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# Working memory, long-term memory and language processing : Issues and future directions

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**Abstract**

We examined different views concerning the relationships between working memory, long-term memory and language processing : working memory considered as a gateway between sensory input and long-term memory or rather as a workspace; working memory considered as not strictly tied to any particular cognitive system (and consequently viewed as separated from the language system) or rather as drawing on the operation and storage capacities of a subset of components involved in language processing. It is argued that further functional imagery studies (along with neuropsychological research) could contribute to decide between these conceptions.

Key-words: working memory, language, long-term memory

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Working memory refers to a limited capacity system responsible for the temporary storage and processing of information while cognitive tasks are performed. The multi component model proposed by Alan Baddeley and Graham Hitch (Baddeley & Hitch, 1974; Baddeley, 1986) represents the most extensively investigated and the best articulated theoretical account of working memory. It consists of a modality-free controlling central executive which is aided by two slave systems ensuring temporary maintenance of verbal and visuospatial information: the phonological loop (composed of a phonological store and an articulatory rehearsal system) and the visuospatial sketchpad. This model has unquestionably contributed to a better understanding of the part played by working memory in various domains of cognition (for a review, see Logie 1993). In particular, numerous findings suggest that working memory (especially the phonological loop and the central executive components) makes significant contributions to some aspects of language processing, namely, sentence comprehension, speech production, vocabulary acquisition, and reading (see Baddeley, Gathercole & Papagno, 1998; Van der Linden & Poncelet, 1998; Van der Linden, Hupet, Feyereisen, et al., 1999).

However, some aspects of Baddeley's working memory model have recently been questioned, especially the relationships between working memory and long-term memory (see Van der Linden, 1998). According to Baddeley (1996), working memory is viewed as a gateway between sensory input and long-term memory. In particular, working memory is considered to be closely involved in the learning of novel information. In this perspective, a vast amount of data have suggested that the long-term acquisition of phonological forms of new words requires the integrity of the phonological store (e.g. Barisnikov, Van der Linden, & Poncelet, 1996). Several studies have led to question this "gateway" view, especially by demonstrating the existence of long-term memory effects in working memory (span) tasks. For example, there exist some results suggesting that memory span performance is better for words than for non-words (Hulme et al., 1995), for high frequency and high imageability words than for low frequency and low imageability items (Watkins & Watkins, 1977; Bourassa & Besner, 1994), and also for words belonging to the same semantic category than for words from different semantic categories (Poirier & Saint-Aubin, 1995). These data indicate that lexical or semantic information (or both) may contribute to memory span. In the same vein, several studies have shown that nonword repetition was better for the more wordlike nonwords (Gathercole, 1995).

In order to accommodate these empirical findings (in particular the contribution of phonological long-term memory to span performance) and the role of the phonological storage component of working memory in the long-term acquisition of new phonological information, Baddeley et al. (1998) postulates the existence of two separate but interrelated (short- and long-term) phonological stores. In this view, the visually or auditorily presented verbal information is maintained in a phonological short-term store. The storage of information in this component depends upon the temporary activation of units in a phonological network. Otherwise, the long-term phonological representations constitute a stable pattern corresponding to phonological structures which are frequently activated. Since the activation in the short-term store spreads

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into the long-term store, the repeated presentations of a phonological information will modify the representations in the long-term phonological system (which explains the learning of novel phonological forms). Moreover, the long-term phonological information also influences the functioning of the short-term store, by reconstructing partially decayed representations in this store.

Logie (1996) proposed a rather different interpretation of the long-term memory contribution to working memory performance. He suggests that working memory operates not as a gateway between sensory input and long-term memory but as a workspace. In this view, the storage components of working memory (the phonological loop and the visuospatial sketchpad) are not input buffers but rather they serve as temporary buffers for the information that has yet to be processed or is about to be rehearsed overtly. Thus, information that has been recently presented to the senses will activate the whole corresponding traces in long-term memory (visual, phonological, semantic, etc.), which then become available for temporary activation in the different components of working memory. This model furnished an explanation of the intervention of long-term memory in span tasks by suggesting that the performance depending on the phonological loop would be increased if semantic and visual information are simultaneously available for the other components of working memory.

