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Repetition-spacing and item-overlap effects in the Hebb repetition task

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ABSTRACT

In four experiments using a variation of the Hebb repetition task, we investigated the effects on learning rate, of repetition spacing and of the overlap in experimental items between repeating and nonrepeating lists. In the first two experiments it was shown that when repeating and nonrepeating lists were all permutations of the same items, learning was slower than when they shared no items. Under no-item-overlap conditions in a third experiment, the learning rate for a repeating sequence was shown to be substantial and essentially equivalent for repetitions spaced at every 6th, 9th and 12th trial. Concurrent learning of several different sequences was also demonstrated. When participants were retested after several months on lists that they had previously learned, there was evidence that the learned representations were long-term and order-specific. The results are discussed in relation to two recent models of the Hebb effect.

Introduction

In this study, we used the Hebb repetition effect (Hebb, 1961) to investigate the build up of long-term representations of serial order in three immediate serial recall (ISR) experiments. A fourth experiment tested the long-term stability of the serial-order information so learned. In carrying out these experiments, we were motivated by two principal considerations. First, the Hebb repetition effect has proved a rich source of data that have recently been helpful in refining several prominent models of immediate serial recall. Accordingly, in the later sections of this paper we discuss, in some detail, two models of ISR and the Hebb effect, namely Burgess and Hitch's (2006) model and Page and Norris's (2009) extended primacy model. Second, and just as important, the experiments that we report here were designed address a working hypothesis that relates the Hebb repetition effect to the serial learning that underlies learning in other contexts, most notably the learning of phonological word-forms. As is laid out in more detail in the General discussion, a body of recent work has not only linked immediate serial recall (and the related nonword-repetition task) with phonological word-form learning, but has also proposed the Hebb repetition effect as a laboratory analogue of the underlying long-term learning process. The experiments described in this paper go some way to testing the strength of this proposal. We begin, however, by describing some basic features of the Hebb repetition effect.

When, unannounced to participants, a given list in an ISR task is repeated several times during the course of an experiment, performance for that list improves relative to that for nonrepeated lists (Hebb, 1961). This finding, known as the Hebb repetition effect (hereafter, the "Hebb effect"), has the potential to provide an insight into the relationship between short- and long-term memory. In the canonical Hebb-effect experiment, every third trial in a series of ISR trials comprises a repetition of the critical list (referred to as the "Hebb list"). Recall performance on the Hebb list improves across repetitions over and above any nonspecific task-practice improvements for the

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nonrepeated lists (referred to here, and elsewhere, as "filler lists").

Although the ISR task itself is an explicit memory task, any learning of the Hebb list can be argued to reflect implicit learning (Seger, 1994), at least for some participants. In a Hebb-effect experiment, participants are typically not told that the lists will be repeated, and are often unaware that they are learning. Nevertheless, they acquire a long-term representation of the repeated sequence. For example, McKelvie (1987) found that the rate of learning did not depend on participants' awareness of the repetition, a result that extended the finding of Hebb (1961) who himself found that only a minority (roughly 40%) of participants reported having noticed the repetition. Further evidence of the implicit nature of the Hebb effect comes from neurological studies. Baddeley and Warrington (1970), found that while their sample of mainly people with Korsakoff's syndrome amnesia was impaired on free recall and neuropsychological tests of memory, they showed unimpaired ISR performance and a preserved Hebb effect. Gagnon, Foster, Turcotte, and Jongenelis (2004) described a patient with a focal lesion of the hippocampal formation, who was very impaired on measures of episodic memory, yet showed Hebb-effect learning, suggesting that even with little or no explicit memory of previous recall episodes, learning can take place. Thus the effect can be characterised as an implicit learning effect manifesting itself in performance of an explicit short-term memory task. That knowledge of the repetition sometimes becomes available explicitly is unsurprising, as even in classic implicit learning tasks such as the serial reaction time (SRT) task (Nissen & Bullemer, 1987), evidence of explicit knowledge of the repeating sequence has been found (Eimer, Goschke, Schlaghecken, & Sturmer, 1996; Schlaghecken, Sturmer, & Eimer, 2000). In the case of the Hebb effect task, an overt recall attempt of the list, verbal or otherwise, is required, increasing the likelihood that participants will notice the repetition, even if only in their responses.

