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Does Early-Life Exposure to Stress Shape or Impair Cognition?

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Abstract
A predominant view in psychology is that early psychosocial adversity (e.g., abuse) impairs cognition, because children from stressful backgrounds (e.g., violent households) score lower on standard tests of intelligence, language, memory, inhibition, and other abilities. However, recent studies indicate that these people may exhibit improved detection, learning, and memory on tasks involving stimuli that are ecologically relevant to them (e.g., dangers), compared with safely nurtured peers. These findings contradict the view that cognition of stressed people is generally impaired; they suggest, rather, that these people's minds are developmentally specialized toward local environmental conditions. Here, we review recent research supporting this hypothesis. In addition, we propose that novel studies should examine whether stressed children show not only improved detection but also improved memory and reasoning on tasks involving stimuli that are ecologically relevant to them. Finally, we discuss clinical implications of switching from conceptualizing stressed minds as "adapted" rather than "impaired."

Keywords
evolutionary-developmental psychology, early-life experience, developmental specialization, cognitive development, learning and memory, maltreatment

Introduction

Organisms adapt to their environments on at least two timescales: (a) across generations by natural selection; and (b) within lifetimes, by adjusting development, acquiring skills and knowledge, and reacting to imminent stimuli. Progress in psychological science depends on considering both levels of adaptation and on how each informs the other. For instance, people, especially those from adverse backgrounds, may prefer smaller immediate rewards over larger future rewards (e.g., $10 now over $20 next year; Brezina, Tekin, & Topalli, 2009). Psychologists often describe this preference as *shortsightedness, impulsivity*, or *inability to delay gratification*, implying that the preference is dysfunctional (Daly & Wilson, 2005). However, in environments (e.g., dangerous, crime-ridden neighborhoods) in which future rewards are substantially more uncertain than immediate ones (e.g., rivals might snatch the valued good), a preference for immediate rewards might actually yield higher returns (Fawcett, McNamara, & Houston, 2012). Developing an environment-fitting (e.g., here and now) orientation, naturally, requires mental adaptations that assess local environmental conditions (e.g., as unsafe) and adjust preferences accordingly (Frankenhuis, Gergely, & Watson, 2013).

The view that behavior is best understood in its evolutionary-developmental context is on the rise (Belsky, 2008, 2012; Ellis et al., 2012; Frankenhuis & Del Giudice, 2012; Glover, 2011; Hawley, 2011; Nederhof & Schmidt, 2012). This position can be contrasted with the predominant developmental psychopathology model. In this model, such behaviors as aggression or devaluing of the future are considered maladaptive or nonoptimal and such behaviors as attentiveness, cognitive control, valuing the future, cooperation, and secure attachment are considered positively adaptive or optimal (Belsky, 2008, 2012; Ellis et al., 2012; Frankenhuis & Del Giudice, 2012; Glover, 2011; Hawley, 2011; Nederhof & Schmidt, 2012). However, desirability and adaptation are independent dimensions. For instance, children growing up in

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dangerous environments (e.g., ghettos) may develop high levels of aggression, which enhance their reputation (as "tough") and increase their reproductive success (Belsky, 2008; Ellis et al., 2012). It is thus crucial to keep normative ("ought") and descriptive ("is") analyses separate.

From a developmental psychopathology viewpoint, early psychosocial adversity (e.g., poverty, abuse) is generally viewed as impairing cognition, because children from stressful backgrounds (e.g., violent households, ghettos) tend to score lower on standard tests of intelligence, language, memory, inhibition (i.e., behavioral restraint), and other abilities (Ayoub et al., 2009; Fernald, Weber, Galasso, & Ratsifandrihamanana, 2011; Goodman, Quas, & Ogle, 2010; Hostinar, Stellern, Schaefer, Carlson, & Gunnar, 2012; Rieder & Cicchetti, 1989; Schliemann & Carraher, 2002; Tottenham, 2012). These findings are compelling and important and have produced many insights that support successful interventions (Diamond & Lee, 2011). However, they may not be the whole story. Recent studies indicate that, compared with safely nurtured peers, people from adverse backgrounds may exhibit improved detection, learning, and memory on tasks involving stimuli that are ecologically relevant to them (e.g., dangers). Here, we highlight these findings. We first discuss the impact of early-life stress on cognition. Then we describe studies on emotion perception, learning and memory, and reasoning. We conclude with clinical implications.

