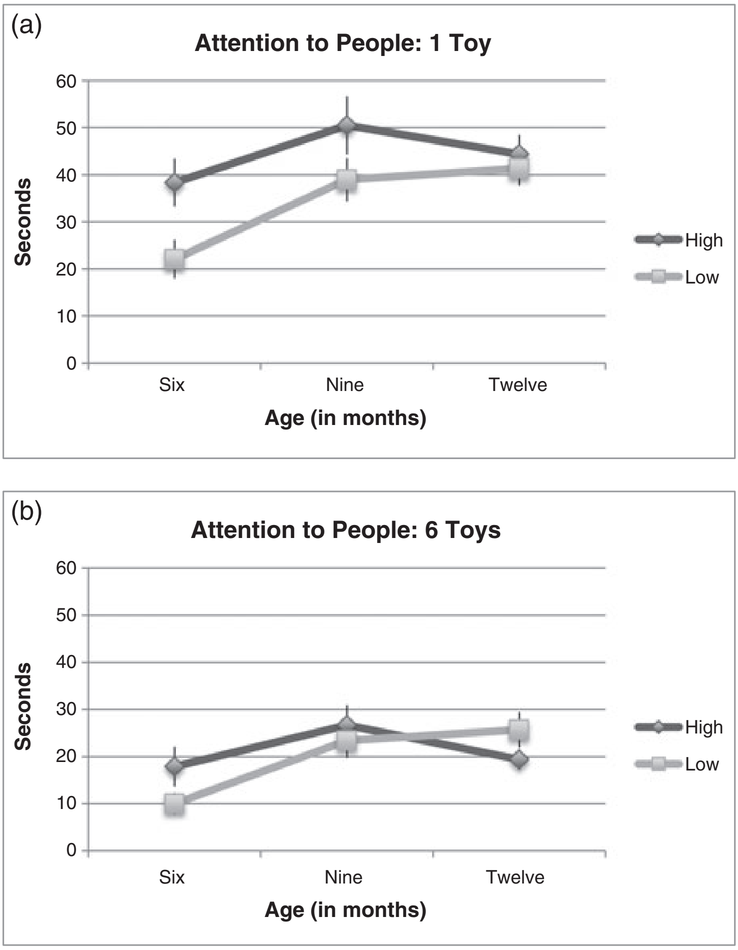

Figure 2. Infant attention to people by high-socio-economic status and low-socio-economic status infants in the one-toy (a) and six-toy (b) conditions.

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$p < .001$, $\eta^2 = .226$), with infants looking less at 6 months compared with at 9 and 12 months. That same pattern was found in the six-toy condition, ($F(2, 29) = 7.51$, $p < .01$, $\eta^2 = .251$). In addition, there was a marginally significant main effect of SES in the one-toy condition ($F(1, 29) = 4.14$, $p = .05$, $\eta^2 = .143$), with high-SES infants looking longer than low-SES infants. This was not found in the six-toy condition ($F(2, 29) = .21$, $p = .65$, $\eta^2 = .007$).

For quiet disengagement, there was again a 3-way interaction (F(2, 58) = 4.39, p < .05, $\eta^2 = .077$; Figure 3). For the low-SES infants, quiet disengagement to toys remained stable across both conditions at all ages tested. In contrast, for the high-SES infants, at 6 months, there were no differences between conditions, but at 9 and 12 months, the high-SES infants showed significantly more quiet disengagement in the one-toy condition than in the six-toy condition (9 months: t(16) = 18.35, p < .005; 12 months: t(16) = 48.93, p < .001). This was confirmed by a 2(SES) × 3 (age) repeated measures ANOVA on each condition. In the one-toy condition, there was a significant interaction ($F(2, 29) = 5.14$, $p < .01$, $\eta^2 = .124$), with high-SES infants showing more quiet disengagement

