Commentary on Ruchkin

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Varieties of Procedural Accounts of Working Memory Retention Systems

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Abstract

The present commentary agrees with many of the points made by Ruchkin et al. but brings up several important differences in assumptions. These assumptions have to do with the nature of the capacity limit in working memory and the possible bases of working-memory activation.

I find much to like about Ruchkin et al.. They agree with my theoretical conception of working memory (Cowan, 1995; 1999) and provide more support than I mustered from previous literature. Nevertheless, I will focus on areas of disagreement.

One subtle disagreement relates to the brain representation of the focus of attention. Ruchkin et al. (Section 5) state: "We assume that the 'number of pointers' is limited (i.e., the amount of information that can be in the focus of attention is limited). Consequently we attribute properties such as short-term memory capacity and displacement of information mostly to the functioning of the prefrontal system." Instead, Cowan (1995, Chapter 8) distinguished between the mechanisms of the *control* of attention (heavily involving frontal areas) versus the *focus* of attention (heavily involving inferior parietal areas). This distinction matches evidence of the existence of anterior and posterior attention systems (Posner & Rothbart, 1991). It considers that the parietal areas are loci for the convergence of information from all senses, making them suitable as multisensory integration areas, and that damage to these areas typically results in deficits of awareness, such as unilateral neglect and anosognosia.

My question about the pointer metaphor is whether the limit is how many pointers the frontal lobe can contain, or how much integrated information can be represented, to which frontal mechanisms can point.

Perhaps one testable distinction is whether frontal damage results in a decrease in the capacity of the focus of attention, or only a decrease in the ability to maintain and shift that focus. Several theoretical suggestions for the mechanisms of capacity limits rely on the concept of confusion due to overlap in the representations of multiple chunks kept active concurrently (e.g., Luck & Vogel, 1998; Usher, Haarman, Cohen, & Horn, 2001), favoring the placement of capacity limitations in the posterior representational system rather than the frontal control system.

Another issue pertains to the classification of theoretical views. According to Ruchkin et al. (Sections 1.1 - 1.2), "Baddeley (1986; 2001; 2002) posited that the working memory short-term storage modules are separate from long-term memory storage modules...Investigators such as Crowder (1993) and Cowan (1995; 1999; 2001) have been proponents of a contrasting view of short-term memory operation, namely that long-term memory and short-term memory are different states of the same representations..." The latter position was termed proceduralist because the memory representation uses the same neural systems (procedures) involved in perception. I agree but, interestingly, my view has more often been considered similar to that of Baddeley and different from that of Crowder. Baddeley and I have differed from Crowder on the role of memory decay in short-term memory, a concept that Ruchkin et al. invoke to define how long activation lasts.

Decay can be conceived as the loss of information from memory as a function of time (as in radioactive decay). There is a question of whether short-term memory representations do decay. I have posited so in most of my theoretical writing, whereas Crowder (1993) has eschewed that concept. According to Crowder (also Nairne, 2002), the loss of information over time occurs only because the most recent information loses distinctiveness in memory. The common analogy is that if one stands near a telephone pole and looks down a long series of poles (a metaphor for a stimulus list), the nearest few poles look more distinct from one another than do farther-away poles. However, if one moves to a point far beyond the end pole (a metaphor for a long retention interval in a memory test), even the end pole begins to blend in with the others.

Although my colleagues and I have addressed this issue in several studies, the existence of decay is as yet neither proved nor disproved. In support of decay, Cowan, Saults, and Nugent (1997) examined two-tone comparisons and found that performance decreased as a function of the time between tones even when it was expressed as a ratio between that time and prior inter-trial interval. However, when we re-examined the data to consider previous intervals in the trial series, we could not totally dismiss the possibility that information is lost at a rate that depends on prior intervals (Cowan, Saults, & Nugent, 2001). This method warrants more systematic investigation.

Baddeley's (1986) conception of working memory relies upon the assumption of decay of the short-term representation and bases that assumption on the finding that the serial recall of words depends upon the spoken durations of those words. For lists of long words there is more time for decay during rehearsal (or during recall: Cowan et al., 1992). Recent evidence suggests that, when one matches linguistic properties of lists of words that can be spoken quickly versus less quickly, word-length effects are unreliable (Lovatt, Avons, & Masterson, 2002; Service, 1998). However, those studies involve only modest differences in the spoken durations of short and long words. In contrast, the original word-length effect was based on lists of monosyllabic words versus words with larger numbers of syllables, which produce much larger differences in spoken durations. Although one cannot use these uncontrolled stimuli to establish a time-based effect, Cowan, Nugent, Elliott, and Geer (2000) demonstrated word length effects in comparisons of the identical word lists under instructions to speak quickly versus much slower.

Without decay, the notion of activation still can be preserved by assuming that it ends through displacement of one representation by another (cf. Atkinson & Shiffrin, 1968). Supporting this idea, some amnesiacs retain story information for up to an hour if no other stimuli intervene, even after sleeping during the retention interval and therefore clearly not rehearsing the story continually (Della Sala, Cowan, Beschin, & Perini, in press). A type of memory activation thus may preserve the most recent information for long periods.

The unitary view of short-term memory (Nairne, 2002) and its precursor, interference theory, hold that short- and long-term memory phenomena follow common rules. This goes well beyond the version of the proceduralist assumption held by Ruchkin et al. It repudiates not only separate short-term memory structures (Baddeley, 1986; 2002), but also separate short-term memory *processes*. In defense of dual processes, Broadbent (1971) argued that we should in fact expect short- and long-term memory results to resemble each other, given that short-term memory is heavily involved in creating long-term memories. Cowan (1995; 2001) described how short- and long-term memory results differ in subtle ways.

Thus, psychological theory is more than dichotomous. The view of Ruchkin et al. resembles unitary memory theory in denying the existence of separate short-term memory structures but differs in retaining separate short- and long-term memory processes. I agree, though remaining unsure of the nature of activation and capacity limitations. Regardless, the target article compellingly demonstrates the usefulness of electrophysiological techniques for understanding psychological processes.

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