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Consistency of attentional control as an important cognitive trait: A latent variable analysis

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ABSTRACT

The present study examined the extent to which consistency in attention control is an important individual difference characteristic related to other cognitive abilities. Experiment 1 demonstrated that intra-individual variability (IIV) on attention control tasks and lexical decision tasks were separate factors with IIV in the attention control factor relating to working memory capacity, fluid intelligence, and long-term memory. Experiment 2 replicated these results and further demonstrated that IIV in attention control predicted everyday cognitive failures (in particular everyday attentional failures). Experiment 3 demonstrated that IIV in attention control was related to subjective reports of mind-wandering but not external distraction, suggesting that fluctuations in attention control are linked to an individual's propensity to mind-wander. Finally, Experiment 3 demonstrated that individual differences in attention control and IIV in attention control are largely the same. These results suggest that the ability to consistently allocate attention control is an important cognitive trait.

Researchers have long been interested in mean level differences between individuals on a variety of tests and tasks. For instance, early research on psychometric intelligence was concerned primarily with finding differences between individuals on basic knowledge and reasoning tests. Likewise, in the experimental domain, much research has focused on examining how individuals differ in speed and accuracy on a number of memory and attention tasks. In each case the dependent variable of interest is a given individual's mean level of performance on the task. Recently, renewed interest has been focused on examining the importance of consistency (or intra-individual variability) in responding on a variety of tasks (e.g., Der & Deary, 2006; Dykiert, Der, Starr, & Deary, 2012; Fiske & Rice, 1955; Hultsch, Strauss, Hunter, & MacDonald, 2008; MacDonald, Nyberg, & Bäckman, 2006; Salthouse, 2007; Stuss, Murphy, Binns, & Alexander, 2003). The focus of this research has been on the amount a given individual varies around their own mean level of performance and how much variability a given individual demonstrates relative to other individuals. Thus, here the main dependent variable of interest is not the mean level of performance, but rather indices of variability (such as individual standard deviation and coefficient of variation).

Much of the work that has been done on intra-individual variability (IIV) has relied on reaction time (RT) tasks. Assume that not only do individuals differ in their mean RT, but individuals also differ in the amount of variability around their mean. That is, Individual A may respond more rapidly on average than Individual B, and there may also be differences in the amount of variability that Individual A demonstrates relative to Individual B. Additionally, it is possible that two individuals will have the same mean RT values, but one individual may have more overall variability (at both the upper and lower ends of the distribution) than the other. Thus, the amount of dispersion an individual demonstrates in their RT distributions can provide some indication of how efficiently aspects of their cognitive system are operating. In particular, the current study focuses on inconsistency, or fluctuations in RT that occur over short intervals (i.e., trial-to-trial variability).

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Prior work examining IIV in different populations has provided evidence consistent with these notions by demonstrating that older adults are more variable than younger adults, frontal patients are more variable than matched controls depending on lesion location, patients with various forms of traumatic brain injury are more variable than normal participants, both Alzheimer's and Parkinson's patients are more variable than normal elderly adults, schizophrenic patients are more variable than control participants, and individuals with attention deficit hyperactivity disorder are more variable than control participants, to name a few (e.g., Der & Deary, 2006; Duchek et al., 2009; Dykiert et al., 2012; Jackson, Balota, Duchek, & Head, 2012; Leth-Steensen, Elbaz King, & Douglas, 2000; MacDonald et al., 2006; Salthouse, 2007; Stuss et al., 2003; Tse, Balota, Yap, Duchek, & McCabe, 2010). Furthermore, a great deal of work examining the relation between RT and measures of intelligence has suggested that IIV in RT is moderately correlated with an individual's level of intelligence (see Jensen, 1992, 1998, 2006 for reviews). Thus, it seems clear that a number of groups who are thought to differ in basic cognitive functioning not only differ on average levels of performance, but also differ in the amount of IIV that they demonstrate. This suggests that this variability may provide an index of the amount of noise or fluctuations in the system which may be associated with mean levels of performance (Li, Lindenberger, & Sikstrom, 2001). That is, these fluctuations provide information about the efficiency of the cognitive system overall as well as determining, in part, mean levels of performance. As such, this points to the need to better examine IIV across tasks and examine the extent to which IIV is related to other cognitive and abilities.

