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Chaotic home environment is associated with reduced infant processing speed under high task demands

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ABSTRACT

Early adversity has profound long-term consequences for child development across domains. The effects of early adversity on structural and functional brain development were shown for infants under 12 months of life. However, the causal mechanisms of these effects remain relatively unexplored. Using a visual habituation task we investigated whether chaotic home environment may affect processing speed in 5.5 month-old infants (n = 71). We found detrimental effects of chaos on processing speed for complex but not for simple visual stimuli. No effects of socio-economic status on infant processing speed were found although the sample was predominantly middle class.

Our results indicate that chaotic early environment may adversely affect processing speed in early infancy, but only when greater cognitive resources need to be deployed. The study highlights an attractive avenue for research on the mechanisms linking home environment with the development of attention control.

1. Introduction

During the early years of life home environment is the primary space where children learn and develop. Bronfenbrenner's bioecological model highlights the role of both the social and the physical microsystem for early development (Brofenbrenner & Morris, 2006). While the majority of research was historically focused on the social microsystem, early work by Wachs, Evans and others demonstrated the influence of physical home environment on the development of young children (Evans & Maxwell, 1997; Wachs, 1979, 1989, 1993). What emerged from this work was the idea that the lack of temporal regularity, high levels of crowding and noise have detrimental effects on cognitive (Swanson, Valiente, & Lemery-Chalfant, 2012; Vernon-Feagans et al., 2012) and socio-emotional functioning (Fiese et al., 2002).

The insufficient structuring of the home environment is captured well by the construct of “chaos”: the presence of crowding, confusion and noise as well as the lack of routines and high unpredictability (Matheny, Wachs, Ludwig, & Phillips, 1995). Household chaos is associated with psychological distress among middle school children (Evans, Gonnella, Marcynyszyn, Gentile, & Salpekar, 2005) and has long-term detrimental effects on child cognitive development (Berry et al., 2016; Petrill, Pike, Price, & Plomin, 2004; Vernon-Feagans et al., 2012), academic achievement (Hanscombe, Haworth, Davis, Jaffee, & Plomin, 2011; Swanson et al., 2012) and mental health (Deater-Deckard et al., 2009; Wang, Deater-Deckard, Petrill, & Thompson, 2012).

Since the majority of studies measuring physical home environment were conducted on families experiencing poverty, chaos has

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often been related to poverty (see: Evans, Eckenrode, & Marcynyszyn, 2009). However, existing evidence suggests that household chaos is a separate construct from poverty (as measured by socio-economic status, SES) and it either predicts child outcomes independently of SES or mediates those effects (Brace et al., 2001; Chen, Cohen, & Miller, 2010; Deater-Deckard et al., 2009; Hart, Petrill, Deater Deckard, & Thompson, 2007; Shelleby et al., 2014; Vernon-Feagans et al., 2012; Wang et al., 2012). Chaos is also found in households of families not experiencing poverty (see Valiente, Lemery-Chalfant, & Reiser, 2007), strongly suggesting that some specific characteristics of physical home environment may affect child development in middle-class families just as well. Considering the constructs of chaos and poverty, Vernon-Feagans, Willoughby, and Garrett-Peters (2016) suggested that chaos is one of the potential proximal mechanisms that may explain the effects of poverty on parental behaviour and child outcomes (Bronfenbrenner & Evans, 2000; Vernon-Feagans et al., 2012).

Chaos affects infant development through influence on parental behaviour. In noisy, crowded environments caregivers are less responsive, less stimulating and less likely to vocalize or provide scaffolding (Wachs, 1989, 1993). They are also more interfering with child's activity, while elevated noise levels reduce parental sense of efficacy (Corapci & Wachs, 2002). For older children high chaos is associated with less frequent positive responses of the parents to child's emotional reactions (Valiente et al., 2007).