The Hebb effect is not simply due to the repeated presentation of a list. Indeed, significant learning seems contingent on a recall attempt's being made, rather than just presentation or rehearsal of the sequence (Cohen & Johansson, 1967, 1968; Cunningham, Healy, & Williams, 1984; Oberauer & Meyer, 2009). Consistent with this, Couture, Lafond, and Tremblay (2008) and Lafond, Tremblay, and Parmentier (2010) have recently shown that there is independent learning of responses in the Hebb paradigm. Other recent work on the Hebb effect suggests that what is learned is specific to the modality of presentation and recall (Page, Cumming, Norris, Hitch, & McNeil, 2006), and is not an abstract, amodal representation of the sequence. Page et al. found that when a Hebb list is learned through visual presentation under conditions of concurrent articulation and with a visuo-spatial response, there is no transfer to verbal recall of the same sequence when it is presented auditorily, and vice versa. Other studies have tried to address more directly the nature of the sequence information learned in a Hebb-effect task. Burgess and Hitch (1999) suggested that the Hebb effect is the result of the strengthening of long-term associations between list items and a representation of list position. However, Cumming, Page, and Norris (2003) reported data that suggested that an account in terms of position-item associations is unlikely to be correct. They showed that when a Hebb list was rearranged as a test list, such that only alternate items changed their list position, there was no indication of any recall advantage for those items that retained the position they occupied in the original repeated Hebb list. If participants had been learning position-item associations, these items should have been recalled in the test list approximately as well as they had been in the original Hebb list. Further evidence against an account of the Hebb effect in terms of long-term learning of position-item associations comes from a study by Schwartz and Bryden (1971). They found that the Hebb effect disappeared if they changed two or more digits at the start of a nine-digit critical sequence each time it was presented, but kept the other items the same. If the same number of digits were changed at the end of the sequence, a significant improvement in recall was found across repetitions. Both of these findings suggest that what is being learned is not just the position of the items within the list. Burgess and Hitch (2006) subsequently modified their model in the light of these, and other, difficult data. This modified model will be discussed later, in the General discussion.

Several models have been published that simulate immediate serial recall with varying levels of qualitative and quantitative accuracy (e.g. Anderson, Bothell, Lebiere, & Matessa, 1998; Brown, Preece, & Hulme, 2000; Burgess & Hitch, 1999, 2006; Farrell & Lewandowsk, 2002; Henson, 1998; Murdock, 1996; Page & Norris, 1998). Only one of these (Burgess & Hitch, 2006) has been properly applied to patterns of performance seen in the Hebb effect, although Page and Norris (2009) have recently supplemented their model, as discussed later. As noted above, one of the major aims of this study is to inform and constrain future modelling of both short and long-term memory for serial order. A focus on the Burgess and Hitch model and on the Page and Norris model is informative because these models are founded on rather different principles. The Burgess and Hitch model is a prominent representative of a class of models that see serial-order memory as being reliant on mechanisms that associate individual list items with some abstract representation of their position in the list. Ostensibly, such an approach might seem incompatible with, say, the learning of multiple lists over the same period (see later), though Burgess and Hitch had mind to this during their models' development. By contrast, the Page and Norris extended-primacy model is an ordinal model, in as much as it represents serial order directly, without reference to list-position or inter-item association. The model is situated in a tradition of "chunking" models that goes back at least to Miller (1956) and was therefore developed with some consideration to the relationship between short-term representation and long-term learning. As it transpires, the experiments presented below offer some stringent constraints on positional and ordinal models alike.

As presaged in our opening paragraph, this study also forms part of an ongoing investigation into whether the Hebb effect can be properly considered a laboratory analogue of word-form learning Word-form learning in the phonological domain is, like the Hebb effect, an example