

and typical development, will be crucial for scientific advance. I also agree with the spirit of his final quote. Were it not for the dissociation of fluid cognitive functions and psychometric *g*, there is a compelling story that relates functioning of the prefrontal cortex and general intelligence, but that “such an explanation would really amount to nothing more than a crafty story and that *g* remains as inscrutable as ever” (target article, sect. 8.1, last para.). Trouble is, it is not the *evidence* cited in this review that illuminates *g*, but a theory that says just how *g* and fluid cognitive functions are different.

Heterogeneity in fluid cognition and some neural underpinnings

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Abstract: In agreement with Blair, I favor the idea of dissociative patterns in cognitive performance, even more when it comes to development. However, such dissociations are present not only between fluid cognition and general intelligence, but also within fluid cognition itself. Heterogeneity of executive attention, even when indexed with a single paradigm, is further discussed in relation to anterior cingulate cortex.

Blair’s target article raises a critical issue: What should be the key area for diagnosis and intervention in cognitive functioning – particularly when addressing early stages of development? Can the assumption of one and only *g* factor underlying mental abilities really be translated into valuable operational tools, as proposed by traditional psychometrics? The main thesis sustained by the author offers a symmetrically opposed answer – there are patterns in cognitive performance delineating not one, but many factors – which offers itself undoubtedly as a good candidate for assessing individual differences and also for targeting interventions tailored to each individual’s needs.

Yet, there must be some caution in treating fluid cognition unitarily – or more specifically, what Blair calls “*gF*” (that part of fluid cognition independent of *g*). The conceptual interchangeability of fluid cognitive functioning with working memory and executive function(s) as if they are overarching the same construct is useful in contrast to a generic general intelligence, but not really valid when one is trying to clarify the true nature of fluid cognition.

In agreement with the author, I favor the idea of dissociative patterns in cognitive performance, even more so when it comes to development, considering that, as Blair acknowledges, diverse aspects of cognition develop rapidly – but unequally – in early life. During development, dissociations of cognitive functions actually seem to be the rule rather than the exception.

However, I argue that such dissociations are present not only between fluid cognition and general intelligence, but also within fluid cognition itself. The equivalent term for fluid cognition executive function(s) is recognized by many authors as an umbrella concept, encompassing at least working memory, inhibition/inhibitory control/executive attention and flexibility/set shifting (see Miyake et al. 2000).

Inhibitory control/executive attention is an essential construct for both developmental and adult studies. It has a reversed U trajectory, being low in children, high in adults, and low again in elderly people. It has been linked to the developmental progression and further regression of prefrontal/medial frontal structures, and it is thought to be involved in the acquirement of mentalizing abilities. Yet it has proved to be a composite, both theoretically and methodologically (e.g., see the aggregate battery scores proposed by Carlson & Moses 2001). Because

many tasks that are claimed to index inhibitory control have additional requirements, they end up measuring other variables, as well; therefore, I suggest that it is rather difficult, but maybe computationally “cleaner,” to choose computationally (neurally) well-defined tasks when trying to assess and explain inhibitory control, rather than more complex ecologically valid tasks (like many neuropsychological tasks).

I chose the spatial conflict task (Gerardi-Caulton 2000), a modified version of the Simon task, commonly used to measure conflict resolution in adults (Simon & Bernbaum 1990) and having a neural correlate at the level of the anterior cingulate cortex (ACC), as shown by functional magnetic resonance imaging (fMRI) (Fan et al. 2003). My computerized version consisted of presenting two visual stimuli (e.g., a teddy bear and an apple), either on the right or on the left of the screen, with the subject being instructed to respond according to the identity of the stimulus while ignoring the relation between the location of the image and the location of the appropriate response key. Children (2–7 years of age), typically developed, were tested under three experimental conditions: spatial conflict without any other requirement (similar to the adult version of the task), spatial conflict plus working memory load (the subject having to remember which stimulus was assigned to each response key), and spatial conflict plus reward (each correct response being followed by animation of the stimulus). My surprising results support the heterogeneity of executive attention and the presence of distinctive intra-individual patterns, since I found no correlation between incongruent reaction times (RTs) in the three conditions and no correlation between conflict rates (incongruent minus congruent RTs), the longest RTs being present in the reward condition (Benga 2004).

In neural terms, these results could be related either to the involvement of different brain circuits of the prefrontal-limbic network – proposed also by Blair as subserving fluid cognition – the ACC having only the role of conflict monitoring in each, or to different divisions (e.g., dorsal versus ventral [see Bush et al. 2000]) of the ACC involved in different tasks. Although adult neuroimaging studies have shown the activation of the dorsal ACC (thought to be mediated by the dopaminergic system) for spatial conflict tasks without additional requirements, I suggest the involvement of ventral ACC structures, mediated by an opioid system, in reward-related spatial conflict task. (I propose two different biochemical underpinnings to the ACC divisions, inspired by the two biochemical systems described by Luciana 2001.)

ACC divisions have often been explored in terms of their critical role in regulatory behaviors and cognition-emotion interaction, which is also emphasized by Blair. Moreover, they can be integrated in the larger framework proposed here: the amenability of fluid cognition to experience.

An opioid mediation of the ventral ACC could explain, in this line of thought, its vulnerability toward early disruptions of attachment (see Panksepp [2003] for linking attachment to opioids). I have suggested previously (Benga 2001) that dysfunctions in maternal contingency – leading to alterations in attachment – have disturbing, long-lasting effects upon the ACC, and they could explain why institutionalized children show later in life coupled deficits in executive function and social/emotional behavior (Gunnar 2001; O’Connor et al. 1999). According to the ontogenetic scenario suggested by Posner and Rothbart (1998; 2000), in the second half of the first year of life, ACC comes into function, being initially the center of emotional control and later of cognitive control. The correct maturation and functioning of the ACC might depend on contingent external input, offered by a constant caregiver. Animal models (Mathew et al. 2003) link early disruptions of maternal contingency to later biochemical modifications in the ACC: the decrease in the NAA/Cr indicating a decrease of neuronal viability, and the Glx/Cr ratio suggesting the activation of the hypothalamic-pituitary-adrenal axis.