The physical properties of chaotic home environment influence children's capacity to process relevant information in addition to the effects on caregiving. Wachs, Morrow, and Slabach (1990) found associations between lower crowding and availability of shelter from noise with lower variability in visual recognition memory in 3-month-olds. In pre-schoolers high levels of noise in the household increase reaction times in a visual search task (Heft, 1979), while in older children noise impairs auditory discrimination and leads to reading difficulties (Cohen, Glass, & Singer, 1973). Long-term effects of environmental noise were found for speech processing and reading, and long-term memory of school-aged children (Evans & Maxwell, 1997; Evans, Hygge, & Bullinger, 1995). Similarly, research using directly the construct of chaos found associations of high chaos with less attention focusing, reduced responding to social cues and externalizing problems (Dumas et al., 2005). Together, these results suggest that household chaos likely affects information-processing capacities from young age. Existing research on infant auditory processing suggests that some of these effects may begin to emerge before the first birthday. Five-month-olds show some ability to selectively attend to a voice in the presence of competing voices (Newman, 2005), but noise affects their speech processing (Polka, Rvachew, & Molnar, 2008). Thus it is likely that persistent crowdedness- and noise-related chaos in the household may affect information processing already in infancy.

How may adverse environment affect information processing in infancy? Recent research from adults experiencing poverty offers some insights. It shows that poverty itself impedes cognitive capacity and may lead to decreased cognitive performance (Mani, Mullainathan, Shafir, & Zhao, 2013). This can be explained either by poverty acting as a distractor (Mani et al., 2013), or poverty leading to self-regulatory failure (Dang, Xiao, & Dewitte, 2015; Hofmann, Vohs, & Baumeister, 2012). These results are in contrast to a large literature that attributes the long-term effects of early adversity to mechanisms critically dependent on specific external factors, such as prenatal exposure to toxins or elevated cortisol. The role of internal, cognitive mechanisms in mediating the effects of adverse early environment during the first years of life is less well understood. Recent research focused on the mediating role of stress-related physiological systems (Blair & Raver, 2015). It has demonstrated that early adversity affects the development of executive functions by reducing the flexibility of stress responses Blair, Raver, Granger, Mills-Koonce, & Hibel, 2011; Evans, 2003), highlighting the role of infant's reactivity and regulation of arousal (Ursache, Blair, Stifter, & Voegtline, 2013).

To date, the majority of research on early adversity has focused on socio-economic deprivation, suggesting causal pathways between socio-emotional environment and children's cognition. While classic studies suggest that physical properties of early environment are closely related to information processing already in infancy (Wachs et al., 1990), such causal links that may exist independently from SES have not been fully investigated. To address this gap in the literature we investigated whether chaotic home environment may affect infants' use of cognitive resources. We studied a sample of infants coming from predominantly middle class families without extreme levels of chaos to investigate whether typical variation in home environment contributes to early emerging individual differences in information processing.

Given the decreased use of cognitive capacities in adults facing adversity (Mani et al., 2013) we hypothesized that a similar, but simpler mechanism may exists early in life. The daily experience of unpredictable and uncontrollable environment may affect infant's cognitive capacities, especially in more demanding situations. Under low task demands information processing may be unimpaired, but reduced availability of cognitive resources due to greater chaos would lead to decreased performance under higher task demands. We tested this prediction in a habituation task by presenting 5.5-month-olds with simple and complex visual stimuli. Infants at that age have sufficient control over their eye movements (Braddick & Atkinson, 2011; Johnson & Tucker, 1996) and relatively well established patterns of attention during interactions (Messinger, Ekas, Ruvolo, & Fogel, 2012), to reveal potential effects of environment on their visual stimulus processing. Task difficulty was conceptualized as the amount of stimulus information, i.e. stimulus complexity, which affects infant looking durations, as well as novelty/familiarity preferences (Hunter & Ames, 1988; Karmel & Maisel, 1975). Moreover, individual differences in looking durations have been linked to differences in cognitive performance already at 4 months of age (Colombo, Mitchell, Coldren, & Freeseman, 1991; Frick & Colombo, 1996; Stoecker, Colombo, Frick, & Allen, 1998). This suggests that looking duration during visual habituation can be used as a measure of infant processing speed (see Colombo & Cheatham, 2006; Colombo & Mitchell, 2009). Thus, in the current study we measured infant's peak looks to simple and complex stimuli in an infant-controlled habituation to assess their processing speed under lower (simple stimuli) and higher (complex scenes) task demands. We expected to see increased processing times for the complex but not for the simple stimuli in infants from families with higher household chaos.

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