Journal of Applied Research in Memory and Cognition 1 (2012) 214–216

Contents lists available at SciVerse ScienceDirect

Journal of Applied Research in Memory and Cognition

journal homepage: www.elsevier.com/locate/jarmac

Commentary

The future promise of Cogmed working memory training

Bradley S. Gibson*, Dawn M. Gondoli, Ann C. Johnson, Christine M. Steeger, Rebecca A. Morrissey

University of Notre Dame, United States

ARTICLE INFO

Article history:
Received 6 July 2012
Accepted 10 July 2012

The idea that working memory capacity (WMC) might be improved following adaptive training interventions has received considerable attention from researchers over the past decade, as evidenced by the publication of at least seven major reviews within the past two years. Although several of these reviews have expressed varying degrees of optimism about the current state of the field (Buschkuehl & Jaeggi, 2010; Diamond & Lee, 2011; Klingberg, 2010; Morrison & Chein, 2011), several other, more recent, reviews have been considerably more pessimistic (Melby-Lervåg & Hulme, 2012; Shipstead, Redick, & Engle, 2012). In their target article, Shipstead, Hicks, and Engle (2012) continue this latter trend by concluding that one well-known and widely used WM intervention known as Cogmed does not provide effective training of WMC or associated higher-level abilities.

Rather than focus on the strengths and weaknesses of previous Cogmed WM training studies, the main focus of this commentary will be to discuss the future promise of Cogmed WM training. In their concluding remarks about the future of WM training, Shipstead et al. state, “we do not rule out the possibility that WM training could be made effective. The largest issue seems to be that, while there is logic to WM training (increase WM and improve related abilities), this literature is still struggling to find a theory” (p. 22). We agree wholeheartedly with this assessment. Fortunately, there are several prominent theories of WMC that could be used to guide future studies of WM training, and below we will describe our own attempts to apply one such theory to WM training. Based on our preliminary findings, we will attempt to make two points in this commentary: (1) there are good reasons to believe that the full potential of Cogmed WM training has not yet been adequately tested; and (2) theories of WMC also have much to gain from empirical studies of WM training.

But first, it is important to recognize that no existing theory of WMC explicitly predicts that capacity should change following training. Indeed, existing theories of WMC attempt to explain differences in capacity that are observed across individuals at a single point in time and not changes in capacity that may occur within an individual across time. Rather, the expectation that capacity may change follows from more general hypotheses about the plasticity of the mind and brain. Thus, it may not be too surprising that initial studies of WM training were designed to test this more general hypothesis about the plasticity of WMC and associated higher-level cognitive abilities without regard for the specific mechanisms that were involved (Olesen, Westerberg, & Klingberg, 2004). However, now that preliminary evidence for the plasticity of WMC has been provided, it is time to understand the nature of this change. For this, we need to attempt to apply existing theories that explain why WMC varies across individuals at a single point in time to training interventions that seek to change WMC within an individual across time.

> “There is nothing so practical as a good theory.”—Kurt Lewin

The validity and utility of WM training interventions will ultimately be judged by their ability to influence higher-level cognitive abilities, as well as by their ability to reveal the causal etiology of these “far transfer effects.” Existing research has demonstrated that individual differences in WMC (as measured by complex-span tasks) correlate positively with individual differences in higher-level cognitive abilities such as fluid IQ. However, WMC is a complex construct, and not all components of WM are thought to be equally important for distinguishing between high-capacity and low-capacity individuals, or for supporting associated differences in higher-level cognitive abilities.

Theories of WMC may have important implications for the design of WM training interventions because it is in virtue of these theories that we come to understand which components of WM

DOI of original article: http://dx.doi.org/10.1016/j.jarmac.2012.06.003.

* Corresponding author at: 118 Haggar Hall, Department of Psychology, University of Notre Dame, Notre Dame, IN 46556, United States. Tel.: +1 574 631 7138; fax: +1 574 631 8883.