Logie's proposition constitutes a intermediate conception between Baddeley's multiple component working memory model and the view which considers that working memory is nothing else than a temporary activation of representations and procedures in long-term memory (e.g. La Pointe & Engle, 1990). This interpretation is also quite consistent with the view that the phonological store plays a role in the long-term acquisition of new phonological information. Indeed, it could be suggested, as Gathercole and Martin (1996) did, that the incoming to-be-acquired new words activate phonological elements in a phonological network and these activated phonological elements are available for temporary retention in the phonological loop. Moreover, the more discriminating and durable is the temporary trace in the phonological loop, the more readily a stable long-term phonological representation can be constructed in the lexical memory system. From this point of view, working memory still plays a role in long-term memory by processing the information it receives and returning it to long-term memory. However, it should be noted that neither Logie's nor Baddeley's view provides a precise description of the mechanisms by which the semantic information contributes to working memory performance.

Contrary to Baddeley's view (as well as Logie's adaptation), R.C. Martin and Romani (1994) suggested that verbal working memory is not a specialized subsystem dedicated to short-term memory storage, and separate from the language system but rather draws on the operation and storage capacities of a subset of components involved in language processing. Martin and Romani (1994) explored the short-term abilities and sentence comprehension of two brain-damaged patients (AB, EA). Although they showed similar span reduction, one patient (AB) demonstrated a better performance on span tasks for phonological rather than for semantic information, while the other patient (EA) showed the reverse pattern. Moreover, the performance of both patients on the sentence processing tasks was consistent with these contrasting working

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memory deficits : the patient with a phonological retention deficit was more impaired on a sentence repetition task whereas the patient with the semantic retention deficit was more impaired on a sentence comprehension task. Another patient (MW) was also described: he showed normal span performance but had a deficit affecting specifically the short-term retention of syntactic structures. From these results, the authors concluded that the different levels of representation involved in memory span and language processing draw on specific resources, which may be conceptualized either as buffers specialized for particular types of representations, or in terms of rate of decay that may differ for different levels of representation (see also, N. Martin & Saffran, 1997).

In a similar vein, Waters and Caplan (1996) proposed to distinguish general-purpose working memory resources from specific working memory resources specifically dedicated to on-line syntactic processing in sentence comprehension. In that perspective, the performance on general verbal working-memory tasks will not predict language-processing efficiency, which is consistent with the existence of patients with a limited verbal span and who do not demonstrate difficulties in processing a wide range of syntactic structures, and also of patients with normal span performance who showed difficulties in sentence comprehension (the patient MW; R.C. Martin & Romani, 1994).

These views clearly differ from Baddeley's conception in that they consider that verbal short-term memory is an integral part of the language system, whereas for Baddeley, the working memory components are not strictly tied to any particular cognitive system. Within the framework of Baddely's model, the temporary storage of semantic (or even syntactic) information might plausibly be viewed as residing in the central executive system or as resulting from a temporary activation of long-term memory information (a long-term working memory; Ericsson & Kintsch, 1995).

In conclusion, there exist different contrasted conceptions of the relationships between working memory and long-term memory, as well as between working memory and language processing. One of the objectives of cognitive neuropsychology in the next Millennium will be to decide between these different views. In this perspective, along with the exploration of brain-damaged patients, functional imagery studies should contribute to achieve this objective**.** Indeed, specific predictions about patterns of cerebral activation can be made in the debate concerning the existence of separate short- and long-term phonological stores (Baddeley et al., 1998) or the existence of one only store responsible for short- and long-term phonological processes (Gathercole & Martin, 1996). So, the existence of only one phonological store for short- and long-term representations would lead to a similar pattern of activation when subjects have to perform span tasks with items having, or not, long-term phonological representations (for example, words and nonwords). On the contrary, the existence of two separate phonological stores would be expressed by supplementary activation when words (in comparison to non-words) have to be maintained in working memory. In a recent PET study (Collette et al., 1999), we compared the cerebral areas activated in span tasks for words and nonwords. Results showed increased activity in the left middle temporal gyrus and temporo-parietal region in the word span task only. These areas were previously related respectively to a phonological word lexicon

(Howard et al., 1992) and to lexico-semantic processes (Price et al, 1997). These data appear to be in agreement with the existence of two separate phonological stores, as postulated by Baddeley et al. (1998). More generally, they confirm that the use of functional imagery should help to confront theorical conceptions about the relationships between working-memory, long-term memory and language.

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