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Storing information in-the-world: Metacognition and cognitive offloading in a short-term memory task ☆

Evan F. Risko *, Timothy L. Dunn

University of Waterloo, Canada

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ABSTRACT

We often store to-be-remembered information externally (e.g., written down on a piece of paper) rather than internally. In the present investigation, we examine factors that influence the decision to store information in-the-world versus in-the-head using a variant of a traditional short term memory task. In Experiments 1a and 1b participants were presented with to-be-remembered items and either had to rely solely on internal memory or had the option to write down the presented information. In Experiments 2a and 2b participants were presented with the same stimuli but made metacognitive judgments about their predicted performance and effort expenditure. The spontaneous use of external storage was related both to the number of items to be remembered and an individual's actual and perceived short-term-memory capacity. Interestingly, individuals often used external storage despite its use affording no observable benefit. Implications for understanding how individuals integrate external resources in pursuing cognitive goals are discussed.

1. Introduction

Human cognition often involves, as an integral part, the manipulation of the body and/or physical/social environment (e.g., Barrett, 2011; Clark & Chalmers, 1998; Goldin-Meadow, 2005; Hutchins, 1995; Kirsh & Maglio, 1994; Pfeifer & Bongard, 2006; Zhang & Norman, 1994). Indeed, our ability to adaptively integrate internal with external processes likely represents a defining feature of what it means to be a successful cognitive agent in a complex environment. Understanding how the cognitive system goes about integrating internal with external processes in pursuit of a cognitive goal is attracting renewed interest (Chisholm, Risko, & Kingstone, 2013, 2014; Dunn & Risko, in press; Eskritt, Lee, & Donald, 2001; Eskritt & Ma, 2014; Fu, 2011; Gilbert, 2015a,b; Kirsh, 2010; Landsiedel & Gilbert, 2015; Risko, Medimorec, Chisholm, & Kingstone, 2014; Sparrow, Liu, & Wegner, 2011; Storm & Stone, 2015) with the increasing popularity of perspectives emphasizing the central role of the body and physical/social environment in cognition (e.g., embodied/embedded cognition; e.g., Glenberg, 2010; distributed cognition; e.g., Michaelian & Sutton, 2013). In considering the interaction between internal and external processes, researchers often describe the latter as being used to "lighten the load" on the former, a phenomenon referred to as cognitive offloading (e.g., Gilbert, 2015a,b; Goldin-Meadow, Nusbaum, Kelly, & Wagner, 2001; Landsiedel & Gilbert, 2015; Martin & Schwartz, 2005; Risko et al., 2014; Storm & Stone, 2015; Wilson, 2002). In the present

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* Corresponding author at: Department of Psychology, University of Waterloo, 200 University Ave W, Waterloo, ON N2L 3G1, Canada.
E-mail address: efrisko@uwaterloo.ca (E.F. Risko).

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investigation we introduce an adaptation of a short-term memory task that allows for the experimental investigation of cognitive offloading in a memory task. We use this paradigm to investigate the factors that determine whether an individual decides to store some to-be-remembered information in-their-head (e.g., in short term memory) versus in-the-world (e.g., written on a piece of paper), how they use the latter when they choose to do so, and the associated metacognitions.

The fledgling literature on cognitive offloading can be usefully divided into addressing two fundamental questions (1) the consequences of cognitive offloading or how does offloading influence cognitive processing and (2) the selection problem or how do we decide, if given the choice, to offload. While cognitive offloading is not limited to any one particular domain (see Risko et al., 2014 for work in the perceptual domain), this behavior is often discussed in the context of memory tasks. One common example of offloading internal memory demands onto the environment is to record to-be-remembered information in some external medium (e.g., write, type into a computer; Cary & Carlson, 1999, 2001; Eskritt & Ma, 2014; Eskritt et al., 2001; Intons-Peterson & Fournier, 1986; Sparrow et al., 2011; Storm & Stone, 2015). Returning to the two questions outlined above, researchers have begun to explore both how this behavior influences memory (or performance in a task involving memory) and how an individual decides to store to-be-remembered information internally or externally.

