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Beyond IQ comparisons: intra-individual training differences

Olivier Houdé

As stated by Deary, Penke and Johnson in their recent article (The neuroscience of human intelligence differences. *Nature Rev. Neurosci.* **11**, 201–211 (2010))[1], it is important to recognize that people differ not only in their general cognitive ability (that is, intelligence quotient (IQ)), but probably also in how they use their brain to reach particular levels of performance. Going further, we need to learn about how the same brains can be used differently for the same tasks. In differential and developmental psychology, such phenomena are known as 'intra-individual differences'[2,3].

Intraindividual brain differences

In their Review, Deary, Penke and Johnson examine only inter-individual IQ differences. I agree with their definition of human intelligence as a general capability that involves the ability to reason and think abstractly, but I disagree with their sole focus on inter-individual differences. In the field of reasoning and abstract thinking (that is, logico-mathematical cognition), some brain imaging studies have confirmed over the past decade that human intelligence also depends on intra-individual variability[4]. For example, we carried out an imaging study to investigate what happened before and after training in error inhibition (an executive function) in a deductive-logic task[5]. We found a clear shift (or switch) in regional cerebral blood flow (rCBF) from the posterior part of the brain before training to the prefrontal part after training. Hence, the same brain can be used differently in the same deductive-logic task. We also found a similar change in rCBF from the pre-training rest period to the post-training rest period[6]. Such results provide insight into the intra-individual differences that lead the human brain towards logical intelligence[7].

A double system of differences

Interestingly, this so-called 'fluid' (as opposed to 'crystallized')[8] aspect of intelligence — in this example, how the brain responds to training in error inhibition — differed between subjects. Indeed, a comparison between subjects who were able or unable to shift from making errors to logical responses after error inhibition training showed that success in the deductive-logic task involved (in subjects who were able to shift) activation in the right ventromedial prefrontal cortex, which is known to sustain logical intuition[9,10]. Together, these results argue for brain variability in human intelligence, dynamic-network cognition[11] and differential training effects.

Considering this double system of intra-individual and inter-individual variability, the crucial question for the neuroscience of human intelligence, beyond IQ comparisons, is: how are inter-individual brain differences related to intra-individual brain differences? The answer to this question, which can be addressed with (quantitative and molecular) genetic studies and brain imaging, lies in determining whether intra-individual differences (for example, the executive training effects described above) take the same form in all individuals. If they do not, genes involved in intelligence might be closely linked, through endophenotypes, to this double system of differences both in children[12,13] and in adults.

Glossary

Executive function
Also called cognitive control, it includes inhibition (resisting habits, temptations or distractions), switching (adjusting to change) and working memory (mentally holding and using information).

Endophenotype
A quantifiable phenotype with an assumed intermediate role in the pathway from genes to complex phenotypes.

Olivier Houdé is at the Department of Psychology, Paris Descartes University, Sorbonne, 46 rue Saint-Jacques, 75005 Paris, France.

e-mail: olivier.houde@parisdescartes.fr

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