E-mail address: bgibson@nd.edu (B.S. Gibson).

http://dx.doi.org/10.1016/j.jarmac.2012.07.003

distinguish high-capacity individuals from low-capacity individuals, and which are important for supporting higher-level cognitive abilities. For instance, some theories have focused exclusively on attention mechanisms such as "executive attention" (Kane & Engle, 2002) or the "focus of attention" (Cowan et al., 2005), whereas other theories have focused exclusively on memory mechanisms such as cue-dependent retrieval (Mogle, Lovett, Stawski, & Sliwinski, 2008).

In our opinion, the theory that has the most promise for WM training interventions is one that acknowledges contributions from both attention and memory mechanisms (Unsworth & Engle, 2007). Evidence in support of this "dual-component" theory has come from two types of experiments. The first type is an extreme groups approach in which individuals who fall in the top and bottom quartiles of WMC abilities (as measured by complex-span tasks) are compared (Unsworth & Engle, 2007). These findings have shown that high-capacity individuals differ from low-capacity individuals in terms of both attention and memory abilities. The second type is a latent variable approach in which the full range of individual abilities is investigated within the context of structural equation modeling (Unsworth & Spillers, 2010). These findings have shown that both individual differences in attention and memory abilities contribute more or less equally to individual differences in overall WMC and fluid IQ. These findings may have important implications for the design of WM training interventions because they suggest that that an intervention that can target both components of WMC should be more potent than an intervention that can target only one component.

Recently, we have investigated whether the attention component, the memory component, or both components of WMC could be enhanced by the Cogmed WM training intervention (Gibson et al., 2011). The main findings showed that the intervention selectively improved the attention component, but not the memory component of WMC. Consequently, the potential benefits of standard Cogmed may not be as potent as they could be.

Fortunately, the dual-component theory also provides a framework for modifying aspects of the Cogmed intervention so that it might target both components of WMC. We have detailed the rationale behind two possible modifications, as well as our progress toward reaching this goal, in our recent papers. Suffice it to say that after initial failure (Gibson, Kronenberger, Gondoli, Johnson, Morrissey, & Steeger, 2012), we believe that it is possible to design an intervention that can target both components (Gibson et al., submitted for publication). For this reason, we believe that the full potential of Cogmed WM training has not yet been adequately tested.

> "If you want truly to understand something, try to change it."—Kurt Lewin

We have thus far argued that the dual-component theory has important implications for the design of WM interventions because it clearly specifies which aspects of WMC should be targeted by these interventions. In addition, these theories also allow us to make quantitative predictions about the relative potency of these interventions. For instance, according to the dual-component theory, an intervention that targets both components of WMC should have stronger effects on WMC and higher-level abilities than an intervention that targets only one component.

However, one important limitation of the dual-component theory (and the other single-component theories noted above) is that it has been based exclusively on pre-existing differences in WMC observed across individuals at single point in time. In other words, up to this point in time, it has been impossible to randomly assign individuals into groups of different WMC. This is no trivial matter. As a result of this non-random assignment (or natural variation) it remains possible that some other critical factor may co-vary with this group assignment (or natural variation) and cause the observed relations. If WM training can truly change the WMC of an individual from low to high, then these interventions may actually provide a means of randomly assigning individuals to high-capacity and low-capacity conditions, or to one-component and two-component conditions. For this reason, theories of WMC may have just as much to gain from empirical studies of WM training as the design of WM training interventions has to gain from theories of WMC.