Early-Life Stress Influences Cognition

Early-life exposure to severe stressors can profoundly affect cognitive development (Champagne, de Kloet, & Joëls, 2009; Oitzl, Champagne, van der Veen, & de Kloet, 2010; Tottenham, 2012). The effects of stressors depend on many factors, including whether these constitute acts of commission (e.g., physical abuse) or of omission (e.g., neglect); their timing during development; their severity, frequency, and consistency (Baram et al., 2012); and the availability of buffering nutritional and social support. In addition, there are large individual differences in stress responses, which depend on the composition of genomes (DNA) and epigenomes (gene-regulatory systems) as well as earlier experiences (Belsky, 2012; Del Giudice, Ellis, & Shirtcliff, 2011; Ellis & Boyce, 2008; Ellis et al., 2012; Frankenhuis & Panchanathan, 2011a, 2011b; Tottenham, 2012). We cannot review all these factors here. Crucially, for our purposes, this work shows that early-life exposure to stress is associated with reduced performance on a variety of cognitive tasks.

On the basis of this reduced performance, stressed children might appear impaired across cognitive domains. General impairments can result, for instance, because certain cognitive processes (e.g., executive functions) are involved in many problem-solving capacities, so if these are disrupted, effects manifest across multiple domains. By analogy, if I damage two of my fingers, my hand will perform worse at many tasks: throwing a ball, peeling an apple, typing, etc. An alternative possibility, however, is that stressed children's brains are in good shape and that these children's perceptual and cognitive systems are specialized for those mental functions that are most important to them (e.g., predicting threats, assessing reputation, procuring resources in a competitive world). In this view, children's brains may be likened to hands developing expertise at certain tasks (e.g., throwing a ball) and less at others (e.g., typing). Such brains are not deficient, but adapted. A third possibility is that stressed children are both damaged and specialized: Their brains may be in poorer overall condition (e.g., due to malnutrition or understimulation), yet also perform better at specific (e.g., stress-relevant) tasks.

Emotion Perception

In hostile environments, it is especially crucial to detect and predict threats. For this reason, presumably, physically abused children are highly attuned to threat-related information (Pollak, 2008; Pollak, Messner, Kistler, & Cohn, 2009). For instance, physically abused children orient more rapidly to angry faces and angry voices than do safely nurtured peers. Strikingly, these children are also more accurate at identifying angry facial expressions from degraded pictures. This improved ability is specific to anger, because performance is equal to that of control children with fearful or happy faces. This effect is also dose-dependent: Children who experienced more severe abuse identify anger the earliest (Pollak, 2008; Pollak et al., 2009). Together, these results suggest that physically abused children's perceptual systems are specialized for detecting and monitoring of threats.

Angry faces imply a direct threat; fearful faces imply threat perceived by others (Davis et al., 2011). Considering this, it may be surprising that physically abused children are only as accurate as control subjects at detecting fearful expressions in the case of limited sensory input (Pollak, 2008; Pollak et al., 2009). However, a study measuring speed of labeling emotions reports that, compared with nonmaltreated children, maltreated children display faster reaction times to (moderately as well as highly) fearful faces but not to happy and neutral faces (Masten et al., 2008). It is noteworthy that despite faster speed, abused children judged these emotions as accurately as their nonabused peers. Thus, across experiments, maltreated children identify fearful faces with accuracy equal to that of nonmaltreated children but arrive at their judgments faster. That maltreated children display greater

speed without sacrificing accuracy is consistent with the hypothesis that their perceptual systems are specialized for detection of fear.

Learning and Memory

An evolutionary-developmental view predicts that "higher-level" cognitive functions—such as learning, memory, and reasoning—may also be specialized to local environmental conditions. For instance, maltreated children's hyperattention to threats may lead to better encoding and subsequently better memory for that information (Goodman et al., 2010). Consistent with this hypothesis, maltreated children are able to recall a greater number of distracting aggressive stimuli than nonmaltreated children (Rieder & Cicchetti, 1989). In addition, when asked to recount "nice" and "mean" stories at increasing levels of complexity, maltreated children younger than 4 years old pass more complex stories of both types (but especially the mean stories) than do nonmaltreated children (Ayoub, O'Conner, Rappolt-Schlichtmann, Fischer, & Rogosch, 2006). However, inconsistent with the hypothesis is that after this age, nonmaltreated children outperformed maltreated children on both story types (Ayoub et al., 2006).

