The relationship between working memory and intelligence in children

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Those who perform better on intelligence tests are typically also more successful in school- and work-related settings and live healthier and longer lives. Intelligence is therefore important for coping with a complex world. Its importance is also reflected in the concept of fluid intelligence – in contrast to crystallized intelligence –, which defines intelligence as a complex ability that allows us to adapt our thinking to a new cognitive problem or situation.

But what does it mean that some individuals are more intelligent than others? Perhaps they are more adept at underlying information processes. Working memory, in particular, is strongly correlated with intelligence in children and adults. When people perform better on a working memory task, they also tend to perform better on an intelligence task.

The term working memory refers to the cognitive system that allows us to keep information available for processing. When we perform a mental calculation, such as $5 + 12 - 7 = 10$, we need to keep the numbers in our head as we carry out the calculation. It is therefore not surprising that children who do better on working memory tasks also score higher on math, language, reading, and intelligence tests. As working memory develops until young adulthood, older children outperform younger ones on working memory tasks.

There is clearly a close relationship between intelligence and working memory, and both play an important role in a variety of developmental areas during childhood. Interestingly, both involve prefrontal areas of the brain. This raises the question of whether, when solving problems involving working memory, more intelligent individuals show more activity in the prefrontal brain relative to those who are less intelligent.

In adults, evidence shows that when solving simple to moderately difficult tasks, more intelligent people exhibit less brain activity than individuals of lower intelligence. More intelligent adults are thus more efficient problem solvers, because they have to summon up less energy.

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Little is known about whether this kind of neural efficiency is also found in children of different age groups, and how it is influenced by age. Hence, my colleagues and I are trying to answer the following question: Are there differences in brain activity between 10- and 12-year-olds of higher and lower intelligence?

To answer this question we visited schools, where 10- and 12-year olds solved a fluid intelligence test (Culture Fair Test 20-R). If the children’s IQ was within our IQ criterion for the lower (IQ ≤ 96) or
higher intelligence group (IQ ≥ 115), they were invited to participate in further sessions at our lab.

Thus, 117 children were asked to solve a working memory task in our lab. In this task children heard a mixed sequence of letters and numbers (e.g., “D-8-M-1”), and were asked to repeat them, with the numbers in numerical order first and the letters in alphabetical order second (e.g., “1-8-D-M”). Brain activity in the prefrontal cortex was assessed using near-infrared spectroscopy (NIRS).

Preliminary results on the NIRS data revealed opposite patterns in the two age groups. In the younger group, more intelligent children showed increased neural activity compared with children of lower intelligence. In the older group, in contrast, children of lower intelligence tended to show an increase in neural activity compared with children of higher intelligence.

These results suggest that both age and intelligence affect the activity in the frontal area of the brain that is triggered by a working memory task.

References
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