Several researchers have suggested that increases in IIV are related to fluctuations in attention control which can lead to lapses of attention (Duchek et al., 2009; Jackson et al., 2012; Jensen, 1992; Unsworth, Redick, Lakey, & Young, 2010; West, 2001; West, Murphy, Armilio, Craik, & Stuss, 2002) or to overall goal neglect (De Jong, Berendsen, & Cools, 1999). In these views it is assumed that it is difficult to maintain attention on a task goal and therefore sustain attention on the task at hand when internal and external interference and distraction are high (Engle & Kane, 2004). In these situations when attention is tightly focused on the task goal performance will be both fast and accurate. However, if attention is not tightly focused on the task goal, lapses of attention can occur which will lead to overall slower responses or to very fast errors that are guided by prepotent tendencies (Unsworth, Schrock, & Engle, 2004). Evidence consistent with these views is the finding that low ability participants (i.e., low working memory, low fluid intelligence) demonstrate a large number of slow responses and an increase in the number of cases found in the tail of the upper end of the distribution which leads to an increase in overall variability compared to high ability participants (e.g., McVay & Kane, 2012; Schmiedek, Oberauer, Wilhelm, Süß, & Wittmann, 2007; Unsworth, Redick, Spillers, & Brewer, 2012; Unsworth, Redick, et al., 2010). This suggests that fluctuations in the efficiency of attention control processes may be an important reason for individual differences in cognitive abilities. Some individuals (high ability individuals) have more efficient attention control processes that allow them to consistently maintain attention on a demanding task than other individuals (low ability individuals) who cannot adequately maintain attention on tasks, but rather experience more fluctuations or lapses of attention leading to performance decrements. This suggests that it is not the overall amount of attention control that matters, but rather how efficiently and consistently one can allocate attention control processes to maintain optimal levels of performance.

Collectively prior work suggests that consistency in attention control might be an important cognitive trait that is linked to a number of other cognitive abilities. However this has not been fully evaluated in prior studies as most prior work has examined IIV in single tasks, has not examined how IIV is related across tasks, and has not examined how IIV is related to other important cognitive abilities such as working memory capacity and fluid intelligence. Thus, a number of outstanding questions remain in determining whether consistency in attention control is an important cognitive trait.

The aim of the present study was to better examine the notion that consistency in attention control is a reliable and valid cognitive trait linked to cognitive abilities in and out of the laboratory. Therefore, four main questions were addressed. First, is there a general consistency factor or does the type of task matter? Specifically, if IIV partially reflects fluctuations in attention control then IIV across a variety of attention control tasks should correlate and form a factor. Additionally, IIV is found in other RT tasks, such as simple and choice RT tasks. Is IIV in these non-attention demanding RT tasks the same as IIV found in attention control tasks? If IIV represents a general trait then IIV across multiple different measures should all correlate and load on the same general factor. But, if IIV in attention control tasks is different from IIV on other tasks then two factors should be found, one for the attention control measures and one for the non-attention RT tasks.

Second, is IIV related to other cognitive abilities such as working memory capacity, fluid intelligence, long-term memory, etc.? If IIV is an important cognitive trait then individual differences in IIV should be related to individual differences in other cognitive abilities. Furthermore, and in relation to the first question, if there are two separate IIV factors, then it is possible that IIV in attention control is related to other cognitive abilities, but IIV in non-attention demanding RT tasks is not related to other cognitive abilities over and above that of attention control. That is, only fluctuations in attention control are related to broad cognitive abilities.

Third, does consistency (or inconsistency) predict real world cognitive failures? If IIV represents fluctuations in attention control then these fluctuations should not only be related to performance on basic laboratory measures, but these fluctuations should predict who is likely to experience cognitive failures in the real world. In particular, IIV measured in the laboratory should predict real world attentional failures.

Finally, if IIV represents fluctuations or lapses in attention then it is important to understand what underlies these fluctuations. In particular, it is possible that lapses of attention are partially due to individuals experiencing off-task thoughts such as mind-wandering about topics unrelated to the experiment (e.g., daydreaming about an upcoming vacation) or being distracted by external information present during the experiment (e.g., a flickering overhead light or a cold room). Thus, IIV might reflect fluctuations in attention whereby participants shift their focus from the experiment inward to more personally pressing concerns (mind-wandering) or to other external information that is distracting (external distraction).