Memory capacities of abused children have also been studied in real-world settings. Children with alleged histories of physical abuse, sexual abuse, or both were asked to recall details of a highly stressful anogenital examination they had received 3 days earlier (as part of an inpatient abuse-assessment program). Children who had experienced greater trauma were more often able to correctly identify in a photo line-up the doctor who examined them (Eisen, Goodman, Qin, Davis, & Crayton, 2007). This improved performance is threat-specific: Maltreated children actually show poorer photo identification accuracy of adults with whom they interacted in a positive, playful social interaction (Goodman et al., 2010). It is important to know whether this pattern generalizes to low-risk populations. This appears to be the case: Among boys from low-risk families, 3-year-olds with insecure attachment histories (measured at 12 months) recalled negative events (e.g., spilling juice) more accurately than positive events (e.g., receiving a present) that they witnessed in a puppet show; the reverse was true of boys with secure attachment histories (Belsky, Spritz, & Crnic, 1996). In this study, no evidence emerged for attachment-related effects on attention paid to positive and negative events.

Whether children's danger learning is modulated by the presence of a caregiver remains unknown (Tottenham, 2012), but such modulation does seem to occur in the case of rodents. Very early in life, pups have a simplistic odor-learning system that ensures pups learn to approach their mother. Specifically, in the first 10 days of life, rat pups learn to approach odors that they previously associated with pleasant or even unpleasant stimuli—e.g., mild shocks, a tail pinch. Starting at around 18 days, training sessions with these same unpleasant stimuli results in avoidance. However, at intermediate ages (between 10 and 17 days), pups trained in the presence or absence of their mothers learn to approach or avoid, respectively, such unpleasant stimuli. In this period, the presence of the mother thus acts as a switch for what is being learned (Sullivan & Holman, 2010; Tottenham, 2012). Presumably, in natural environments, this mechanism could result in precocious danger learning in intermediate-age pups receiving lower levels of care.

Other work shows that rat pups of low-caring mothers better memorize fearful contexts (Bagot et al., 2009; Champagne et al., 2008) and more readily learn to associate neutral stimuli (a tone) with fearsome stimuli (e.g., shocks) than pups of high-caring mothers (Oomen et al., 2010). One review concluded:

> Although offspring of low maternal care dams seemingly display lower cognitive performance under basal conditions when compared when [sic] offspring of high maternal care dams, a different outcome is observed when rats are tested under stressful conditions, i.e. a situation reminiscent of their early-life environment. Within the stressful context, the offspring of low maternal care dams perform better in a cognitive task than offspring of high maternal care dams. . . . These findings suggest that what used to be perceived as a maladaptive phenotype may turn out to represent an adaptation to the environmental context that prevailed during development, which appropriately predicts and "matches" with environment later in life. (Champagne et al., 2009, p. 141)

The importance of matching early and later environments for cognitive performance is also coming in focus in human developmental research (Frankenhuis & Del Giudice, 2012; Glover, 2011; Nederhof & Schmidt, 2012). Few empirical studies exist, but initial results are promising. For instance, infants exposed to concordant levels of maternal depression (high levels or low levels both before and after birth) show superior motor and mental development in their first year compared with infants exposed to discordant levels (e.g., high prenatal levels and low postnatal levels) (Sandman, Davis, & Glynn, 2012). These results and others (Glover, 2011; Glynn & Sandman, 2011) suggest that human infants' minds and bodies begin to adapt in the womb and benefit (in at least some developmental domains) if their postnatal environment matches their intrauterine environment,

even if both are stressful. Both the rodent and human findings underscore that, in mammals, mothers profoundly influence their offspring's learning and development.

Reasoning

To our knowledge, few studies have explored stressed children's reasoning abilities on tasks involving stimuli ecologically relevant to them (e.g., dangers). There is, however, a rich tradition in psychology showing that people may better solve reasoning problems when these are posed in the context of practical, real-world situations rather than abstractly (Schliemann & Carraher, 2002). For instance, young Brazilian street vendors that are unable to solve complex arithmetic problems in school-like settings solve these same problems, quickly and accurately, while selling and buying goods on the market (Schliemann & Carraher, 2002). These results were considered surprising at the time because these children came from poor backgrounds, were considered undernourished, received little or no formal education, and were thought incapable of learning mathematics.

