

General intelligence is an emerging property, not an evolutionary puzzle

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Abstract

Burkart and collaborators contend that general intelligence poses a major evolutionary puzzle. This assertion presupposes a reification of general intelligence, i.e, assuming that it is one “thing” that must have been selected as such. However, viewing general intelligence as an emerging property of multiple cognitive abilities (each with their own selective advantage) requires no additional evolutionary explanation.

Main text

As the authors acknowledge, the concept of general intelligence is empirically grounded solely in the observation of positive correlations between all test scores, hence of a general factor termed g explaining a large share of variance in all tests (Spearman, 1904). All other accounts are simply debatable interpretations or hypotheses attempting to relate g to some other cognitive or biological constructs. They run the risk of reifying what is primarily a statistical construct, and of seriously confusing the search for an evolutionary explanation. For instance, Gottfredson’s (1997) definition of intelligence is little more than a scholarly formulation of the folk concept of intelligence, but offers no guarantee of matching psychometric g . Burkart et al. initially conflate g with executive functions, but this changes the nature of the problem. If general intelligence reduced to executive functions, then to the extent that each executive function offers a selective advantage, the evolution of general intelligence would not be a major puzzle. Similarly, general intelligence is also identified with domain-general cognitive processes, which is a different, and unnecessary hypothesis, as we will show. Furthermore, many putative domain-general cognitive functions turn out to be less general than they seem. For instance, there are separate working memory systems for verbal, visuo-spatial and other modalities. Similarly, words such as inhibition and attention wrongly suggest unitary phenomena, whereas they are used to describe a host of distinct processes, none of which can be said to be truly domain-general, and none of which is an evolutionary puzzle. Finally, certain cognitive functions can serve domain-general purposes while having been selected for more specific adaptive value. This may be the case of language, which serves as a mediator across many cognitive functions, yet may have evolved for purely communicative purposes (Jackendoff, 1999; Pinker & Bloom, 1990).

More generally, every attempt to reduce general intelligence to a single cognitive (processing speed, working memory, etc.) or biological (brain volume, nerve conduction velocity, etc.) construct has failed, each construct showing moderate correlation with g and being best described as simply one contributor to the g factor (e.g., Mackintosh, 2011). Thus, trying to tackle the evolution of general

intelligence by addressing the evolution of any of these constructs is a form of attribute substitution (Kahneman & Frederick, 2002)

Understanding the evolution of psychometric g requires understanding how it comes about. As early as 1916, Thomson (1916) showed that it is sufficient to postulate underlying group factors that influence several tests to obtain a positive manifold without a general factor (see also Bartholomew, Deary, & Lawn, 2009). Reframed in modern psychological terms, an elementary analysis of tests shows that no test is a pure measure of a cognitive function (or construct). The relationship between cognitive functions and test scores is many-to-many: each test score is influenced by several cognitive functions, and each cognitive function influences several test scores (in the same direction). The latter observation suffices to explain that test scores are positively correlated. We submit that the logic of Thomson's bonds model is much more general, as it also applies to factors underlying cognitive functions. Indeed, each brain function or property (e.g., frontal grey matter volume, nerve conduction velocity, dopamine synthesis, etc.) influences several cognitive functions, thereby inducing intrinsic positive correlations between cognitive functions. One step further back, each gene expressed in the brain (e.g., genes that code for neurotrophic factors, transcription factors, and any molecule involved in neurotransmission) typically influences several brain functions and properties, thereby inducing positive correlations between them. In parallel, many environmental factors (e.g., nutrition, socioeconomic status, education, diseases...) influence more than one brain or cognitive function, thereby inducing further correlations. Finally, van der Maas et al. (2006) et al. have shown that positive correlations between cognitive functions may emerge through mutual interactions in the course of cognitive development, even in the absence of intrinsic correlations. Thus all the factors underlying test performance are pleiotropic and conspire to produce positive correlations at all levels of description, hence the emergence of the positive manifold.

Note that, according to the explanation given above, the positive manifold can arise in an entirely modular mind (because modules selected for different purposes nevertheless have to share underlying factors), and therefore there is no antagonism between modularity and general intelligence. Furthermore, the very same pleiotropic mechanisms are at work in other species, and therefore readily explain that a g factor can be measured in non-human primates, rodents, and probably all organisms with a nervous system. Finally, in the speciation process, genes that progressively diverge between two populations influence more than one brain and cognitive function, therefore the two populations are bound to eventually differ in more than one brain and cognitive function. This directly predicts that performance in different tests should covary across species, what the authors term G . Thus all the evidence that the authors gather in support of a reified notion of general intelligence is more parsimoniously explained by the pleiotropy of the underlying factors, within and across species. The "independent evolution of large numbers of modules instead of general intelligence" is not "particularly difficult to reconcile with interspecific findings of G ", it directly follows from an understanding of what modules are made of: the same building blocks, shared between species.

There is therefore no need to postulate that the positive manifold reflects one particular cognitive function, or one brain function, whose evolution would require a special explanation. The positive manifold emerges spontaneously from the pleiotropy of all the underlying factors. Only these underlying factors require an evolutionary explanation. It is indeed very interesting to enquire about

the evolution of genes involved in brain development and function, the evolution of brain functions and properties, and the evolution of cognitive functions. If there is any brain or cognitive function whose evolution is a major puzzle, then it should be identified and studied as such. However, this is not the case for general intelligence, which does not reduce to a single brain or cognitive function, and whose evolution follows directly from that of the underlying biological, cognitive and environmental factors.

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