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Attentional Predictors of 5-month-olds' Performance on a Looking A-not-B Task†

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Abstract

In the first year of life, the ability to search for hidden objects is an indicator of object permanence and, when multiple locations are involved, executive function (i.e. inhibition, cognitive flexibility and working memory). The current study was designed to examine attentional predictors of search in 5-month-old infants (as measured by the looking A-not-B task), and whether levels of maternal education moderated the effect of the predictors. Specifically, in a separate task, the infants were shown a unique puppet, and we measured the percentage of time attending to the puppet, as well as the length of the longest look (i.e., peak fixation) directed towards the puppet. Across the entire sample ($N=390$), the percentage of time attending to the puppet was positively related to performance on the visual A-not-B task. However, for infants whose mothers had not completed college, having a shorter peak looking time (after controlling for percentage of time) was also a predictor of visual A-not-B performance. The role of attention, peak fixation and maternal education in visual search is discussed.

Keywords

object permanence; looking A-not-B; sustained attention; peak fixation; low maternal education

The development of object permanence, defined as the knowledge that objects exist in time and space independent of our sensory experience of them, is a critical milestone in the emergence of representational thought. We take the perspective that the object permanence concept is linked directly to emerging executive function skills, and the purpose of this study is to determine the effect that different measures of attention have on object permanence, and thus executive function, at 5 months of age.

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Piaget (1954) operationalized the concept of object permanence as the ability to search for a fully hidden object and reported that the first instances typically appeared in stage IV of sensorimotor development (i.e. between 8 and 12 months of age). Even at this stage, the concept was fragile and prone to the A-not-B error (for reviews, see Harris, 1989; Marcovitch & Zelazo, 1999; Thelen, Schöner, Scheier & Smith, 2001; Wellman, Cross & Bartsch, 1986). Piaget's claims of a relatively late emerging object permanence concept have been called into question via several lines of research. In one notable paradigm, infants as young as 5 months of age have been reported to reach for objects after the room is darkened, demonstrating an understanding of the existence of objects independent of visual cues (Bower & Wishart, 1972; Clifton, Perris & McCall, 1999; Clifton, Rochat, Litovsky & Perris, 1991; Hood & Willatts, 1986; Shinskey & Munakata, 2003; Wishart, Bower & Dunkeld, 1978). Another influential demonstration was provided by Baillargeon, Spelke and Wasserman (1985) who reported longer looking times by 5-month-old infants when they witnessed violations of object permanence (i.e. a drawbridge obscured and then appeared to fall right through a solid block; but see Bogartz, Shinskey & Schilling, 2000, for an alternative explanation relying on perceptual features of the task). Finally, under certain perceptual conditions and often with training, 5-month-old infants (and younger) are found to anticipate the reemergence of an object that travels behind a screen (Bower, Broughton & Moore, 1971; Bremner et al., 2005; Johnson et al., 2003; Johnson & Shuwairi, 2009; Johnson, Slemmer & Amso, 2004; but see Moore, Borton & Darby, 1978 for an alternative explanation that relies on object identity and not object permanence).

We take the view espoused by Munakata (1998) that object permanence is tied to the development of executive function as they both require various levels of representational strength. Specifically, Munakata (1998; Munakata, McClelland, Johnson & Siegler, 1997) demonstrated using Parallel Distributed Processing (PDP) simulations how object permanence abilities is related to the strength of active representations, and further strengthening these representations leads to success in executive function tasks. This view is supported by the neural evidence that failures in object permanence can be traced to immaturity of, or deficits in, the prefrontal cortex (Diamond & Goldman-Rakic, 1989) – a region strongly associated with executive function throughout the lifespan (Anderson, Jacobs & Anderson, 2008).

