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Review

How is working memory content consciously experienced? The 'conscious copy' model of WM introspection

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ABSTRACT

We address the issue of how visual information stored in working memory (WM) is introspected. In other words, how do we become aware of WM content in order to consciously examine or manipulate it? Influential models of WM have suggested that WM representations are either conscious by definition, or directly accessible for conscious inspection. We propose that WM introspection does not operate on the actual memory trace but rather requires a new representation to be created for the conscious domain. This conscious representation exists in addition and in parallel to the actual memory representation. The existence of such a separate representation is revealed by and reflected in the qualitatively different functional characteristics between the actual memory trace and its conscious experience, and their distinct interactions within external visual input. Our model differs from state-based models in that WM introspection does not involve a change in the state of WM content, but rather involves the creation of a new, second representation existing in parallel to the original memory trace.

Contents

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1. Introduction

Working memory (WM) refers to short-term maintenance of information in service of goal-directed behavior (e.g. Baddeley, 1992a; Cowan, 1998). In WM, information is stored in an online fashion, allowing its contents to be easily accessed by other cognitive processes. In addition to the storage of perceptual input, WM is also involved in the retrieval of episodic memories from long-term memory (Ericsson and Kintsch, 1995). Some of the behavioral consequences of WM operations occur automatically, without the need for conscious utilization of WM content. For example, WM can automatically guide attention in a visual search context (Soto et al., 2005, 2006). Nonetheless, a key feature of WM is that its content can be consciously accessed, manipulated and examined (i.e. introspected).

Here, we address the question of how such introspection takes place. We will focus particularly on WM operations in the visual domain, i.e. on visual short-term memory (VSTM). While previous research and theoretical discussion has focused on whether WM operations can take place outside of awareness (cf. Hassin et al., 2009), and whether subliminal visual information can reach WM (Rosenthal et al., 2010; Soto and Silvanto, 2014; Soto et al., 2011), here we focus on how visual information can be consciously accessed and experienced, *after* it has been committed to WM. On the basis of recent empirical evidence and theoretical considerations, we propose that we do not consciously experience the actual memory representation. Rather, in order for memory content to be phenomenally experienced, a new representation needs to be created for the conscious domain. This representation, which exists in addition and parallel to the actual memory representation, forms the basis of the conscious experience of memory content. The need to create a separate representation for introspection is a consequence of the distinct functional characteristics and roles of conscious perception and certain aspects of WM.

2. Conventional views of how WM content reaches consciousness

One may argue that in many VSTM tasks, it is not necessary to bring the memory item into conscious experience at all. Memory accuracy is often assessed using forced-choice measures, which do not necessarily require conscious inspection of the memory item. There is ample evidence that forced-choice tasks can be performed on visual stimuli which are outside of conscious experience (Lau and Passingham, 2006; VanRullen and Koch, 2003; Weiskrantz, 1986). This has also been found to be the case for VSTM (Soto et al., 2011). Furthermore, many behavioral consequences of WM occur automatically (for example, attentional guidance (Soto et al., 2005, 2006), and are thus unlikely to require conscious inspection of memory content. However, a key feature of WM is that its content can be consciously scrutinized and manipulated (i.e. introspected). Below we describe and evaluate two influential viewpoints on the relationship between WM content and its conscious experience.

2.1. Viewpoint 1: All WM content is by definition conscious

In the psychological literature, there is a long tradition of equating WM processes with conscious experience (see Fig. 1a). The gist of this view, originating in the 19th century, is that the original memory trace is needed for conscious experience:

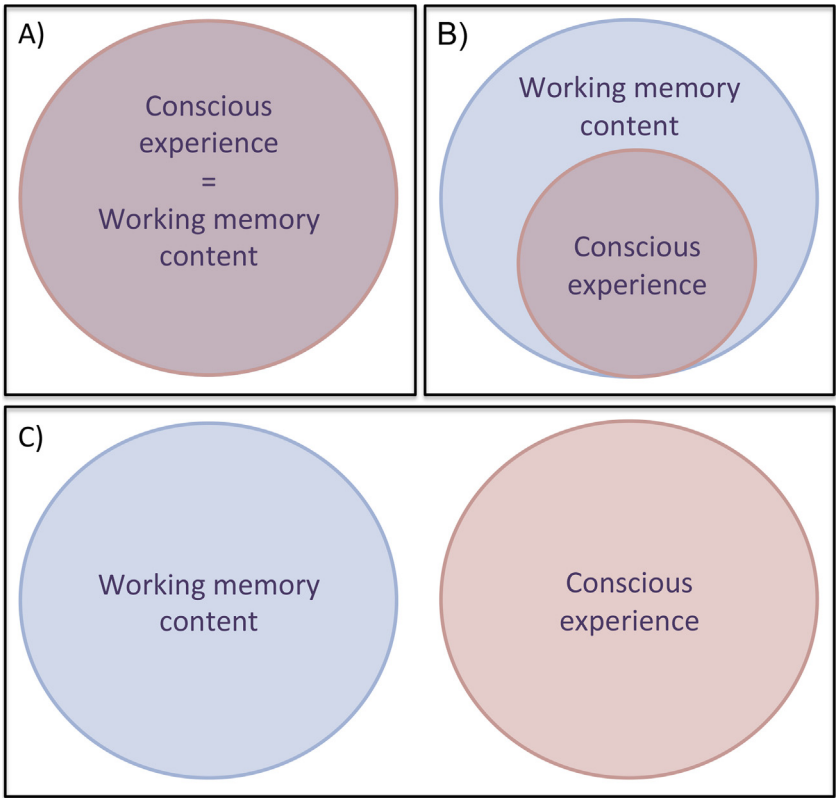

Fig. 1. Possibilities of the relationship between WM content and its conscious experience. The representation of all WM content is reflected by the blue circles, whereas the red circle depicts the representations currently in consciousness: (A) WM content is always conscious. (B) WM content is not automatically conscious, but with the aid of attention, a memory representation can be consciously experienced. The area of overlap between the two circles reflects the zone of direct access. (Note conscious experience is depicted here as part of WM. One might argue that there can be conscious experience outside of WM, but as the figure concerns the conscious experience of WM content, rather than consciousness in general, for reasons of clarity this view is not depicted here.) (C) Our proposal that the actual memory representation is never directly consciously experienced. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)