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Working memory capacity, short-term memory capacity, and the continued influence effect: A latent-variable analysis

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ABSTRACT

Misinformation often affects inferences and judgments even after it has been retracted and discredited. This is known as the continued influence effect. Memory processes have been theorized to contribute to the continued influence effect, and much previous research has focussed on the role of long-term memory processes at the time misinformation is retrieved during inferential reasoning and judgments. Recently, however, experimental research has focussed upon the role of working memory (WM) processes engaged in the updating and integration of information, when the retraction is encoded. From an individual differences perspective, susceptibility to continued influence effects should be predicted by a person's WM abilities, if continued reliance on misinformation is influenced, at least in part, by insufficient integration of the initial misinformation and its subsequent retraction. Consequently, we hypothesized that WM capacity would predict susceptibility to continued influence effects uniquely and more substantially than short-term memory (STM) capacity. Participants (N = 216) completed a continued-influence task, as well as a battery of WM and STM capacity tasks. Based on a latent variable model, our hypothesis was supported (WM capacity: $\beta = -0.36$, $p = .013$; STM capacity: $\beta = 0.22$, $p = .187$). Consequently, we suggest that low WM capacity is a measurable "risk factor" for continued reliance on misinformation.

1. Introduction

1.1. The continued influence effect

When individuals are provided with incorrect information about a certain event or causality, they may still rely upon this misinformation in their inferential reasoning even after the information has been retracted and discredited; this phenomenon is known as the continued influence effect (CIE; Johnson & Seifert, 1994; Lewandowsky, Ecker, Seifert, Schwarz, & Cook, 2012). For example, participants may be presented with a report, where a sentence will explicitly disconfirm an earlier sentence (e.g., "A driver involved in a car crash was thought to be drunk" is shortly followed by "Police later stated the driver was not drunk"). When participants are subsequently presented with inference statements that they are asked to agree/disagree with (e.g., "The driver should be charged with drink driving"), participants' responses are often significantly biased by the original retracted misinformation, despite this misinformation being explicitly stated to be false.

The CIE makes the spread of misinformation particularly concerning. For example, it is a matter of public concern if misinformation, such as the mythical link between childhood vaccinations and autism, results in adverse public health outcomes, such as decreased vaccination rates and increased rates of vaccine-preventable disease (Larson, Cooper, Eskola, Katz, & Ratzan, 2011). The societal impact of misinformation has been of particular concern since the rise of social media; for example, it has been reported that in the lead-up to the 2016 U.S. Presidential election, the 20 most popular fake news stories got over 1.3 million more Facebook shares, reactions, and comments than the 20 most popular legitimate stories (Silverman, 2016). Thus, it is clear that research into the CIE is timely and important (also see Lewandowsky, Ecker, & Cook, 2017).

1.2. Predictors of the CIE

Previous cognition research has theorized that the CIE may result primarily from memory retrieval failure (Ecker, Lewandowsky, & Tang, 2010; Swire, Ecker, & Lewandowsky, 2017). This view assumes that memory entries compete for activation during retrieval, regardless of their validity (Ayers & Reder, 1998). A piece of stored misinformation that can be plausibly situated within a retrieved event may thus be automatically activated by a given retrieval cue. If this occurs in the context of an inferential reasoning task, strategic monitoring processes

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will be needed to prevent the activated piece of misinformation from influencing the reasoning process. If strategic monitoring fails, however, reliance on misinformation may occur. A related view assumes that retractions lead to the "tagging" of misinformation as incorrect (Ecker, Lewandowsky, Swire, & Chang, 2011; Gilbert, Krull, & Malone, 1990); this retraction tag may not be recovered during memory retrieval (Mayo, Schul, & Burnstein, 2004), allowing the misinformation to unfold its impact without being offset by its retraction.

By contrast, reliance on corrected misinformation may also arise when there is a failure to integrate a piece of misinformation with its retraction and then update one's mental event model accordingly (Kendeou, Walsh, Smith, & O'Brien, 2014; Rapp & Kendeou, 2007; Verschueren, Schaeken, & D'Ydewalle, 2005). In other words, to the extent that processing of the retraction does not result in immediate, adequate updating and revision of the initial, incorrect event model, later reasoning may rely unduly on corrected misinformation. A recent neuroimaging study lends some support to this notion, as the CIE was associated with failure of integration and coherence-building mechanisms mediated by the medial parietal and dorsolateral pre-frontal cortex (Gordon, Brooks, Quadflieg, Ecker, & Lewandowsky, 2017).

If the CIE arises from integration failure during (or immediately after) encoding of the retraction, then a person's ability to integrate conflicting pieces of information, and transform and update the corresponding mental event model accordingly, should be predictive of CIE susceptibility. Arguably, integration and updating processes are core functions of working memory (WM), and thus, a person's WM capacity should predict their susceptibility to the CIE.

