



Difficulty, effort and cardiovascular response to a working memory challenge: Older adults with and without mild cognitive impairment[☆]



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ABSTRACT

We presented cognitively healthy older adults and patients with mild cognitive impairment (MCI) three versions of a modified Sternberg memory task designed to range in difficulty from low to high. Among cognitively healthy older adults, blood pressure responses assessed during the work periods rose with difficulty. By contrast, among MCI patients, blood pressure responses assessed during the work periods were low irrespective of difficulty. Findings are discussed primarily in relation to a conceptual analysis concerned with ability determinants of effort (task engagement) and associated cardiovascular responses. They also are discussed in the context of other recent cardiovascular studies involving older adults and with regard to the potential for exaggerated cardiovascular responses to accelerate cognitive decline in advanced age.

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1. Introduction

A long-standing program of research has addressed effects of ability on effort and associated cardiovascular (CV) responses in people confronted with performance challenges, that is, opportunities to alter some course of events by acting (Gendolla et al., 2012; Richter et al., in press; Wright, 1996, 1998; Wright and Kirby, 2001; Wright and Stewart, 2012). Studies have been guided in part by two assumptions. One is that certain CV responses – specifically those linked to beta-adrenergic stimulation of the heart – increase with effort (Ahlquist, 1948; Obrist, 1976, 1981). The other assumption is that perceptions of task difficulty are inversely proportional to ability, that is, higher for performers whose relevant capacity is low. Consider for example students pressed to run one mile in ten minutes. They should find the task harder if they are out of shape (capacity low) than if they are fit (capacity high).

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Studies also have been guided by a theory of motivation intensity by Brehm (Brehm and Self, 1989; Brehm et al., 1983; Wright, 2008; Wright and Brehm, 1989). Motivation intensity theory (MIT) asserts that effort does not vary directly with the importance of meeting performance challenges, as has been commonly assumed. Instead, it varies with the difficulty of meeting the challenges. If little effort is required to succeed, then little should be deployed. As difficulty rises, so should effort until success appears impossible or excessively difficult, given the importance of success. At and beyond this difficulty level, effort should be withheld. Thus, in short, effort should be a saw-tooth function of difficulty, first rising and then falling sharply, with the fall occurring where performers believe success will require more than they can or will do.

Combined with the assumptions, MIT offers distinctive insight into the role ability should play in determining effort and CV responses to performance challenge. One implication is that people with less ability should exert more effort and evince stronger CV responses than people with more ability so long as they view success as possible and worthwhile. Another is that those with less ability should withhold effort at a lower objective difficulty level, because success appears excessively difficult or impossible for them. This means that as difficulty rises, there should be a difficulty level or set of difficulty levels at which effort and CV responsiveness are greater for those with more ability. A third implication is that as difficulty continues to rise, a point should be reached at which even those with more ability withhold effort, because they will not or cannot do what is required to succeed. At and beyond

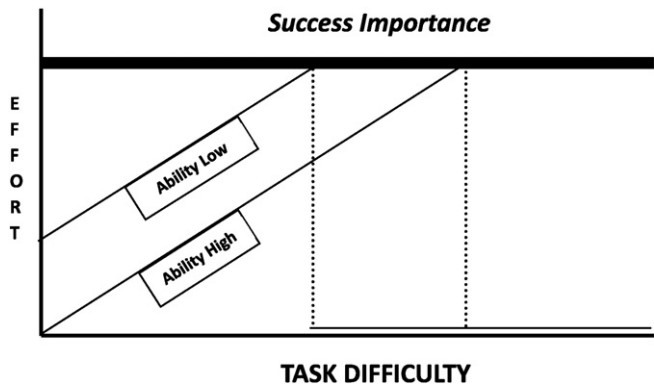


Fig. 1. Effort as a function of difficulty and ability, with effort limits determined by success importance and associated CV responses following.

this point, CV responsiveness should be low irrespective of ability (Fig. 1).

1.1. Representative evidence

Evidence for the preceding implications is robust (Brinkmann and Gendolla, 2008; Gendolla and Krüsen, 2001, 2002; Marcora et al., 2008; Schmidt et al., 2010; Stewart et al., 2009; Wright and Dismukes, 1995; Wright et al., 2003, 2007, 2012, 2013). Representative are findings from an early experiment (Wright and Dill, 1993) that (1) first led participants to believe they had low- or high scanning ability, and then (2) presented them a scanning task with instructions that they could earn a prize by meeting an objectively low or high performance standard. As expected, systolic blood pressure (SBP) responses just before and during the work period were in a crossover pattern, with diastolic blood pressure (DBP) responses running in rough parallel. Responses were or tended to be greater for low ability participants when the standard was low, but greater for high ability participants when the standard was high. The crossover effect was expected because SBP responses are partially determined by heart contraction force – considered to be a “gold standard” index of beta-adrenergic activation (Brownley et al., 2000; Fairclough and Mulder, 2012; Kelsey, 2012; Levick, 2003; Papillo and Shapiro, 1990).

