It is better than you think: fluid intelligence across the lifespan

The growth and decline of fluid intelligence is associated with brain structural changes. For example, development of fluid IQ is associated with cortex thickness during the critical period between 6 to 12 years old[1]. On the other end of the lifespan, poor performance in cognitive functioning is attributed to a decrease of frontal gray matter density in elderly populations[2]. In particular, there is a sharp decline in fluid IQ scores after 65 years of age[3]. There is substantial evidence that working memory and fluid intelligence (Gf) share neural substrates, such as the prefrontal and parietal cortices[2,4]. However, very little research has examined whether the pattern of growth and decline in working memory mirrors that of fluid intelligence. For example, does the decline of working memory skills in elderly populations mirror fluid intelligence? Is the rate of working memory decline similar to the rate of growth?

In order to investigate these issues, we included individuals aged from 5 to 85 years old from a range of demographic backgrounds in a cross-sectional study. They participated in a series of verbal and visuo-spatial working memory assessments. Unlike IQ tests[5], there is evidence to suggest that working memory tests may be a culture-fair measure of cognitive ability. For example, it is relatively impervious to environmental influence such as the quality of social and intellectual stimulation in the home, the number of years spent in pre-school education[6], and financial background[7]. Recent research comparing immigrant populations to native European speakers identify similar patterns in working memory skills in across these groups[8]. One explanation is that working memory is a relatively pure measure of a child's learning potential, rather than a measure of what acquired skills[9-11]. It is therefore possible that working memory skills across the lifespan might reflect a different pattern of growth and decline than that of IQ.

Working memory assessments requires the individual to process and store increasing amounts of information until recall errors are made. In the present study, working memory was measured using an online version of a standardized memory assessment consisting of two verbal and one visuo-spatial working memory test[12]. In the letter recall test, the individual saw a letter on the computer screen, immediately followed by another letter. They verified whether the letters were the same and then remembered the target letters in sequence. In the backwards digit recall test, the individual recalled a sequence of spoken digits in the reverse order. In the shape recall test, the individual saw a shape on a grid, immediately followed by another shape. They verified whether the shapes were the same and then remembered the target shape in the correct grid location. All stimuli were randomized and the data are displayed as standard scores (mean=100; SD=15; Fig. 1).

Several patterns emerged. First, there was a tremendous rise in working memory skills during development. The growth in working memory capacity between 5 to 19 years of age was on average 23 standard points. Contrast this remarkable growth to two other 20-year-periods: between 20 to 39 years of age, there was only an average of a 4 standard point increase; and between 50 to 69 years of age, there was a average decline of one standard point.

Another key pattern is that there was a peak in working memory capacity in 30-year olds. Previous research only examined working memory growth up till 25 years and had indicated that working skills reached maximum capacity in the teenage years[13]. The present study revealed that working memory continues developing even in our twenties, reaching peak performance in our thirties (see Table in Supporting Materials for levels of significance between age groups).

A surprising finding is that there was little decline in working memory capacity: between 50 to 85 years old, there was a slight decline of an average of 6 standard points. Contrast this with fluid intelligence where decline in 80-year-olds was reported to be 15 standard points (1SD) below the average and reflected levels of cognitive impairments[3]. The rate of decline in working memory skills is very different from their rate of growth: it is much slower. In fact, data from this study demonstrate that working memory skills remain intact throughout much of adulthood. People in their sixties performed at the same level as those in their twenties.

Finally, there were marked differences in the nature of working memory decline. Verbal working memory skills remained robust and individuals in their seventies to mid-eighties performed as well as those in their teenage years. In contrast, visuo-spatial working memory skills in the same age group (70-85 years) were at the same level of nine and ten year olds.

These distinctive patterns in the trajectory and decline of working memory skills suggest that while working memory and fluid intelligence may share neural substrates, they have dissociable cognitive profiles across the lifespan. Compared with IQ[3], the growth of working memory occurs more rapidly and the decline more slowly, with functioning in those in their sixties similar to those in their twenties.

These findings have important implications for a range of fields. In education, there are key applications for the tremendous growth of working memory during the school-years: six-times greater compared to adulthood. In a recent longitudinal study, working memory skills at 5 years of age was a better predictor than fluid intelligence of literacy and numeracy six years later[14]. On the other end of the lifespan spectrum, given that the decline of working memory is not as dramatic as that of fluid intelligence, there is scope for using working memory training to boost fluid intelligence as we get older[15].

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Figure: Working Memory across the Lifespan