Although the majority of executive function research in childhood focuses on conceptual shifts between 3 and 5 years of age (e.g. Zelazo, Müller, Frye & Marcovitch, 2003), an increased concentration on early or foundational executive function skills is emerging. As an example, consider the Piagetian A-not-B error, which was initially associated with failures in object permanence (Piaget, 1954). Contemporary theories have postulated that this error reflects shortcomings in executive functions such as working memory and inhibition (Diamond et al., 1994), the inability for current representations to override established habits (Marcovitch & Zelazo, 2009) or the failure to maintain attention towards the correct location after establishing a bias to the original location (Thelen et al., 2001). This classic paradigm has allowed us to assess emerging executive function skills as early as the first year of life.

One potential candidate for a task that may elicit object permanence and/or executive function skills in infants as young as 5 months is the looking A-not-B task (Bell, 2001,

2012). In this analogue to the reaching task, infants watch as an attractive toy is hidden under one of two buckets, and then after attention is brought back to the midline, they are encouraged to look for the toy. The critical measure is the location where the infant looks, as they are unable to reach. Importantly, Bell and Adams (1999) found no differences in search behaviour between the looking A-not-B task and the canonical reaching task in a sample of 8-month-old infants.

The looking task begins with only one bucket present, and early competence can be assessed as to whether infants look at the bucket – presumably, for the hidden toy – after attention is drawn away from the hiding scene. If the infants are successful, the task continues to an A-not-B task, which assesses a more complex understanding of the existence of hidden objects. Although it is not certain that this (or any other) task can capture true object permanence, it does allow us to probe behaviours that are precursors to the eventual knowledge that hidden objects continue to exist.

It is important to note that the looking A-not-B task has not commonly been used with infants under 8 months of age (but see Cuevas & Bell, 2010), and in this study, we argue that in 5-month-old children it is assessing elements of both object permanence and executive functions. In particular, some infants will not be able to locate a toy once it is hidden, perhaps indicating a lack of object permanence. Other infants will be able to find the toy under the first bucket, but not under the second bucket, indicating difficulty in inhibition and cognitive flexibility. Finally, some infants will be able to switch with no delay, but not when a delay is imposed, indicating difficulty with working memory.

It is well established in older infants that attention to the stimuli during the A-not-B task is required to be successful (Harris, 1973; Horobin & Acredolo, 1986; Keenan, 2002). We rationalized that information about an object – including its permanence – is processed by the infant primarily through attentional processes. The integration of attention and executive capabilities has best been described by the works of Posner, Rothbart and colleagues, particularly in their concepts of executive attention and effortful control (e.g. Posner & Rothbart, 2010, 2013; Rothbart, Sheese & Posner, 2007), and it stands to reason that attention is involved in the earliest instance of voluntary control. In the present study, we focus on two measures of attention: (a) The proportion of time attending to a unique or interesting stimulus; this has been linked to cognitive processes (Posner & Rothbart, 2007) and has been proposed to be a foundation for the development of executive function (Bell & Deater-Deckard, 2007; Garon, Bryson & Smith, 2008; Rothbart, Posner & Kieras, 2006). (b) The length of the longest look (i.e. peak fixation; Frick, Colombo & Saxon, 1999) to a unique stimulus, where brief looks have been linked to greater learning of the environment (Ruff & Rothbart, 1996). Shorter peak fixation times are thought to be indicative of advanced levels of attentional control, demonstrated by mastery over lower level components such as shifting and disengagement (Colombo, 2001, 2002).

The proportion of looking time and peak fixation are expected to be highly correlated, as the measures were assessed during the same task and the peak fixation contributes to the overall proportion of looking time. However, even when assessed independently, fixation time and attention to novel items have been shown previously to be related. For example, Pêcheux and

Lécuyer (1983) found a relation in 4-month-old infants between how long it took them to habituate to a particular item and the amount of time spent manually exploring a different item. This supports the notion that at this point in development, there is a relation between processing efficiency and attentional control, a relationship that may not hold at later points in development (see Colombo 2001, for a description on how the relation between looking times and attention shifts with age). Even though the measures are related, we predict that each measure will contribute uniquely to our understanding of the role of attention on cognitive processing.