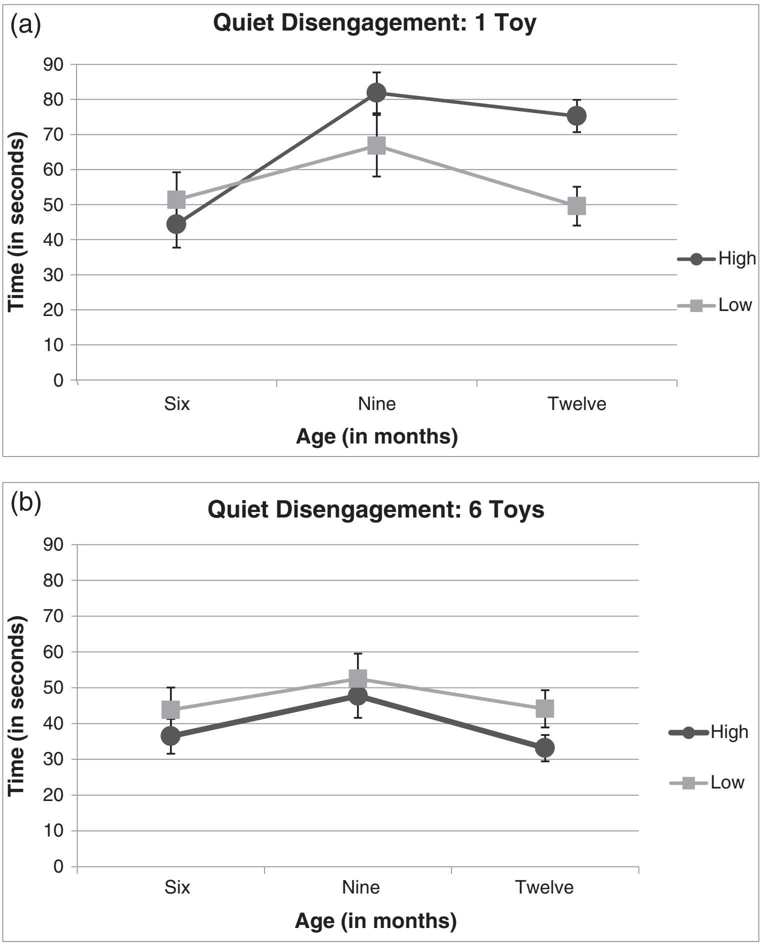

Figure 3. Quiet disengagement by high-socio-economic status and low-socio-economic status infants in the one-toy (a) and six-toy (b) conditions.

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at 9 and 12 months. There were no significant effects or interaction in the six-toy condition.

For the final measure, inattention, there was a main effect of SES, with low-SES infants showing significantly higher inattention at all ages and in both the one-toy and six-toy conditions compared with the high-SES infants (F(1, 29) = 8.89, p < .01, $\eta^2 = .306$; Figure 4). There were no other effects or interactions. Again, we ran separate ANOVAs by condition and found a main effect for SES in both the one-toy condition ($F(1, 29) = 6.23$, $p < .05$, $\eta^2 = .215$) and the six-toy condition ($F(1, 29) = 5.22$, $p < .05$, $\eta^2 = .180$), with low-SES infants showing more inattention than high-SES infants. There was also a main effect of age in the one-toy condition only ($F(2, 29) = 6.62$, $p < .01$, $\eta^2 = .201$), with significantly more inattention at 6 months.

DISCUSSION

We hypothesized that low-SES infants would show lower levels of focused attention to both toys and people and higher levels of total inattention compared with

