Frequency of Mentally Stimulating Activities Modifies the Relationship Between Cardiovascular Reactivity and Executive Function in Old Age

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Objectives: *Recent evidence suggests that younger and middle-age adults who show greater cardiovascular reactivity (CVR) to acute mental stress demonstrate better reasoning and memory skills. The purpose of this study was to examine whether older adults would exhibit a similar positive association between CVR and executive function and whether regular engagement in mentally stimulating activities (MSA) would moderate this association.* **Design:** *Secondary cross-sectional analysis.* **Setting:** *Three clinical research centers in the Midwest and on the West Coast and East Coast.* **Participants:** *A total of 487 older adults participating in an ongoing national survey.* **Measurements:** *Heart rate (HR) and low-frequency (LF) and high-frequency (HF) domains of heart rate variability (HRV) were measured at baseline and in response to standard mental stress tasks (Stroop color word task and mental arithmetic). Executive function was measured separately from the stress tasks by using five neuropsychological tests. MSA was measured by self-reported frequency of six common MSA.* **Results:** *Higher HR reactivity was associated with better executive function after controlling for demographic and health characteristics and baseline HR, and the interaction between HR reactivity and MSA was significant for executive function. Higher LF-HRV reactivity was also associated with executive function, but subsequent analyses indicated that frequency of MSA was the strongest predictor of executive function in models that included LF-HRV or HF-HRV.* **Conclusions:** *Higher HR reactivity to acute psychological stress is related to better executive function in older adults. For those with lower HR reactivity, engaging frequently in MSA produced compensatory benefits for executive function.* (Am J Geriatr Psychiatry 2013; ■:■−■)

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CVR, Cognition, and Mental Activity

The notion that the mind (central nervous system) and body (peripheral systems) interact to contribute to both mental and physical health has become increasingly evident.[1] For instance, both the sympathetic and parasympathetic branches of the autonomic nervous system regulate cardiovascular activity at rest and also in response to environmental challenges, measured as cardiovascular reactivity (CVR) from rest. Higher CVR to short-term (acute) stressors is implicated in cardiovascular health risk, such as increased incident coronary heart disease in patients with heart disease history, or elevated blood pressure,[2,3] but is also associated with positive health outcomes, including better self-perceived health and lower incident depression and obesity.[4] More recent evidence suggests that both cognitive function and CVR to acute stressors are regulated by similar neural pathways, suggesting a new avenue to explore the neurobiological underpinnings of a health outcome that is critical for older adults: age-related cognitive decline.[5]

A few recently published cross-sectional studies have found that greater CVR to acute stress is associated with enhanced cognitive performance (in particular, attention, memory, and reasoning) in younger or middle-age adults.[6–8] Similarly, in a prospective cohort study in Scotland, lower CVR was a risk factor predicting future decline in reasoning and reaction time, and the relationship was stronger in old age relative to young and middle-age groups.[9] Reasoning, attention, and reaction time are components of executive function, which is a higher-order cognitive system controlling multiple cognitive processes that regulate goal-directed behaviors and information organization.[10] Executive function declines early in the aging trajectory.[11] It is unclear whether the relationship between CVR and overall executive function remains at older ages. Furthermore, the positive association between increased CVR to acute stress and better cognitive function, as well as the other positive health outcomes observed in previous studies, may reflect a more adaptive central nervous system.[5] For instance, the prefrontal cortex (PFC), which regulates executive function, also regulates the autonomic nervous system during acute stress.[4] Thus, examining the direct relationships between executive function and CVR may shed light on links between cognitive and autonomic regulation.

A potentially important contributor to individual differences in cognitive function is lifestyle behaviors.[5,12] Routine engagement in mentally stimulating activities (MSA), such as playing puzzles, Sudoku, or computer games that rely on sustained attention and information processing, is a lifestyle behavior considered to protect against cognitive decline in the aging process; accumulated evidence supports a positive causal relationship between routinely engaging in MSA and improving cognitive function or slowing cognitive decline.[13,14] Whether MSA are related to acute stress responses is unknown but plausible. Active engagement in MSA seems to improve executive function by enhancing neuroplasticity in cortical networks,[15] including networks of the PFC,[16] which, as mentioned, also contribute to regulation of the autonomic nervous system and CVR.[17,18] Thus, MSA may be related indirectly to CVR via their effects on central physiologic stress regulation. This finding would suggest concurrent associations among MSA, CVR, and executive function. Furthermore, MSA may serve to protect cognitive function in the context of neurobiological alterations that are typically associated with impaired cognitive performance. For example, mental activities compensated for high white matter lesions in protecting processing speed in the aging process.[19] Likewise, autonomic regulation may show less covariation with cognitive function, when cognitive function is being protected by MSA. As such, we examined whether regularly engaging in MSA would diminish the association between CVR and executive function in older adults.

In this cross-sectional study, we examined the association between CVR and cognitive function by measuring cardiac activity during acute stressors (i.e., stressful mental tasks) and executive function in older adults, as well as the possible moderating effect of regular engagement in MSA. Cardiac activity at rest and in response to acute stressors was indexed according to both time and frequency domain indices derived from electrocardiogram (ECG) readings. The time domain index was heart rate (HR). Heart rate variability (HRV), a measure of the variation in the time interval between heart contractions, was derived from spectral analysis of the ECG signal to provide frequency domain indices. The high-frequency domain of HRV (HF-HRV; 0.15–0.5 Hz) indexed

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