We also took into account the roles of infant sex and maternal education. Sex differences benefitting girls are sometimes found in the first year of life in tasks involving inhibition (e.g. Diamond, 1985). Maternal education was included as a proxy for socio-economic status (e.g. D'Angiulli et al., 2008; Stevens, Lauinger & Neville, 2009). Not only does maternal education correlate with family income, but it has also been associated with performance on object permanence reaching tasks. For example, Clearfield and Niman (2012) found that infants with low maternal education lagged behind higher maternal education peers in normative reaching patterns on an object permanence task. Specifically, the infants with high maternal education tended to pass a reaching version of an A-not-B task universally by about 12 months of age, while the infants with low maternal education were still making errors at that age.

METHODS

Participants

The final sample consisted of 390 (200 girls) 5-month-old infants ($M_{age}=162.3$ days, $SD=7.8$, range: 141–204) who were participating in the first wave of a longitudinal study focused on the early indicators of executive function. An additional 20 infants (4.9%) were tested but excluded for not providing data on the looking A-not-B task ($n=9$) or the attention task ($n=11$). Participants were recruited from an examination of birth records, visits to Women, Infants, & Children (WIC) programs, mailing lists and advertising from two sites in the Southeast (Blacksburg, VA and Greensboro, NC). The final sample was 4% Hispanic, 81% Caucasian, 15% African American, 2% Asian America and 2% Other. Two per cent of mothers did not complete high school, while 63% held at least a college degree (for more information on maternal education, see Section on Analysis). Mothers' age at the time of birth was $M=29.3$ years (range: 14–42years).

Materials

For the looking A-not-B task, a testing table (90cm×60cm×75cm), brightly coloured plastic tubs (diameter: 17 cm; depth: 11 cm) and a variety of toys (e.g. toy train car and large plastic rooster) were used. For the attention task, a uniquely decorated glove puppet was used (Diaz & Bell, 2011).

Procedure

Parents filled out a demographic questionnaire in which, among other items, they self-reported on their education levels at the time of birth. The tasks in the current study were

presented as part of a large-scale battery, during which electrophysiology was also recorded but not reported here (Cuevas, Bell, Marcovitch & Calkins, 2012; Diaz & Bell, 2011; Morasch & Bell, 2012; Patriquin, Lorenzi, Scarpa & Bell, 2014). Our two tasks of interest, the looking A-not-B task (successfully used with infants as young as 5 months; Cuevas & Bell, 2010) and the attention task (intended to be the first phase of a visual paired comparison task; Diamond, Prevor, Callender & Druin, 1997), were presented late enough in the battery to ensure that infants were already acclimated to the experimental setup. The order of tasks was the same for all infants; the A-not-B task immediately preceded the attention task. For both of these tasks, the infant sat on the parent's lap 1.1 m from the experimenter. Parents were told what was about to happen but were encouraged not to point or communicate with the infant during the trial.

Looking A-not-B task—In the first phase of the looking A-not-B task, there were two trials where infants watched as the experimenter manipulated a toy and then hid the toy under a tub. The toy was attention grabbing and made noise (although not when hidden, e.g. small toy train, small red rooster), and the infants were not allowed to manipulate the toy prior to or during the task. The infants' gaze was then brought to midline by the experimenter snapping his or her fingers while calling the infants' name. When the gaze was at midline, the experimenter asked, 'Where is the toy?' The task was discontinued – and infants were given a score of zero (see scoring system later in the text) – if they failed to look at the tub on both trials.

If infants were successful on at least one of the one-bucket trials, the experimenter proceeded to the A-not-B portion of the task where the toy could now be hidden under one of two (17.5 cm on either side of midline) differently coloured tubs. The initial side of hiding was counterbalanced, and the same procedure of breaking the infants gaze, calling the infants' name and asking 'Where's the toy?' was employed directly after the hiding event. The direction of the infants' first eye movement after being brought to midline was scored as either correct or incorrect. Two consecutive successful trials resulted in the toy then being hidden under the opposite tub (e.g. Right-Right-Left), and hiding continued at this location until two consecutive correct trials, initiating another reversal (and so on). Note that if the infant did not look at either bucket (e.g. looked at parent and looked at the ceiling), then the trial was repeated.