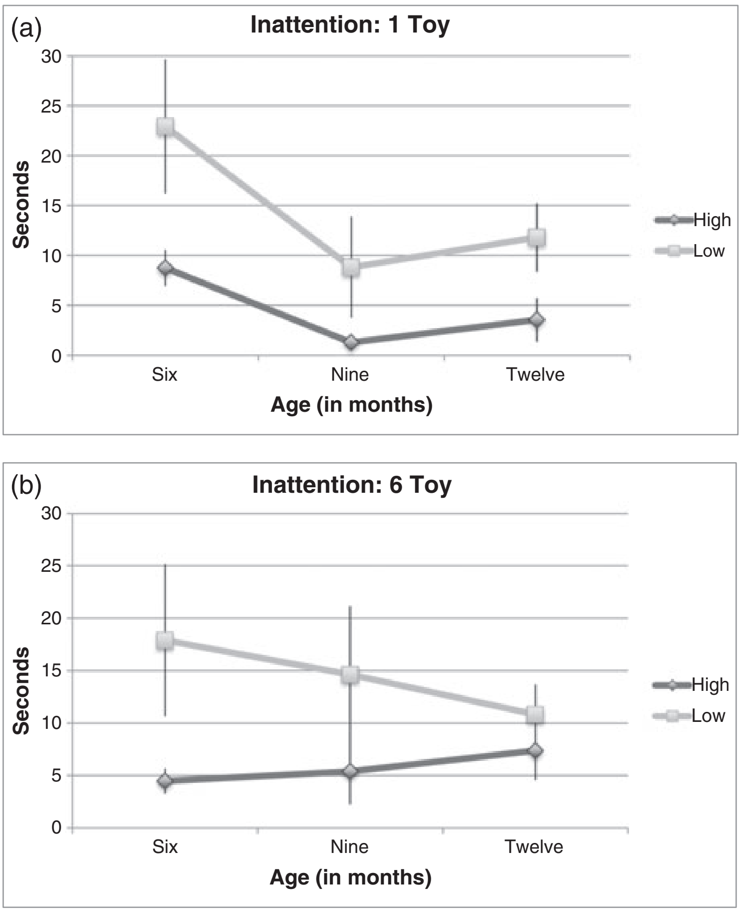

Figure 4. Inattention by high-socio-economic status and low-socio-economic status infants in the one-toy (a) and six-toy (b) conditions.

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their high-SES peers. The findings largely supported the hypotheses. The high-SES infants engaged in more focused attention in both conditions and showed longer focused attention as the stimulus complexity increased (comparing the one-toy condition to the six-toy condition). The developmental trajectory of focused attention shown by the high-SES infants matches the literature on attention trajectories quite well (e.g. Colombo, 2004; Colombo et al., 2004). Over the course of the first year, these infants' look durations for the simpler stimulus decreased, reflecting improved efficiency of information processing (Colombo, 2004). And in the more complex condition, these infants showed more focused attention, perhaps reflecting their ability to disengage from one object and attend to another, a sign of increasing maturity (Frick, Colombo, & Saxon, 1999). If they did this multiple times for each of the multiple objects, this would result in higher overall looking. In contrast, the low-SES infants showed no change in focused attention over time and no difference based on stimulus complexity, remaining low across all 6 months.

For attention to people, there were no differences between groups during the six-toy condition, but in the one-toy condition, the high-SES infants showed greater attention to people than their low-SES peers. Both the high-SES and low-SES infants looked more at people in the one-toy condition compared with the six-toy condition. This is consistent with previous research on infants' preferences for static versus dynamic displays, where infants generally look longer at a dynamic display (such as the live person in the present study; e.g. Courage et al., 2006). Low-SES infants also showed significantly higher total inattention than high-SES infants at all three ages and conditions. The one finding contrary to our hypothesis was for quiet disengagement. For the low-SES infants, quiet disengagement remained stable, but the high-SES infants modulated their behaviour on the basis of the stimulus complexity.

The most striking finding is that low-SES infants performed consistently worse at 6 months than their high-SES peers in every measure of attention and inattention. Detecting these early differences is critical, because it has already been established that inattention at 1 year is predictive of attentional behaviour and hyperactivity at 3.5 years (Ruff et al., 1990). Moreover, attention-related skills in childhood are predictive of school readiness (Duncan et al., 2007; Horn & Packard, 1985) and test scores and grades in early elementary school (Alexander, Entwisle, & Dauber, 1993). As children move into higher grade levels, attention is an important determinant of success, and inattention mediates the relationship between behavioural problems in school and academic achievement (Barriga, Doran, Newell, Morrison, Barbetti, & Dean Robbins, 2002). The present results indicate that the origins of these school-related attention problems begin much earlier than previously thought.

In addition to showing significantly less attention, the low-SES infants also showed an inability to modulate their attention on the basis of the visual complexity of the stimuli. It is well established that infants preferentially attend to complex stimuli more than simple stimuli (e.g. Brennan, Ames, & Moore, 1966; Greenberg, 1971; Martin, 1975; Richards, 2010). Although much of the research has used visual displays to assess infant preferences, researchers have also used different numbers of toys as varying levels of complexity (Hunter, Ames, & Koopman, 1983). In the current study, the one-toy condition provided limited visual stimulation, whereas the six-toy condition provided much greater visual complexity and interest.

Indeed, high-SES infants increased attention to whichever stimulus offered more visual complexity; they attended more to people in the one-toy condition and more to toys in the six-toy condition. By 9 months, the single toy condition was not as interesting to the high-SES infants, although attention to the six toys remained high. Although we can surmise that a live dynamic face is more stimulating than a single toy (Courage et al., 2006), we cannot be certain about the complexity

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comparison between six toys and a single dynamic face. It is certainly possible that social interaction may trump interest in objects, and this competition may change over time. However, on the basis of the pattern of the results, it appears that infants focused their attention on the toys when there were six of them, but when there was only one toy, they spent more time looking at the dynamic face. In contrast, the low-SES infants did not vary their attention to toys in the two conditions as much as the high-SES infants and did not display as much attention to people in the one-toy condition, suggesting that the low-SES infants remain engaged with the single toy or were unable to adjust their focus to observe the complex faces.