1.2. Age-related cognitive decline

Recently, Hess and colleagues applied aspects of the ability analysis above to address questions pertaining to effort and CV responsiveness in older adults (Ennis et al., 2013; Hess, 2014; Hess and Ennis, 2012, 2014; Smith and Hess, 2015). They reasoned that, due to normal (i.e., asymptomatic), age-related declines in cognitive function, older adults should find it more difficult to initiate and maintain cognitive performance. As a result, older adults should try harder and evince stronger associated CV responses than younger adults so long as they perceive success as possible and worthwhile. Further, they should withhold effort at a lower objective difficulty level, with success importance determining the point at which they do so as long as they perceive success as possible (see Stewart et al., 2009). When older adults withhold effort and younger adults do not, older adults should experience diminished CV arousal relative to their younger counterparts.

Findings have been supportive. For example, Hess and Ennis (2012) found stronger SBP responses in older adults during both a fatigue induction period in which participants were presented a simple or complex counting challenge and an ensuing fatigue influence period in which participants solved multiplication problems. In a follow-up, Ennis et al. (2013) found higher difficulty appraisals and stronger SBP responses in older adults responding to a Sternberg (1966) type memory task whose difficulty was varied across trial blocks. They also

found that older adults (1) displayed greater reductions in SBP responses at higher difficulty levels and (2) evinced SBP responses that were more sensitive to rated success importance. Regarding the latter, among older adults (who as a group rated success to be more difficult), SBP responses were higher when importance appraisals were high. Among younger adults (who as a group rated success to be less difficult), SBP responses were relatively low regardless of importance appraisals.

1.3. Present research

The present research followed the theme of the preceding work by applying the ability reasoning to CV responses in cognitively healthy (i.e., asymptomatic) older adults and patients diagnosed with mild cognitive impairment (MCI), the prodromal state of clinical dementia. MCI is characterized by cognitive decline that is greater than that expected with normal aging, but not so great that it significantly interferes with everyday functions (which would be characteristic of clinical dementia) (Albert et al., 2011). MCI patients are at markedly increased risk for progressing to dementia compared to cognitively healthy older adults (Petersen, 2004). Neuropathologically, MCI is heterogeneous, but most often due to Alzheimer's disease pathology alone or Alzheimer's disease pathology plus cerebrovascular pathology (Albert et al., 2011; Schneider and Bennett, 2010).

We executed the present research with two purposes in mind. One was to leverage the resources of a specialized Alzheimer's disease research center housed in a university-based medical center. This allowed us to examine effort-related CV responses among well-characterized samples of older adults who were diagnosed by experts as cognitively healthy or as having MCI on the basis of extensive workup, including neurological and neuropsychological evaluations. The diagnosis of MCI versus cognitive health is essential, in our opinion, but has been absent in previous research (e.g., Brown et al., 2009; Ennis et al., 2013). The other purpose was to begin an exploration of CV response processes among older adults, for whom exaggerated CV responses might pose a special risk. Special risk is indicated by studies associating elevated CV responses among older adults with poorer cognition (Brown et al., 2009) and greater cerebrovascular pathology (Waldstein et al., 2004). Some have even hypothesized that cerebrovascular dysfunction is directly involved in the neuropathogenesis of Alzheimer's disease pathology (de la Torre, 2005, 2009, 2010; de la Torre and Mussivand, 1993). Insofar as elevated CV responses contribute to declines in cognition or the accumulation of neuropathology, they might hasten the progression from cognitive health to MCI and/or the progression from MCI to dementia.

The ability reasoning suggested that mild impairment should elevate the difficulty of relevant challenges, with different effort and associated CV responses following depending on the objective difficulty of the challenge at hand and the perceived importance of meeting it. So long as mildly impaired performers view success as possible and worthwhile, they should exert compensatory effort and evince CV responses that are exaggerated relative to their non-impaired peers. If mildly impaired performers' difficulty or importance appraisals are such that success appears excessively difficult or impossible, they should withhold their effort and demonstrate diminished CV arousal.

In the current study, cognitively healthy control participants and MCI patients performed three versions of a Sternberg memory task while their blood pressure and heart rate (HR) responses were monitored. Difficulty was manipulated in blocks across low, medium, and high difficulty levels by altering the duration of character strings viewed. Firm predictions regarding effort and associated CV responses were impossible considering uncertainties pertaining to the study groups, including performance capacity and success importance appraisals. However, two guiding assumptions seemed fair. The first was that the control group would view success as possible and worthwhile at all levels of challenge difficulty. The second was that the MCI group

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