Infants who were correct on two out of three reversal trials (i.e. the first trials after switching hiding locations) were then tested with a delay, in which the experimenter called the infants' name, counted out the delay period and then asked, 'Where's the toy?' Delay was incremented in 2-s intervals (following the same procedure as described earlier) until infants looked at the incorrect tub in two out of three reversal trials at any given delay, after which the task ended.

Attention task—The experimenter put on a unique eye-catching glove puppet and moved it to capture the infants' attention. Once infants were looking at the puppet, the experimenter held still until infants looked away (all 'looks' were at least 2 s in duration). Importantly, the puppet was always held a sufficient distance from the experimenter's face to ensure that looking at the experimenter's face was not mistakenly coded as looking at the puppet. This

was repeated until infants had accrued four individual looks at the puppet and with a delay of no less than 3 s between looks. Looking time was coded by a research assistant using Video Coding System software (James Long Company, Caroga Lake, NY, USA). Mean looking time across all four trials was 56 s ($SD = 24$ s; range: 24–187 s), and all infants in the final sample provided looking data on all four trials. Note that unlike Diamond et al. (1997), the infants did not manipulate the objects. This change was instituted so as to minimize artefact effects in the psychophysiological recordings (not reported in this study).

RESULTS

Scoring

Performance on all tasks is reported in Table 1. The scoring for each measure is described in the following:

Looking A-not-B—We employed a scoring procedure based on Bell and Adams (1999) that capitalizes on the developmental associations between object permanence skills and executive function and results in one continuous measure (see Table 2 for scoring codes).¹ To establish reliability, approximately 20% of the videotapes were coded by two raters (Cronbach's $\alpha = .99$).

The number of trials administered varied from infant to infant, with $M = 3$, and $SD = 2$ (range 1 to 19). As can be seen from Table 1, this scoring procedure yielded $M = 0.7$, and $SD = 1.0$, and the percentage of children who earned each score can be seen in Table 2.

Attention measures—We calculated two measures of attention: (a) the percentage of looking time that was spent focusing on the puppet over the entire task and (b) the length of the longest look that was recorded. The percentage of looking time could be thought of as a measure of sustained attention (i.e. attention to the focal item as opposed to other stimuli in the environment), while the longest look has been used as a measure of processing efficiency, with shorter looks representing more efficient information processing (e.g. Colombo & Mitchell, 1990; Frick et al., 1999).

Approximately 20% of the videos were coded by two raters (Cronbach's $\alpha = .95$). Given that the longest look contributed to the overall percentage of looking time, the two variables were expected to be correlated with each other, and they were $r(388) = .69$, $p < .001$.

However, we were interested in the potential unique contributions of each attention variable after controlling for the other.

Analysis

The analytic strategy was to use linear regression to predict the A-not-B looking score (logarithmically transformed to account for skew) from the percentage of looking time

¹One can reasonably argue that object permanence can be scored as present/absent, requiring a simpler scale that does not take delay into account. Yet, there are three reasons that we prefer this scoring system: (a) It is the standard scoring system that can allow for comparisons across studies. (b) Reasonable arguments can be made regarding gradations of object permanence understanding (e.g. Munakata, 1998; Piaget, 1954). (c) We acknowledge that our looking A-not-B task can also be seen as a measure of executive functions including working memory, rendering the scale very relevant.

