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Comparing methods for measuring peak look duration: Are individual differences observed on screen-based tasks also found in more ecologically valid contexts?

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ABSTRACT

Convergent research points to the importance of studying the ontogenesis of sustained attention during the early years of life, but little research hitherto has compared and contrasted different techniques available for measuring sustained attention. Here, we compare methods that have been used to assess one parameter of sustained attention, namely infants' peak look duration to novel stimuli. Our focus was to assess whether individual differences in peak look duration are stable across different measurement techniques. In a single cohort of 42 typically developing 11-month-old infants we assessed peak look duration using six different measurement paradigms (four screen-based, two naturalistic). Zero-order correlations suggested that individual differences in peak look duration were stable across all four screen-based paradigms, but no correlations were found between peak look durations observed on the screen-based and the naturalistic paradigms. A factor analysis conducted on the dependent variable of peak look duration identified two factors. All four screen-based tasks loaded onto the first factor, but the two naturalistic tasks did not relate, and mapped onto a different factor. Our results question how individual differences observed on screen-based tasks manifest in more ecologically valid contexts.

1. Introduction

Research is increasingly suggesting that early-developing, domain-general aspects of attentional control may mediate subsequent skill acquisition in a variety of areas (e.g. Heckman, 2006; Karmiloff-Smith, 1998; Wass, Scerif, & Johnson, 2012). For example, aspects of domain-general attentional control have been shown to predict, on starting school, children's' subsequent learning on literacy and numeracy tasks (e.g. Welsh, Nix, Blair, Bierman, & Nelson, 2010). And research into the development of attentional control within clinical disorders suggests that early disruption to attentional control may play a key role in impairing early learning in social settings, for example during word learning, leading to subsequent catastrophic developmental cascades (e.g. Karmiloff-Smith, 1998). This suggests the importance of researching the ontogenesis of attentional control during the first few years of life.

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Cohen suggested that infant attention involves at least two different mechanisms: an attention-getting process which determines whether an individual will orient towards a stimulus presented in his periphery, and an attention-holding process which determines how long his attention will be maintained once he fixates (Cohen, 1972). This second phase, the attention-holding process, is commonly described as 'sustained attention' (Richards, 2011). However, although individual differences in attention are frequently reported in applied and developmental psychology, the terms used are rarely precisely defined and are conventionally assessed using a variety of methods.

Historically, the most widely used technique for measuring infants' looking behaviour involves presenting static stimuli using a slide projector or computer screen across a number of discrete but contiguous trials; the infant's viewing behaviour is coded either live by an experimenter viewing the infant on a video feed, or post hoc (Colombo & Mitchell, 2009). Two variables are typically derived: peak look duration, the duration of the longest unbroken look to the screen, and habituation rate, i.e. the rate of change of looks over time. Colombo and Mitchell argued in favour of peak look duration as the better metric of individual and developmental differences in visual attention during infancy because it is more reliable, and shows more robust relationships with long-term cognitive outcomes (Colombo & Mitchell, 1990).

Previous research has demonstrated that peak look duration to novel, static, screen-based stimuli show a U-shaped trajectory over the first year of life (Colombo & Mitchell, 2009; Colombo & Cheatham, 2006; Courage, Reynolds, & Richards, 2006). Research has also robustly demonstrated that peak look duration to novel stimuli during the first year of life relates negatively with long-term cognitive outcomes: shorter look duration during the first year is associated with better performance on later IQ and language measures (Colombo, 1993; McCall & Carriger, 1993; Tami-LeMonda & Bornstein, 1989) and recognition memory (Rose, Feldman, & Jankowski, 2003a, 2003b). Shorter looking is also associated with higher pre-existing knowledge bases and general arousal levels (de Barbaro, Chiba, & Deak, 2011; Dixon & Smith, 2008).

An alternative technique for assessing looking durations during infancy involves presenting dynamic stimuli on a computer screen (Courage et al., 2006; Shaddy & Colombo, 2004; see Richards, 2010 for a review). This work has generally used either TV clips (e.g. Richards & Anderson, 2004) or specially filmed naturalistic or semi-naturalistic dynamic scenes (Wass, Porayska-Pomsta, & Johnson, 2011). These techniques have been used to investigate how autonomic indices change in different attention states (Richards, 2011; Richards & Cronise, 2000), how looking behaviour towards the screen changes over time (Anderson, Choi, & Lorch, 1987; Richards & Anderson, 2004), and how these changes are different in children with Attention Deficit Hyperactivity Disorder (ADHD) (Lorch et al., 2004). To our knowledge, no research has investigated whether individual differences in look duration are consistent across static vs. dynamic looking time paradigms.

A third paradigm that has been used to assess looking durations involves presenting a number of unfamiliar objects consecutively or concurrently in a table-top setting, and performing video coding post hoc to analyse looking behaviour. For example, Kannass and Oakes (2008) videoed 9-month-old and 31-month-old infants playing with toys, in both single-object (objects presented consecutively) and four-object (objects presented concurrently) conditions; they also measured 31-month language performance in the same children (see also Sarid & Breznitz, 1997). They found that shorter look durations in the single-object task correlated with larger vocabularies at 31 months (Kannass & Oakes, 2008). For the multiple object condition, however, they found the opposite relationship: longer durations at 9 months correlated with larger vocabularies at 31 months (see also Choudhury & Gorman, 2000).

Despite the strong face similarities between these paradigms, no previous research has assessed whether individual differences using one type of looking time paradigm are consistent across different assessment techniques. A number of studies have addressed this indirectly, but none directly. Kagan and Lewis (1965) examined the relationship between looking behaviour towards static stimuli at 6 and 13 months and the amount of free-play locomotor activity at 13 months, and found that infants with long fixation times at 6 and 13 months were more sedentary during free play. Coldren found that infants' attention to stimuli in laboratory tasks correlated with the attention to their caregiver in face-to-face interactions at 3- and 4-month-olds but not at 6 months (Coldren, unpublished data, described in Colombo & Mitchell, 1990). Pêcheux and Lécuyer (1983) found with 4-month-olds that fixation time towards static stimuli was positively correlated with their visual exploration of a toy (Fig. 1).

This gap in the literature is important for a number of reasons. As we note in Part 2, there are a number of marked differences between these different looking time paradigms, such as: the size of the target towards which attention is being directed, the presence or absence of movement in the target or periphery of the visual field of the child, and the relative luminance of the target relative to other elements within the infants' field of view (Fig. 2). In the absence of data showing cross-paradigm consistency, we cannot be sure how individual differences in attention as assessed using screen-based tasks might relate to individual differences in attention in naturalistic settings. Are the dissimilarities between screen-based and naturalistic attention tasks documented in Fig. 2 incidental to the individual differences that are assessed on these tasks? Or are they central to them?

Within the habituation literature, shorter looking to static stimuli during the first year is frequently described as an index of 'faster processing speed'; this is frequently posited as an explanation for the negative correlations noted between look duration during the first year and long-term outcomes (Colombo & Cheatham, 2006). One question that follows from this is: does 'faster processing' as assessed using screen-based attention tasks also manifest as different ('better', or 'more efficient') orienting in naturalistic contexts? Or is shorter looking to screen-based stimuli associated with better long-term outcomes because both measures tap some underlying, 'pure' aspect of cognition that is entirely independent of naturalistic orienting? The present study is intended as a small step towards addresing these questions.