Behavioral and Brain Sciences (2006), 29: 134-135 Cambridge University Press
doi:10.1017/S0140525X0630903X
Published online by Cambridge University Press 05 Apr 2006

Behavioral and Brain Sciences (2006), **29**(2):134–135 Cambridge University Press

Open Peer Commentary

There is more to fluid intelligence than working memory capacity and executive function

Dennis Garlick[a1] **and Terrence J. Sejnowski**[a1]

[a1]Computational Neurobiology Laboratory, Salk Institute, La Jolla, CA 92037. dgarlick@salk.edu terry@salk.edu http://www.cnl.salk.edu

Abstract

Although working memory capacity and executive function contribute to human intelligence, we question whether there is an equivalence between them and fluid intelligence. We contend that any satisfactory neurobiological explanation of fluid intelligence needs to include abstraction as an important computational component of brain processing.

Understanding fluid intelligence is a fascinating problem for behavioral and brain research. Fluid intelligence problems such as Raven's Progressive Matrices, Number Series, and Word Analogies involve presenting participants with problems that they are unlikely to have seen before. Successful performance cannot then be attributed to any simple learning mechanism based on previously seeing and memorizing the correct answer to the exact same problem. However, despite this, humans are able to solve these kinds of problems, suggesting that fluid intelligence is an important construct for assessing the human capacity to perform successfully across a wide range of situations. This is also supported by psychometric findings suggesting that fluid intelligence is the best predictor of performance in situations that involve human intelligence, including performance at school, at university, and in cognitively demanding occupations (Gottfredson 1997).

Understanding the nature of fluid intelligence has been a profound problem for psychometric intelligence research. Indeed, even recent reviews admit that we still have no satisfactory explanation of what causes differences in fluid intelligence (Brody 1992; Jensen 1998; Neisser et al. 1996). Blair suggests an answer, using the constructs of working memory capacity and executive function (see also Kane & Engle 2002). Indeed, the notions that working memory capacity and executive function are explanations of fluid intelligence are plausible. After all, the solution of fluid intelligence tasks undoubtedly involves the use of working memory. Similarly, executive functions are the result of an evolutionary recent brain area, so equating the operation of this brain area with fluid intelligence, again a capacity that is most evident in humans, would again seem plausible. It is also logical to identify fluid function with the prefrontal cortex, an area that is notable for playing a control function and not having direct connections with sensory input.

However, though the answer Blair gives has been suggested in the past, it is endorsed by relatively few current researchers. One reason for the lack of support for a relationship between fluid intelligence (gF) and working memory and executive function is that tasks that assess working memory and executive function often do not reflect gF. For instance, tasks developed according to working memory principles often do not correlate with gF. Researchers arguing for a working memory capacity explanation of intelligence have then sought to strengthen this relationship by simply making working memory tasks involve the manipulation and transformation of information, elements that are commonly involved in fluid intelligence tasks (see Kyllonen & Christal 1990). However, this would then suggest that it is not working memory capacity per se that is leading to the correlations between these tasks and fluid intelligence, and leads to a circular argument. Unsworth and Engle (2005) also found that a working memory capacity task predicted performance equally on Raven's problems that varied based on difficulty, memory load, and rule type. This again suggests that it is not working memory capacity per se that mediates the relationship between working memory capacity and fluid intelligence. Similarly, performance on executive function tasks often are not related to performance on fluid intelligence tasks. Blair describes the Wisconsin Card Sorting Task (WCST), a well-known measure of executive function, as a fluid intelligence measure, even though the WCST is not known to be an indicator of fluid intelligence. The relationship between prefrontal cortex and fluid intelligence is again complex. Only the most difficult Raven's problems show activation in the prefrontal cortex (Prabhakaran et al. 1997), even though the easier Raven's problems are still measures of fluid intelligence. This indicates that fluid intelligence does not depend on something that is specific to the prefrontal cortex.