(arcsine square root transformed to account for proportional data) and the longest look (logarithmically transformed to account for skew). As regression uses type III sum of squares, the impact of each predictor variable already controls for (i.e. partials out) the variability of the other predictors. We also included as predictors infant's sex (0 = *female*; 1 = *male*) and its interactions with the attention variables, and the level of maternal education (see Section on Methods for scoring; 0 = *did not complete high school*, $n = 8$; 1 = *complete high school*, $n = 107$; 2 = *complete technical college*, $n = 23$; 3 = *complete college*, $n = 163$; 4 = *complete graduate school*, $n = 84$) and its interactions with the attention variables. Note that for our sample, the level of maternal education was higher for mothers who identified as White ($M = 2.7$, $SD = 1.1$) as opposed to those who did not ($M = 2.0$, $SD = 1.3$), $t(383) = 4.4$, $p = .002$, Cohen's $d = 0.57$.

In all analyses, α was set to .05, and p -values between .05 and .10 were identified as marginally significant trends. For $n = 5$ infants, there was no report of the mother's level of education, and we used a 'hot deck' imputation to replace the scores (Myers, 2011). Note that, as expected, preliminary analyses that included exact age in days of infant as an additional predictor did not alter any of the results reported.

The results from the regression can be seen in Table 3. Notably, there was a significant effect of the proportion of looking time, $\beta = .562$, $t(388) = 2.42$, $p = .016$, a significant effect of the longest look $\beta = -.481$, $t(388) = -2.07$, $p = .039$, and a trend towards an interaction between levels of maternal education and the longest look, $\beta = .620$, $t(388) = 1.68$, $p = .095$. No other main effects or interactions approached significance.

As we were anticipating differential roles of maternal education, we conducted follow-up analyses to discover the nature of the marginal interaction between maternal education and longest looking time. We created two groups based on the level of maternal education: mothers who did not complete technical college or college ($n = 115$) and mothers who did complete technical college or college ($n = 275$). Given that there were no main effects or interactions involving infants' sex, those variables were removed from the follow-up regression. For infants whose mothers did not attain a higher degree, there was a significant effect of the proportion of looking time, $\beta = .427$, $t(112) = 2.31$, $p = .023$, and a marginal effect of the longest look, $\beta = -.349$, $t(112) = -1.89$, $p = .061$. In contrast, infants whose mothers did attain a higher degree only demonstrated a significant effect of the proportion of looking time, $\beta = .202$, $t(272) = 2.01$, $p = .045$, but no effect of the longest look, $\beta = -.036$, $t(272) = -.36$, $p = .716$.

DISCUSSION

In the current study, we examined the impact of two attention variables on 5-month-olds' performance on an early assessment of object permanence and executive function. When examining the full sample of 5-month-old infants, the novel finding emerged that focused attention is a predictor of locating an object after it is hidden from view. Specifically, the percentage of time infants are engaged with focal stimuli predicted performance on the looking A-not-B task. For infants whose mothers did not complete college or technical school, having a shorter peak fixation also predicted the ability to locate hidden objects.

There was also a main effect of peak fixation, but upon splitting the sample, it was revealed that this was due primarily to infants whose mothers did not complete college or technical school.

Contrary to a previous report, in this study the sex of the infant had no influence on performance on the looking A-not-B task. This may be due to the age of the infants or the fact that no reaching behaviour was involved, as sex differences have only been reported in slightly older infants in a reaching version of the A-not-B task (Diamond, 1985).

Why would focused attention be related to the ability to locate hidden objects? One possibility is that infants who can sustain focused attention are more likely to instantiate a viable memory trace (i.e. a representation) that is necessary for guiding behaviour towards a correct hiding location (Marcovitch & Zelazo, 2009). Munakata (1998) has argued that 'infants' knowledge of an object's location is not treated as a reified entity, disembodied from underlying processing mechanisms' (p. 164) and that both active memory traces (or conscious representations) and latent memory traces (outside of consciousness) of the object contribute to the infants' knowledge and influence behaviour on how to act on the object. In other words, focused attention allows infants to encode a host of information about the object (e.g. colour, shape and function of the object), and it is this process that embodies other pertinent information such as the object's location, even when hidden from view. Although the binding of an object's location to its features may not occur reliably until 7 months of age (Oakes, Messenger, Ross-Sheehy & Luck, 2009), there is evidence that features (e.g. colour) is encoded at younger ages (e.g. by 5 months, Catherwood, 1994), as well as location (e.g. by 5 months, Baillargeon et al., 1985). This is broadly consistent with other findings linking infant attention to cognitive abilities that draw upon flexibility and memory. For example, Taylor and Herbert (2013) found that memory, as assessed through delayed imitation, was stronger for infants who demonstrated more focused attention on the central acts (specifically, the person controlling the puppet) than on the background.