In this contextualist tradition, however, many studies examine reasoning capacities similar to those typically assessed on intelligence tests (e.g., mathematics, language) but examine them in a naturalistic context. As a complementary line of research, it would be interesting to examine stressed children's abilities for solving other types of reasoning problems, such as predicting threats, assessing reputation, and procuring resources in a competitive environment. Naturally, such studies would need to present questions in a suitable format (e.g., conversational rather than pencil and paper) and with suitable content (e.g., other people, not abstract numbers) matching how children typically confront these problems in real life. For instance, children from dangerous neighborhoods could be presented with tests that require efficient information gathering—e.g., using as few actions or as fast as possible—to find out whether another person is likely to pose a threat.

In addition, it would be interesting to develop "mind-reading" tasks that require inferring malicious intent to accurately predict behavior. Such tests might reveal that stressed children show relatively highly developed mind-reading abilities in challenging scenarios they commonly face (e.g., inferring the intention to harm) compared with other scenarios (e.g., nonthreatening) and compared with children from supportive backgrounds. Such studies should include clear normative benchmarks defining correct performance to distinguish between general overattribution of hostile intent (Crick & Dodge, 1994) and enhanced skill (e.g., increased speed or greater accuracy).

Conclusions

In this article, we have highlighted recent findings showing that people from stressed backgrounds may exhibit improved detection, learning, and memory on tasks involving stimuli that are ecologically relevant to them, compared with safely nurtured peers. These findings contradict the view that cognition of stressed individuals is generally impaired, and suggest rather that minds are developmentally specialized according to local environmental conditions (Ayoub et al., 2006; Blair & Raver, 2012; Ellis et al., 2012; Frankenhuis & Panchanathan, 2011a, 2011b). Whether stressed children's cognition is merely specialized (albeit atypically) or impaired in some ways as well is an open and important question for future research. What counts as specialization rather than impairment depends on the kinds of adversities to which a child is adapting (e.g., violence, neglect). Addressing this issue requires case-by-case analysis. In general, however, an evolutionary-developmental view suggests that it will be essential to focus on the costs and benefits (to children) of developing specific mental functions in particular environments (Belsky, 2012; Ellis et al., 2012; Frankenhuis & Del Giudice, 2012; Glover, 2011; Hawley, 2011; Nederhof & Schmidt, 2012).

There are also clinical implications of switching from conceptualizing stressed minds as "impaired" to "adapted." First, if stressed minds are adapting, and one wishes to influence them, one must understand the causal processes shaping their development. For instance, if people who perceive life to be "nasty, brutish, and short" develop—as a result—strong preferences for immediate over future rewards, and these preferences make crime a more attractive option, then interventions that improve perceived life expectancies (by improving actual life expectancies) may reduce crime more successfully than education about long-term prison sentences or awareness-raising schemes (Brezina et al., 2009; Nettle, 2009). Second, if distressing behaviors (e.g., high levels of vigilance) serve a function for the individual (e.g., protect against violence), modifying these behaviors may entail not only benefits (e.g., stress reduction) but also costs (e.g., underdetection of threats)—especially if the individual remains in the environment in which he or she developed. Such costs may be considered in interventions (for discussion, see Ellis et al., 2012; Frankenhuis & Del Giudice, 2012).

Recommended Reading

Champagne, D. L., de Kloet, R., & Joëls, M. (2009). (See References). A clearly written and relatively comprehensive review of what is known about the immediate and long-term effects of early-life stress on mammalian brain and cognitive development.

Ellis, B. J., Del Giudice, M., Dishion, T. J., Figueredo, A. J., Gray, P., Griskevicius, V., . . . Wilson, D. S. (2012). (See References). A comprehensive formulation of the evolutionary-developmental basis of risky adolescent behavior, which includes detailed discussion of implications for clinical practice and policymaking.

Goodman, G. S., Quas, J. A., & Ogle, C. M. (2010). (See References). A comprehensive, accessible overview of what is known about the impact of child maltreatment on memory.

Nettle, D. (2009). (See References). An outstanding, highly accessible introduction to evolutionary developmental approaches to human behavior.

Pollak, S. D. (2008). (See References). A focused, highly accessible review discussing studies showing that children developing in dangerous environments specialize their perceptual abilities for the detection of threats.

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