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Fluid Intelligence

General fluid intelligence (Gf) refers to the ability to solve new problems, particularly when mentally effortful reasoning processes are required (such as inference, induction, abstraction, or synthesis). That is, Gf is involved in working out a novel solution, but not in simply remembering a previous solution. Gf is often contrasted with general crystallized intelligence (Gc), which represents culturally relevant knowledge and skills. Although Gf and Gc are distinct, Gf can support the acquisition of skills and knowledge that contribute to Gc.

Technically, Gf is a statistical construct derived from the factor analysis of mental-test scores. Factors representing the shared variance among particular tests are often interpreted as reflecting specialized latent abilities, talents, or intelligences that determine performance. Gf is typically derived from hierarchical factor analyses, in which the positive correlations among *factors* (rather than correlations among specific tests) specify common ability dimensions at a higher level, or "stratum," of generality. An overarching Gf factor emerges at the second stratum when a test battery produces several reasoning factors at the first (e.g., verbal induction, figural sequencing, and quantitative reasoning). The presence of a Gf factor indicates that people who are skilled at reasoning in one domain tend to be skilled in other domains; Gf represents the shared variance among reasoning domains.

The Gf-Gc theory of intelligence was first proposed by Cattell and elaborated by Horn. It is intermediary between views that intelligence is unitary or general (e.g., Spearman) and views that intelligence is a collection of many independent abilities (e.g., Guilford). One of the theory's primary strengths is in accounting for changes in intelligence across the life span. Whereas Gf rises until young adulthood and begins to decrease thereafter, Gc continues to rise through middle age and either levels off or drops slowly thereafter. A unitary (general) theory of intelligence cannot account for this differential developmental pattern.

The cognitive and neural mechanisms that support Gf are topics of active research. Working memory and the executive control of action are strongly linked to Gf and to the function of the lateral prefrontal cortex (PFC). The lateral PFC appears to be involved more in Gf than Gc: Patients with PFC damage often have normal IQ as assessed by Gc tests, but they show impairment on Gf tests. Although the specific ways in which PFC and other brain regions contribute to intelligence is less well understood, neuroimaging studies indicate that PFC and parietal brain regions are activated when people perform prototypical Gf tests, including reasoning and working memory. In a study by Gray and colleagues, individuals with higher Gf were more accurate on a working memory task, and had greater neural activity during the most demanding components of the task, particularly in lateral PFC and parietal cortex. Thus, working memory, executive control, and the lateral PFC appear to be important cognitive and neural contributors to Gf.

Genetic studies consistently show that general cognitive abilities are partly heritable. Although few genetic studies have examined Gf specifically, fluid intelligence is very strongly related to general intelligence and IQ. Importantly, environmental factors have a greater influence on childhood IQ in impoverished families than in families of higher socioeconomic status. That is, intelligence may be influenced by genetics only when environmental conditions are favorable. Other environmental

influences include lead poisoning (negatively related) and the duration of breast-feeding (positively related). Situational factors, including anxiety, can adversely influence performance on tests, especially on tests described as assessing mental ability.

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See also:

References

Carroll, J. B. (1993). Human cognitive abilities: A survey of factor-analytic studies. New York: Cambridge University Press.

Cattell, R. B. (1943). The measurement of adult intelligence. Psychological Bulletin, 40, 153-193.

Cattell, R. B. (1963). Theory of fluid and crystallized intelligence: A critical experiment. Journal of Educational Psychology, 54, 1-22.

Duncan, J., Burgess, P. & Emslie, H. (1995). Fluid intelligence after frontal lobe lesions. Neuropsychologia , 33, 261-268

Gray, J. R., Chabris, C. F., & Braver, T. S. (2003). Neural mechanisms of general fluid intelligence. Nature Neuroscience, 6, 316-322.

Gray, J. R., & Thompson, P. M. (2004). Neurobiology of intelligence: Science and ethics. Nature Reviews Neuroscience, 5, 471-482.

Guilford, J. P. (1967). The nature of human intelligence. New York: McGraw-Hill.

Horn, J. L. (1986). Intellectual ability concepts. In R. J. Sternberg (Ed.), Advances in the psychology of human intelligence (pp. 35-77). Hillsdale, NJ: Erlbaum.

Horn, J. L., & Cattell, R. B. (1966). Refinement and test of the theory of fluid and crystallized general intelligences. Journal of Educational Psychology, 57, 253-270.

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, 637-671

Spearman, C. (1927). The abilities of man: Their nature and measurement. London: Macmillan.