With respect to the memorial consequences of offloading, Sparrow et al. (2011) demonstrated that participants who typed to-be-remembered information into a computer that they expected would save the information remembered less than individuals who typed to-be-remembered information into a computer and did not think it would be saved (memory was assessed in both cases without the memory aid). The authors attributed this effect to the former group not putting the effort into encoding the information. In a similar vein, Eskritt and Ma (2014; see also Eskritt et al., 2001) compared memory for identity and location information in a concentration game and gave half the participants the opportunity to study and take notes (which they expected to have access to during the test) and the other half only the opportunity to study the information. A memory test with the notes group's notes removed revealed equivalent memory for identity information but impaired memory in the note-taking group for location information relative to the study-only group. The author's attributed this pattern to individuals engaging in a kind of intentional forgetting (via external storage) of the location information because it was the more difficult type of information to store internally. Consistent with this kind of idea, Storm and Stone (2015) recently demonstrated that offloading can improve memory for non-offloaded items by reducing pro-active inhibition. Thus, it seems clear that the decision to store information in-the-world versus in-the-head has consequences for memory performance.

A critical feature of most experiments focused on the consequences of cognitive offloading for cognitive processing is that participants are in a sense compelled to engage in the putative offloading behavior thus allowing for a clean comparison of the impact of offloading (see Siegler & Lemaire, 1997 for discussion of the underlying logic). For example, in Storm and Stone (2015) participants either had to save information in a file or had to store it in memory – they did not choose one strategy or the other. While permitting a direct comparison of the influence of these different strategies, this kind of design does not allow for an investigation into how individuals decide to offload in the first place. Our day-to-day cognitive lives are full of decisions either to complete some cognitive task while relying solely on internal resources or by integrating some external resource (e.g., "do I write this down or just try to remember it"). It is to the nature of this decision that we turn in the present investigation.

The decision to offload internal processing onto some external medium is most often conceived of as being based on an effort based cost benefit analysis (Cary & Carlson, 2001; Clark, 2010; Gray & Boehm-Davis, 2000; Gray, Sims, Fu, & Schoelles, 2006; Kirsh, 2010; Risko et al., 2014). While intuitive, one important issue with this approach is the difficulty inherent in operationalizing effort independently of the behavior (Dunn & Risko, in press). One common answer to this issue is to define effort in terms of performance (i.e., X is more effortful than Y to the extent that X takes longer and/or leads to more errors during performance). For example, Gray et al. (2006) define effort explicitly in terms of time. In the present context, such a view would suggest that individuals would rely on an external strategy to the extent that it improves performance (in this case accuracy in a memory task) relative to relying on internal storage. This is a straightforward and testable claim but two issues arise when considered more deeply. First, this approach blurs the possible distinction between maximizing performance and minimizing effort and second it implies a mechanism for online performance monitoring or making judgments about how the use of external processes might influence performance, but leaves the nature of that mechanism unclear. One potential mechanism for performing this latter function, which has been discussed recently, is through some form of metacognitive processing (Arango-Muñoz, 2013; Dunn & Risko, in press; Gilbert, 2015a,b). Metacognition is thought to involve metacognitive monitoring, which involves an individual's subjective assessment of their cognitive processing, and metacognitive control, which involves actions taken to regulate cognition (e.g., Nelson & Narens, 1990; Koriat, 2007). From this perspective, cognitive offloading can be seen as a form of metacognitive control based on a subjective assessment of the relative costs/benefits of integrating an external process versus performing a given cognitive function while relying completely on internal means. In Experiments 1a and 1b we focus on participant's spontaneous use of offloading and the performance associated with storing information in-the-world versus in-the-head in a novel variant of an STM task. In Experiments 2a and 2b we focus on the subjective assessment of performance (accuracy) and effort and their relation to choice behavior in the same STM task.