Editorial

Specifying the Link Between Brain Integrity, Cognitive, and Affective Functioning in Aging Individuals

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This special issue presents methodologically innovative work that advances our understanding of the relationship between cognitive performance and affect, in particular highlighting the contribution of brain to behavior. Studies investigating the effects of aging on brain anatomy and physiology suggest targeted areas which are most affected by aging, and are characterized by cerebral atrophy, synaptic loss, changes in receptor numbers and function, among other anatomical changes. These changes are likely responsible for most of the observed age-related changes in cognitive function reported in many studies of aging. Identifying precisely how these brain changes affect cognition is a formidable challenge, though new testing methodologies, along with advances in neuroimaging analysis techniques, have led to testable hypotheses and models of the link between brain and behavior. A key question in the field of cognitive aging is whether we can identify factors that can account for the considerable variability that exists in cognitive decline across normal aging individuals. For example, research shows that extensive brain atrophy and synaptic density reduction can result in dementia symptoms in some individuals, while surprisingly, others are much more resilient and asymptomatic, despite having equivalent neural degradation (Katzman et al., 1988). Such protection from dementia symptoms has been linked to elevated “cognitive reserve,” defined as one’s efficiency at using existing neural circuits, and/or one’s flexibility in using compensatory mechanisms to accomplish cognitive tasks.

Propensity for physical activity, among other factors (Stern, 2012), appears to elevate cognitive reserve. It is possible that such a stimulating environment fosters plasticity, and neurogenesis, through the production of growth factors within the brain (Hötting & Röder, 2013), and these in turn could produce redundancy or duplication in the brain’s circuitry, making the brain more resilient to damage. The studies featured in this issue all aim to uncover more sensitive measures of brain integrity in the hopes of better specifying the relationship between biological changes in aging, and cognitive changes associated with aging.

Vaughan and colleagues examined whether engagement in cognitive activities would be associated with improved cognitive task performance, as well as brain volume. Because cognitive training studies have been shown to lead to macrostructural brain changes, they left open the possibility that differences in everyday level of cognitive activity could increase gray matter, allowing more of a cognitive reserve which would protect the individual from the usual age-related decline in cognitive performance. Similarly, the stability and robustness of white matter tracts (axons) may also benefit from daily cognitive activity as pathways connecting clusters of active gray matter would be strengthened by daily use, increasing their volume. In their study, engagement in cognitive activity was measured by self-reported participation in a variety of pastimes such as reading books, playing games, computer activities, and other similar activities during the previous 12 months. Vaughan and colleagues also measured cognitive performance on traditional tests of attention, working memory, verbal fluency, executive function, and memory. Magnetic resonance imaging measures of the integrity of the brain were also collected and quantified as volume of gray and white matter.

The authors showed a strong relationship between engagement in cognitive activity and cognitive performance. Thus it appears that measurable immediate benefits to task performance are possible due to lifestyle changes. Why do such activities benefit performance? It may be that regular engagement in cognitive activities allows one to build, and call on, a larger cognitive reserve or set of cognitive approaches or strategies to aid performance. Of note though, long-lasting effects on performance over time were not found, and it is likely that any significant changes in cognition over time are influenced more by biological factors. In line with this, Vaughan and colleagues showed that the volume of gray and white matter was associated with cognitive task performance, but not with self-reported daily engagement in cognitive activities.

Another study in this special issue, by Desjardins-Crépeau and colleagues similarly aimed to account for variability in age-related decline in cognition, by better specifying the physical factors that might contribute to task performance. Prior research suggests the prefrontal cortex (PFC) is particularly vulnerable is those with cardiovascular risk factors (Gunning-Dixon & Raz, 2000), suggesting to Desjardins-Crépeau and colleagues that performance on tests of executive function, mediated by the
Brain-derived neurotrophic factor (BDNF) is a secreted protein that is expressed widely in the central nervous system as psychiatric disorders such as late-life depression (LLD). Why low BDNF would play a role in LLD requires further investigation, though the study by Diniz and colleagues suggests that BDNF may potentiate other coexisting abnormalities associated with normal aging: lowered BDNF concentrations exert a negative impact by reducing one’s “brain reserve,” making it more vulnerable to further insults and contributing to increased risk for dementias.

As the previous three studies have highlighted, there are likely differences, and limitations, in how a younger versus older adult brain accomplishes cognitive tasks due to changes in the brain’s integrity. In the final study featured in this issue, Allard and Kensigner demonstrated an innovative method of documenting age differences in how the brain accomplishes a cognitive task, in this case one requiring emotional regulation. They suggest successful emotional regulation requires the use of cognitive strategies to reappraise events. This makes sense as one would want to link current information to past experiences, to allow one to gain perspective on a particularly negative or positive situation. They showed the anterior cingulate cortex’s functional connectivity with the PFC, specifically ventromedial PFC and orbitofrontal regions, was higher in older adults when completing a reappraisal of a negative film clip (with the intention of reducing their emotional reaction to the clip), compared with a passive viewing condition. Younger adults, in contrast, showed connectivity with different regions of PFC, namely the lateral portions of dorso-medial PFC, the dorso-lateral PFC, and ventro-lateral PFC. The ability of the healthy older adults in their sample, to alter their brain’s functional connectivity in light of brain changes associated with aging, is an excellent example of using cognitive reserve (i.e., relying on alternative strategies and brain regions) to solve a task. Those with reduced BDNF, and with LLD, may lack the brain reserve (specifically neurotrophic factors) needed to uphold gray matter, as well as the functional connectivity between brain regions. Without this, the ability of the individual to reappraise emotional events is compromised, and may contribute further to LLD, though of course further research is needed to test this hypothesis.

The four studies featured in this issue each allow a unique perspective on the brain–behavior relationship. Each highlights a novel testing methodology, and analysis technique, to better specify the relationship between cognitive performance, affect, and aging.

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