In conclusion, we agree with Shipstead et al. that the full potential of WM training is not likely to be realized unless these efforts are brought into closer alignment with current theories of WM. Based on our own recent theoretical analysis, we believe that the standard Cogmed WM training intervention may not be as potent as it could be because it appears to target only one of two important components of WMC. Within this theoretical context, Shipstead et al.'s conclusion that standard versions of Cogmed have resulted in weak or ineffective training of WMC and associated abilities is neither surprising nor cause for concern; rather, such findings are entirely consistent with current theories of WMC. Hence, the full potential of Cogmed WM training remains unknown at this point in time. Perhaps more importantly, if an intervention that targets both components can be developed, the possibility remains that Cogmed WM training can fulfill its promise not only as an effective intervention with a number of practical applications, but also as a powerful experimental tool by which to test theories of WMC.

References

Buschkuehl, M., & Jaeggi, S. M. (2010). Improving intelligence: A literature review. *Swiss Medical Weekly*, *140*, 266–272.

Cowan, N., Elliott, E. M., Saults, J. S., Morey, C. C., Mattox, S., Hismjatullina, A., et al. (2005). On the capacity of attention: Its estimation and its role in working memory and cognitive aptitudes. *Cognitive Psychology*, *51*, 42–100.

Diamond, A., & Lee, K. (2011). Interventions shown to aid executive function development in children 4 to 12 years old. *Science*, *333*, 959–964.

Gibson, B. S., Gondoli, D. M., Johnson, A. C., Steeger, C. M., Dobrzenski, B. A., & Morrissey, R. A. (2011). Component analysis of verbal versus spatial working memory training in adolescents with ADHD: A randomized, controlled trial. *Child Neuropsychology*, *17*, 546–563.

Gibson, B. S., Gondoli, D. M., Kronenberger, W.G., Johnson, A. C., Morrissey, R. A., & Steeger, C. M. *Development of an adaptive training intervention that can target the secondary memory component of working memory capacity*, submitted for publication.

Gibson, B. S., Kronenberger, W.G., Gondoli, D. M., Johnson, A. C., Morrissey, R. A., & Steeger, C.A. (2012). Component analysis of simple span versus complex span adaptive working memory exercises: A randomized, controlled trial. *Journal of Applied Research in Memory and Cognition 1*, 179–184.

Kane, M. J., & Engle, R. W. (2002). The role of prefrontal cortex in working-memory capacity, executive attention, and general fluid intelligence: An individual-differences perspective. *Psychonomic Bulletin & Review*, *9*, 637–671.

Klingberg, T. (2010). Training and plasticity of working memory. *Trends in Cognition Sciences*, *14*, 317–324.

Melby-Lervåg, M., & Hulme, C. (2012, May 21). Is working memory training effective? A meta-analytic review. *Developmental Psychology*, http://dx.doi.org/10.1037/a0028228(advance online publication)

Mogle, J. A., Lovett, B. J., Stawski, R. S., & Sliwinski, M. J. (2008). What's so special about working memory? An examination of the relationships among working memory, secondary memory, and fluid intelligence. *Psychological Science*, *19*, 1071–1077.

Morrison, A. B., & Chein, J. M. (2011). Does working memory training work? The promise and challenges of enhancing cognition by training working memory. *Psychonomic Bulletin & Review*, *18*, 46–60.

Olesen, P. J., Westerberg, H., & Klingberg, T. (2004). Increased prefrontal and parietal activity after training of working memory. *Nature Neuroscience*, *7*, 75–79.

Shipstead, Z., Hicks, K. L., & Engle, R. W. (2012). Cogmed working memory training: Does the evidence support the claims? *Journal of Applied Research in Memory and Cognition 1*, 185–193.

Shipstead, Z., Redick, T. S., & Engle, R. W. (2012). Is working memory training effective? *Psychological Bulletin*, *138*, 628–654.

Unsworth, N., & Engle, R. W. (2007). The nature of individual differences in working memory capacity: Active maintenance in primary memory and controlled search from secondary memory. *Psychological Review*, *114*, 104–132.

Unsworth, N., & Spillers, G. J. (2010). Working memory capacity: Attentional control, secondary memory, or both? A direct test of the dual-component model. *Journal of Memory and Language*, *62*, 392–406.