Multiple mechanisms in aging but no PASA

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We thank Craig Myrum for his thought-provoking review of our recent paper (Morcom and Henson, 2018).

A major challenge for the cognitive neuroscience of aging is to understand the degree to which adaptive brain changes contribute to maintenance of cognitive function in later life. A candidate signature of this proposed compensation is the increased activity in older people often found in functional brain imaging studies. Our study addressed the specific proposal that there is a compensatory posterior-to-anterior shift (PASA) in task-related brain activity in later life. Using a model-based multivariate decoding approach, we were able to show across two different memory tasks that the increased anterior (prefrontal) activity in older people did not carry additional information. Despite overall decreases in this task-relevant information with age, it remained possible that the relative contribution of anterior versus posterior regions increases. However, a direct comparison of models with combined versus separate brain regions showed that any "boost" provided by adding information in anterior regions did not increase with age. These results contradict predictions of the compensatory PASA theory. We suggested instead that the increased prefrontal activity reflects detrimental age-related change, such as less efficient or less specific neural processing. Like Myrum, we concluded that the data were more consistent with the view that preserving cognition in older age requires maintaining youth-like brain function.

Myrum notes that compensation and maintenance may well coexist in the aging brain. We entirely agree. Our study only tested one specific compensatory theory (PASA). For example, application of the same methods to other regions may reveal evidence of age-related increases in task-relevant information, suggesting other compensatory mechanisms. Moreover, our results apply only across the two memory domains we examined; although this is sufficient to reject PASA, which proposes a task-general compensatory shift. More generally, we agree that yet other mechanisms of plasticity and life-long maturation are likely to occur, which are not necessarily compensatory.

We appreciate Myrum's suggestion that broader conclusions about human cognitive aging benefit from converging evidence from animal models. The Arc expression studies in rats he cites are important and suggest, like human functional imaging studies, that striking differences in the patterns of brain activity in young versus old brains may be present even when gross cognitive performance is maintained. However, both imaging approaches share two intertwined challenges: to establish which of the cross-sectional differences reflect true age-related change, and to test whether they are compensatory or merely reflect detrimental effects of aging.

While we have shown that progress can be made with a simple model, it is essential to go further by testing joint models of detrimental mechanisms and the compensation they trigger (Morcom and Johnson, 2015). Animal models can contribute with shorter time-line longitudinal studies, and easier combination of functional and lesion methods. In humans, a key manipulation will be to use cognitive demand as a probe to evaluate adaptive functional responses (Cabeza et al., 2018). These multiple converging approaches are needed to build a comprehensive account of cognitive change over the lifespan.

References

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