The Development of Reasoning Skills: The Roles of Processing Speed and Memory in Adults compared to Children

The human ability to think logically and solve novel problems may be constrained by how rapidly we can process information, and how much information we can handle at once. Twenty years ago, a "cascade model" was proposed that, as children develop, they become faster information processors, which gives rise to greater working memory capacity, which gives rise to greater reasoning ability. Since then, questions have been raised about how to measure working memory and speed appropriately. For example, many researchers now distinguish between short-term memory (STM) - the capacity to store information for a brief period and then recall it - and working memory (WM) – which incorporates the capacity available for mental manipulation and transformation of information. Researchers generally agree that it is WM, not STM, that best predicts reasoning ability in adults. Similarly, although many researchers use reaction time (RT) – the time taken to make a decision about a particular stimulus and choose the appropriate response – it has been argued that this is unduly sensitive to fine motor control rather than cognitive speed, especially in children. An alternative measure, inspection time (IT) seeks to avoid this confound by measuring speed of decision-making without requiring a rapid fine motor response.

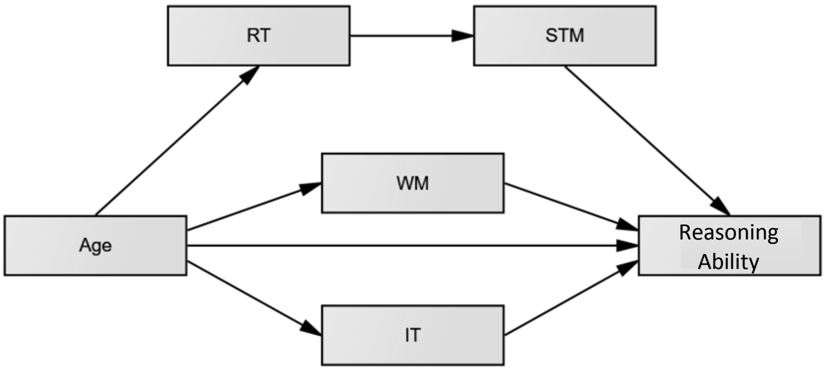

Figure 1. Structure of Reasoning Ability in Children

A recent study of children included all four measures (RT, IT, STM and WM) and found that the original "cascade" was replicated when the original measures were used: age predicted RT, which predicted STM, which predicted reasoning ability. However, WM had its own unique age-related influence on reasoning ability, and so did IT. Thus, rather than one simple cascade giving rise to the development of reasoning ability, it appears that all these factors contribute at once. The present study aimed to replicate these findings in adults to see whether the factors predicting reasoning ability in childhood persist into adulthood.

Method

Volunteer university students (*N* = 71) were recruited to participate in a battery of tests assessing their reasoning ability and the other components within a single 2-hour long session. To assess their reasoning skills, participants are tested on their reasoning and pattern recognition skills using a series of abstract images. STM and WM were assessed by simple recall tasks, and recall tasks involving mental rearrangement of information, and a recall task where the information rehearsal was interrupted by simple logic tasks. For IT and RT, participants had to determine whether a stimulus image shown by a computer program was symmetrical. For RT they then had to press a button as quickly as possible to indicate their decision. For IT, the computer controlled how much time they were allowed to see the stimulus before requiring a best-guess, but participants did not have to respond quickly.

Since WM tasks are more complex and involve the other two components, the tasks results were statistically "controlled" by to account for the effects of STM and speed to better distinguish between the components. We then tested how closely the relationship structure of reasoning ability in adults resembled that in children, as well as exploring other possible relationship structures that may better represent the way the components relate to adult reasoning ability.

Results

Although the analysis found similarities between the relationship structures of the components in adult and children, they were far from being identical. Firstly, IT, which was an important fluid intelligence predictor in children, did not predict adult fluid intelligence but was instead correlated with RT. Secondly, reaction time no longer correlated with short-term memory and, instead, both components directly correlated with reasoning ability. Thirdly, working memory was also a significant contributor to adult fluid intelligence, even after controlling for the effects of short-term memory and information processing speed. Finally, age was found to be only significantly related to inspection and reaction time. When age was controlled for, inspection time did not correlate with any other measures in the study.

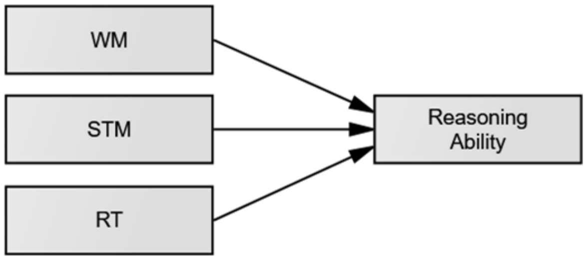

Figure 2. Structure of Reasoning Ability in Adults

Conclusion

The results suggest that the process of growing up changes not simply the strength of the components' influence on our reasoning ability, but also the way in which they interact amongst themselves. It was not unexpected that inspection time did not correlate with reasoning ability given that literature review has shown previous studies to associate it with a factor of a specific test that was mistakenly thought to represent our reasoning ability. However, all the other three components correlated with reasoning ability concurrently which is in contrast with the wealth of literature that found only one or two to significantly predict it at any one time. This could be due to the differences in the nature of the tasks chosen to represent the components in this study and the studies reviewed. The results suggest that different people may have different strengths and weaknesses and we saw evidence that those who are weak in one area may be able to compensate by being better in another. It is suggested that future studies look into a concurrent examination of these components in tandem brain imaging technology to examine the relationship of the observed changes with the physical development of the brain over time.