Our concern is that Blair is then making the supposed fit between fluid intelligence and working memory capacity and executive function by redefining fluid intelligence in working memory and executive function terms. Evidence that then supports this correspondence is selectively referenced, while evidence that contradicts this framework is neglected. This is of crucial importance. When Blair claims to find a dissociation between fluid intelligence and *g*, we suspect that he is in fact finding a dissociation between fluid intelligence and working memory capacity/executive function. Indeed, while criticizing current research for ignoring relevant distinctions between cognitive processes, Blair is in fact guilty of this himself when he chooses to lump the constructs of gF, working memory, and executive function into the one construct. It may be that cortical damage compromises executive function while fluid functions remain largely intact, such as in the case of the absentminded professor. Only by using measures that assess all of these functions can we hope to understand their interplay. Simply assuming at the outset that fluid intelligence, working memory capacity, and executive function are the same construct is likely to mean that effects are missed that would be detected if the constructs were recognized as being distinct.

Even more problematic for the proposed neurobiological model of fluid intelligence is that it makes no mention of abstraction, even though, unlike working memory capacity and executive function, all fluid intelligence problems involve abstraction. Abstraction is also recognized as being the hallmark of intelligence (e.g., Snyderman & Rothman 1987). Until theories of fluid intelligence address this issue of abstraction, they will continue to fail to provide an explanation that enables us to actually understand the nature of intelligence. Examining localization in the brain is likely to be of only limited help at best in this endeavor. Different areas of the cortex are likely to be important for representing different abstract properties. This does not contradict the notion of a general fluid factor, as these different areas may depend on a common mechanism to extract abstract information out of the environment (Garlick 2002). Rather, the answer is likely to lie in understanding how the brain computes abstraction. Unfortunately, little is known about the neural basis for abstraction. This needs to be a goal of future research.

ACKNOWLEDGMENTS

- TOP
- REFERENCES

Terrence J. Sejnowski is supported by the Howard Hughes Medical Institute, the Salk Institute for Biological Studies, La Jolla, California, and the Division of Biological Sciences, University of California, San Diego, La Jolla, California.

REFERENCES

- TOP
- ACKNOWLEDGMENTS

Brody, N. (1992) *Intelligence*, 2nd edition. Academic Press. [OpenURL Query Data]

Garlick, D. (2002) Understanding the nature of the general factor of intelligence: The role of individual differences in neural plasticity as an explanatory mechanism. *Psychological Review* **109**: 116–36. [OpenURL Query Data] [Medline]

Gottfredson, L. S. (1997) Why g matters: The complexity of everyday life. *Intelligence* **24**: 79–132. [OpenURL Query Data]

Jensen, A. R. (1998) *The g factor: The science of mental ability*. Praeger. [OpenURL Query Data]

Kane, M. J. & Engle, R. W. (2002) The role of prefrontal cortex in working memory capacity, executive attention, and general fluid intelligence: An individual-differences perspective. *Psychonomic Bulletin and Review* **9**(4): 637–71. [OpenURL Query Data] [Medline]

Kyllonen, P. C. & Christal, R. E. (1990) Reasoning ability is (little more than) working memory capacity?! *Intelligence* **14**: 389–433. [OpenURL Query Data]

Neisser, U., Boodoo, G., Bouchard, T. J.Jr., Boykin, A. W., Brody, N., Ceci, S. J., Halpern, D. F., Loehlin, J. C., Perloff, R., Sternberg, R. J. & Urbina, S. (1996) Intelligence: Knowns and unknowns. *American Psychologist* **51**: 77–101. [OpenURL Query Data]

Prabhakaran, V., Smith, J. A. L., Desmond, J. E., Glover, G. H. & Gabrieli, J. D. E. (1997) Neural substrates of fluid reasoning: An fMRI study of neocortical activation during performance of the Raven's Progressive Matrices Test. *Cognitive Psychology* **33**: 43–63. [OpenURL Query Data] [Medline]

Snyderman, M. & Rothman, S. (1987) Survey of expert opinion on intelligence and aptitude testing. *American Psychologist* **42**: 137–44. [OpenURL Query Data]

Unsworth, N. & Engle, R. W. (2005) Working memory capacity and fluid abilities: Examining the correlation between operation span and Raven. *Intelligence* **33**: 67–81. [OpenURL Query Data]

back to top