Tuning in by tuning out distractions

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Working memory is a limited workspace for temporarily holding information in mind, and it is critical for thinking and problem solving. A person's ability to perform a variety of complicated intelligent behaviors, such as abstract reasoning, mathematics, and acquiring new languages, depends greatly on his or her specific working memory capacity. Those with a high capacity perform better on measures of fluid intelligence and scholastic aptitude than their low-capacity counterparts (1, 2). For the past 15 years, much of the work on individual differences in capacity has indicated that differences between people are largely because of attentional control, which allows one to focus on relevant information and ignore distractions (3, 4). However, it has always been unclear whether the advantages of high-capacity individuals are due to their ability to "tune in" the important stuff or to their ability to "tune out" the unimportant stuff. In PNAS, Gaspar et al. (5) provide exciting new evidence that the main benefit of a high-capacity mind is the ability to quickly and effectively suppress distracting information.

Two Modes of Attention

It has been notoriously difficult to figure out whether attention works through enhancement or suppression, because both hypothesized mechanisms of attention lead to the same behavioral outcomes. For example, imagine that you take a call on your phone while the television loudly plays in the background. To make it easier to hear the caller, you can either turn up the volume on your phone (target enhancement) or you can turn down the volume on the television (distractor suppression). In the end, either approach leads to the same result: you hear the phone call better. Luckily, even in the absence of an informative behavioral difference, neural measures can provide key insights into the underlying mechanisms driving behavior.

To uncover the relationship between working memory capacity and these two mechanisms of attention, Gaspar et al. (5) took advantage of neural markers that differentially track target selection and distractor suppression (6, 7). Specifically, the authors (5) measured two separate brain waves of the human electroencephalogram: the N2pc, which measures the enhancement of an attended target, and the distractor positivity (P_D), which measures the suppression of distractors. Gaspar et al. (5) first measured each participant's memory capacity using a standard working memory task. Next, they examined how well individuals with different working memory capacities could quickly search for a relevant target while ignoring a salient (but irrelevant) distractor item. Participants were shown 10 colored circles and attempted to locate a uniquely colored target as quickly as possible (e.g., a yellow circle among green circles). On distractor-present trials, participants needed to ignore a distractor item (e.g., red circle) to quickly find the target.

Suppression Is Key

If higher working memory capacity is related to enhanced selection of the target, then increased N2pc magnitude should correlate with working memory capacity. Similarly, if higher working memory capacity is related to better suppression of distractors, then increased P_D magnitude should correlate with working memory capacity. Of course, these possibilities are not mutually exclusive; with separate estimates of these two aspects of attention, Gaspar et al. (5) could independently assess the relative contributions of each. The strength of this design is that the authors could have observed that both attentional processes, only a single process, or neither process predicted working memory capacity.

Interestingly, high- and low-capacity participants were able to enhance the target representation equally well; there was no correlation between working memory capacity and either N2pc magnitude or latency. This means that high- and low-capacity subjects were equally good at tuning into target information. On the other hand, individuals with low working memory capacities showed selective deficits in suppressing salient, irrelevant distractors. Working memory capacity was negatively correlated with both P_D magnitude and latency. High-capacity subjects showed a large P_D that occurred early in time, suggesting that they quickly and efficiently suppressed

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distractors. On the other hand, low-capacity subjects showed a P_D that was much smaller and occurred later. This finding indicates individuals with low working memory capacities were less able to suppress distracting information and were slower to do so.

When coupled with recent findings, Gaspar et al.'s (5) work sets the stage for a more nuanced understanding of why working memory ability varies. For example, although working memory capacity is known to be a stable trait of the individual, recent work has demonstrated that working memory performance fluctuates dramatically from moment to moment within a testing session (8). In particular, low-capacity individuals have more frequent attentional lapses than high-capacity individuals, and this propensity to experience lapses contributes substantially to overall capacity estimates. In the absence of such lapse periods, low-capacity individuals can perform just as well as high-capacity individuals (8–10), suggesting that the waxing and waning of attentional control is critically important for determining working memory capacity. Thus, when coupled with Gaspar et al.'s (5) new findings, a more focused picture emerges in which low-capacity individuals are consistently inconsistent at tuning out distractions.

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