Note that even though infants are capable of storing information about objects' features and their location independently (i.e. they can store information about the colour of an object as well as its location), it appears that the binding of this information may not occur reliably until 7 months of age (Oakes, Messenger, Ross-Sheehy & Luck, 2009).

Would the relation between the proportion of looking time and performance on tasks that assess object permanence hold later in development, say for 9- to 12-month-olds? We are inclined to think that it would, drawing primarily from studies where attention was manipulated as part of the A-not-B task. In one study, Horobin and Acredolo (1986) found associations between attention and A-not-B performance on a standard reaching version at 9 months of age. Specifically, during the 3-s delay between hiding and searching, infants who attended to the B location were more likely to search there.

In another study, Watanabe, Forssman, Green, Bohlin and von Hofsten (2012) demonstrated that, on a looking A-not-B task, 10- and 12-month-old infants increased perseverative behaviour when additional attentional demand was required. Specifically, performance deteriorated when a distracting video of a bouncing ball was shown immediately after the

hiding event on B trials, implying that the distracting event compromised the attentional demands needed for this task. Notably, in both of these studies, the attention measure occurred within the context of the A-not-B task and likely had more to do with location and timing of attention (e.g. attention had to be at the right place at the right time) than the amount of attention. There has thus far been no demonstration that the amount of attention, as measured in an independent task, is associated with A-not-B performance in older infants and the question remains open for empirical investigation.

It is important to note that the A-not-B error is a demonstration of the fragility of the object permanence concept but does not necessarily imply that the concept itself is not present in the infant. Ahmed and Ruffman (1998) have demonstrated that 8- to 12-month-old infants who fail the standard A-not-B task actually demonstrate permanence knowledge by passing a looking version of the task (different from the one we present in this study). They interpret this as evidence that infants at this age have object permanence abilities, but their behaviour is constrained by their reaching experience (see Marcovitch & Zelazo, 2009, and Thelen et al., 2001, for similar arguments).

We had predicted that shorter peak fixation times (and thus greater processing efficiency) should be related to performance on the looking A-not-B task, but this was true only for the infants whose mothers did not complete college or technical school. This finding was unexpected and needs further investigation, especially given that it only was revealed as a trend. One possible explanation is that processing efficiency serves as a protective factor or a buffer for infants of low maternal education (Yates, Egeland & Sroufe, 2003). Under this explanation, an infant's ability to process visual information efficiently could overcome other delays or deficiencies often reported in infants of low maternal education. For example, mothers with low maternal education have infants who have delays with attention (Clearfield & Jedd, 2013), object exploration (Clearfield, Bailey, Jenne, Stanger & Tacke, 2014; Tacke, Bailey & Clearfield, 2015), cognitive flexibility (Clearfield & Niman, 2012; Lipina, Martelli, Vuelta & Colombo, 2005) and means-ends behaviour (Clearfield, Stanger & Jenne, 2015).

In contrast, infants with high maternal education may have more redundancy in their cognitive system. The notion of redundancy in the cognitive system comes from a theory of resilience for children in poverty (Yates et al., 2003), where development is described as a hierarchically integrative process where earlier patterns of adaptation impact later experiences. They posit that a child's history of consistent supportive care creates resilience, where minor perturbations can be absorbed. But children in poverty (a correlate of low maternal education) do not have those experiences, so they have no other cognitive resources to draw on in the face of perturbations. The increased redundancy for infants with high maternal education reduced the need for a direct connection between processing efficiency and performance.