For quiet disengagement, the low-SES infants treated the one toy and six toys equally, indicating a lack of differential attention to varying levels of stimulation. In contrast, the high-SES infants engaged in more quiet disengagement at 9 and 12 months in the one-toy condition. This could be because a single static toy does not provide enough stimulation, especially when there is an option to look at a dynamic face. These findings provide further evidence that stimulus complexity influences attentional behaviour. The ability to regulate information intake in the presence of complex stimuli may provide more opportunities for learning and interaction with the environment. Low-SES infants already show differences in this skill by 6 months, indicating that they may struggle to adjust attentional focus to the demands of a changing environment.

Finally, the decreased attention to people displayed by low-SES infants in the current study may signal a delay in early social learning in infants in poverty. General attention in infancy is associated with positive emotionality and positive affect (Wilson & Matheny, 1983; Sheese, Voelker, Posner, & Rothbart, 2009), and inattention with negative emotionality (Kockanska, Coy, Tjebkes, & Husarek, 1998). Attention to faces in particular is connected with the development of emotions. For example, infants who were better able to attend to and follow their mother's gaze at 6 months showed better self-directed emotion regulation (Morales, Mundy, Crowson, Neal, & Delgado, 2005). Attention to faces also allows children to understand the mental processes of others, which predicts the development of theory of mind (Wellman, Lopez-Duran, LaBounty, & Hamilton, 2008; Wellman, Phillips, Dunphy-Lelii, & LaLonde, 2004). Thus, the decreased attention to people by the low-SES infants in the present study may set them up for later negative affect, poor emotional regulation and a weakened understanding of the intentions and feelings of others.

The present results do not identify a mechanism underlying the reduced attention in low-SES infants. However, we speculate that a primary mechanism is nutrition, both pre-natal and post-natal under-nutrition. Maternal education (our primary measure of SES) has been linked to nutrition choices for children. Less educated mothers are less likely to use family money to promote good nutrition in their babies and are less likely to be involved in decisions about how to allocate those resources (Wachs, 2008). Children in poverty are therefore more likely to experience malnutrition, which is associated with cognitive deficits (e.g. Wachs, 1995). Malnutrition and under-nutrition lead to long-term alterations in the cerebral cortex, a region closely connected with cognitive functioning (Levitsky & Strupp, 1995). Additionally, malnutrition causes deficits in specific micronutrients that aid brain development. One of the most important of these is iron, which, when lacking, leads to decreased attention, learning and memory (e.g. Evans, 1985; Pollitt, Leibel, & Greenfield, 1983; Soewondo, Husaini, & Pollitt, 1989; Yehuda & Youdim, 1989). Tanner and Finn-Stevenson (2002) further found that protein deficiencies cause lethargy, emotional unresponsiveness and decreased motor skills, which could contribute to decreased exploration and attention. Insufficient levels of calcium and copper result in lower

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activity levels and decreased symbolic play, and vitamin B deficiencies result in decreased vocalization and difficult maternal–infant behaviour and interactions (Tanner & Finn-Stevenson, 2002). These deficiencies can lead to snowball effects, as difficult maternal interactions can then lead to reduced interactions, which then provide poor infants with even fewer opportunities for learning. Given the finding that infants show reduced attention and increased inattention by 6 months, we believe further investigation into levels of micronutrients would be a good first step in identifying a physiological mechanism.

Limitations of the current study include a relatively small sample size. A larger sample would increase the statistical power and strengthen the conclusions. Additionally, it is possible that the results would show stronger differences if the assessment of SES status had been more precise. Although the same measure is commonly used in research of SES (e.g. Stevens et al., 2009), with only two categories, high and low, the potential for wide variability within the groups is high. Some families may have been close to the boundary line between high and low SES, whereas others may have been far in the periphery. In spite of these limitations, the fact that there were strong significant differences suggests that the differentiation between groups was strong enough to detect developmental variation related to SES.

The present study represents an important step in determining when the well-established attention delays associated with poverty emerge. Although the precise mechanism has yet to be determined, these results indicate that further studies on attentional mechanisms must begin early, in the first few months of life. These results also provide an impetus for developing early interventions for infants in low-income families. Although there are many effective interventions for attention (e.g. Rueda, Rothbart, McCandliss, Saccomanno, & Posner, 2005), they do not begin until pre-school at the earliest. Because attention is a key component of healthy socio-emotional and cognitive development, the design and application of interventions that specifically address attention in infancy may be an effective method of decreasing the SES gap in achievement.

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