1.3. *Working memory and short-term memory*

WM is a limited capacity system that is responsible for the storage, manipulation, and updating of information required for ongoing cognition (Baddeley & Hitch, 1974; Oberauer, 2009), whereas short-term memory (STM) refers to just the passive storage of information (Atkinson & Shiffrin, 1968). That is, STM could be considered a subcomponent of WM, consistent with Baddeley and Hitch's (1974) model of WM where the slave systems (the phonological loop and the visuospatial sketchpad) are STM constructs, and the central executive is associated with the active manipulation and updating of information (Engle, Tuholski, Laughlin, & Conway, 1999). As such, WM capacity is typically measured with complex-span tasks, whereas more traditional simple-span tasks are thought to measure the storage component only, viz. STM capacity. Engle et al. (1999) and Kane, Bleckley, Conway, and Engle (2001), among others, have suggested that the major difference between WM and STM is that WM requires additional attentional control processes in order for updating, manipulation, and removal of information to occur. Correspondingly, this would help explain why WM capacity often correlates more substantially with executive functions and fluid reasoning, in comparison to STM capacity (Cowan, 2008). Given that a retraction of misinformation requires information integration and the updating of a mental model, it seems plausible that WM capacity may be more strongly associated with the CIE than STM capacity.

1.4. *Summary and purpose*

In summary, the CIE may arise from a failure of WM processing. That is, misinformation may continue to be relied upon as a result of incomplete or incorrect updating, manipulation, and removal of information from WM, as opposed to mere storage of information. Consequently, the purpose of this investigation was to evaluate the potential differential validity associated with WM capacity and STM capacity as predictors of the CIE. To our knowledge, no studies have yet investigated memory variables as potential predictors of a person's susceptibility to the CIE; this was the aim of the present study. Two hypotheses were proposed. First, it was hypothesised that WM and STM capacity would be related, but to some degree distinct, constructs, as evaluated from a latent variable perspective. Secondly, it was hypothesised that WM capacity would be substantially and uniquely associated with the CIE, in contrast to STM capacity.

2. Method

2.1. *Participants*

Participants were 285 undergraduate students from the University of Western Australia. Based on various a-priori outlier and minimum-performance criteria (see below), 69 participants were excluded from analysis, yielding a final sample of $N = 216$ participants (139 female, 75 male, 2 other; mean age $M = 22.8$ years, $SD = 7.0$, range 18–58). Participants received course credit for participation.

2.2. *Materials*

The study involved six memory tasks—two verbal tasks and a visuospatial task assessing WM and STM capacity, respectively. Memory tasks were administered online through Inquisit Web Player 5.0.6 (Millisecond Software, Seattle, WA). The misinformation task was administered online via Qualtrics software (Qualtrics, Provo, UT).

2.2.1. *WM capacity tasks*

The present study used three complex-span tasks—symmetry span (SS), operation span (OS), and reading span (RS)—to measure WM capacity. These paradigms are described in detail by Redick et al. (2012). In the OS and RS tasks, participants were presented with visual sequences of letters (set size 3–7) that needed to be recalled in order at the end of each trial. Each study letter was preceded by either a sentence problem in the RS task (e.g., "Andy was stopped by the policeman because he crossed the yellow heaven.") or a mathematical problem (e.g., "$8 \times 2 - 8 = 9$") in the OS task. For each distractor, participants had to decide whether the sentence made sense or if the proposed math solution was correct. Letter recall was tested by asking participants to select letters from a provided matrix of 10 letters (i.e. the 3–7 targets and the remainder were distractors).

In the SS task, participants were presented visual sequences of red squares (set size 3–7) in a 4 × 4 matrix. Each study item was preceded by a symmetry judgment: participants were shown an abstract black and white image and had to decide whether it was symmetrical along the vertical axis. Serial recall of the squares was tested by asking participants to click on the cells of a 4 × 4 matrix in the order that the study squares had appeared in. For all three WM capacity tasks, partial credit unit scoring was used in line with recommendations by Conway et al. (2005).

2.2.2. *STM capacity tasks*

Forward digit span and forward letter span were identical tasks with the exception of the presented stimuli. Participants were presented with digit/letter sequences and had to recall them in order by selecting the digits/letters from a circular array of ten digits/letters with the mouse. The initial set size was 3; if a trial was completed correctly, set size increased by 1 on the following trial; if a participant completed consecutive trials of a given set size incorrectly, set size decreased by 1. In total, there were 14 trials, and the greatest achievable set size was 16. The dependent variable extracted from these tasks was the maximum set size a participant correctly recalled.

In the Corsi block task, participants were presented with a screen of nine squares. Squares lit up in a predetermined sequence and participants were then asked to recall it by clicking on the squares in the order they had lit up. Initial set size was 2. There were two trials at each set size, and set size then increased by 1 if at least one of the two trials was completed correctly. If neither of the two trials at a set size were completed correctly, the task was discontinued. In total, there was a