Although we must be cautious in attributing a mechanism for visual processing differences by maternal education, we do believe that this research presents an important step in describing these differences. There is now a growing literature on the link between fewer years of maternal education, lower family income and early developmental delays in

developing cognitive systems (e.g. Clearfield & Niman, 2012; D'Angiulli et al., 2008; Noble et al., 2015, Stevens et al., 2009). Describing the landscape of differences must precede a search for a mechanism. That mechanism is likely to be quite complex, involving both prenatal and postnatal nutrition, stress and environment, to name just a few factors. But only when we understand the unique constellation of deficits and strengths in infants from low-SES families will we be able to search for an underlying mechanism and eventually, successful interventions.

There are a number of potential limitations to the current study. The scoring system for the looking A-not-B was developed for use with slightly older infants. It is possible that applying this scoring system to 5-month-olds might be inappropriate, perhaps dampening our interpretation of their level of understanding. It should be noted, however, that Cuevas and Bell (2010) used a similar scoring procedure previously with 5-month-old infants. In a related issue, it is possible that our stopping rule in the one-bucket trials of the looking A-not-B task was too strict. In our task, testing stopped and infants were given a score of zero if they failed to look at the single tub on both one-bucket trials. Perhaps if a more liberal stopping rule was used (e.g. looked at tub on two out of three trials), then more infants would have continued with the task and thus been credited with object permanence capabilities.

It is clear that for most infants, the looking A-not-B task was a measure of object permanence (i.e. the vast majority of infants could not search reliably for the object once it was hidden). As such, it is reasonable to conclude that for 5-month-old infants, this task is more appropriate for assessing object permanence, rather than cognitive flexibility. Although we believe the processes to be linked, and indeed flexibility may emerge from the concept of object permanence, we cannot rule out the possibility that the task does not measure flexibility, or any other component of executive function (EF), in 5-month-olds.

It may also be an issue that both attention measures were derived from the same task. Ideally, the peak fixation and percentage of looking times could be collected in a way that yielded independent estimates, but this was not possible in our design. That being said, we did control for their relation in our analyses.

In sum, we found that attention is related to emerging object permanence and cognitive flexibility skills at 5 months of age. In addition, infants whose mothers had less education demonstrated higher object permanence and cognitive flexibility skills when they had shorter peak fixation times, suggesting a protective mechanism from potential environmental stressors. In any case, the link between attentional skills and emerging cognitive flexibility needs to be investigated further, and integrated with contemporary frameworks of executive function used to explain changes in the preschool ages, which tend to be based on language skills.

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Table 1

Performance on study tasks

	Mean	SD	Range
Proportion of looking time	0.585	0.173	0.133 to 0.948
Peak fixation (in seconds)	11.99	10.68	1.53 to 76.08
Looking A-not-B score	0.7	1.0	0 to 7

Table 2

Scoring of looking A-not-B task

Score	Behaviour	% of infants
0	Does not look for toy with one bucket	58.5
1	Does not look for toy at A or B when two buckets are introduced	26.9
2	Many incorrect looks at B throughout first AA sequence	10.0
3	Made AB error (i.e. looks correctly at A during A trials but incorrectly at A during B trial) at 0 s delay	3.1
4	Success (i.e. both A and B trials) at 0 s delay	1.3
5	Success at 2 s delay	0.0
6	Success at 4 s delay	0.0
7	Success at 6 s delay	0.3

Table 3

Results from regression analysis on looking A-not-B performance

	<i>b</i>	<i>SE (b)</i>	β	<i>t</i>	<i>p</i>
Proportion of looking time (X1)	.902	.372	.562	2.423	.016
Peak fixation (X2)	-.472	.228	-.481	-2.067	.039
Maternal education (X3)	.011	.063	.042	0.173	.863
Sex (X4)	.105	.151	.175	0.697	.486
X1 by X3	-.146	.126	-.575	-1.162	.246
X1 by X4	-.263	.288	-.404	-.913	.362
X2 by X3	.127	.076	.620	1.676	.095
X2 by X4	.084	.176	.149	0.476	.634