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## Research report

# Impaired acquisition of a mirror-reading skill in Alzheimer's disease

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## ABSTRACT

Several studies using the mirror-reading paradigm have shown that procedural learning and repetition priming may be preserved in the early stages of Alzheimer's disease (AD) (e.g., Deweer et al., 1994). According to the classical interpretation, improved reading time for repeated words is sustained by a repetition priming effect, while procedural learning is demonstrated when this improvement is also observed for new words. Following Masson (1986), the hypothesis tested in the present study was that improved reading of new words could also be due to a repetition priming effect rather than to the acquisition of a mirror-reading skill. Indeed, because the same letters are presented throughout the task, a repetition priming effect for the letters could suffice to explain the improvement in performance. To test this hypothesis, we administered to 30 healthy young and elderly subjects and to 30 AD patients a new mirror-reading task in two phases: an acquisition phase comprising pseudo-words constructed with one part of the alphabet, and a test phase in which both pseudo-words constructed with the same part of the alphabet and pseudo-words constructed with another part of the alphabet were presented. If the new pseudo-words composed with repeated letters were read faster, it would reflect a repetition priming effect; if pseudo-words composed of 'new' letters were read faster, it would reflect a procedural learning effect. The results show comparable repetition priming effects in AD patients and in healthy elderly subjects, whereas only healthy subjects showed a procedural learning effect. These results suggest, contrary to previous studies, that the learning of a new perceptual skill may not always be preserved in AD.

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## 1. Introduction

Determining the preservation of learning abilities in Alzheimer's disease (AD) is an important topic of research, especially from a clinical point of view. Some studies have demonstrated that, in the early stages of the disease, different aspects of cognitive functioning may be preserved in AD

patients. At least in its early and moderate stages, AD is no longer considered as a pathology characterized by diffuse and global deterioration; on the contrary, AD may affect some processes (executive function, attention) or cognitive systems (episodic memory) in a relatively isolated way and leave other aspects (skill learning abilities, repetition priming) of cognitive functioning preserved (see Collette et al., 2003). Thus, AD

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patients may retain certain residual learning abilities; because they can be used in a rehabilitation setting, it is very important to understand these preserved learning abilities.

One of the preserved learning abilities that is often highlighted in AD is procedural learning, which refers to our capacity to acquire new skills as a result of long and repetitive practice (Cohen and Squire, 1980). Several authors (for a review, see Salmon, 2000) agree that perceptual–motor skills are preserved in AD. For example, AD patients perform as well as healthy elderly subjects on a pursuit rotor tracking task (Bondi et al., 1993; Deweer et al., 1994; Dick et al., 1995; Heindel et al., 1988, 1989; Libon et al., 1998), a mirror tracing skill task (Gabrieli et al., 1993; Rouleau et al., 2002), a tactile maze learning task (Grosse and Wilson, 1991; Sabe et al., 1995), and a bimanual coordinated tracing task (Hirono et al., 1997; Mochizuki et al., 2004).

Perceptual–verbal learning skills are often evaluated with the mirror-reading paradigm, which constitutes a methodology for studying both the acquisition of a new procedural skill and the repetition priming effect (Cohen and Squire, 1980; Deweer et al., 1993; Grober et al., 1992). Repetition priming refers to facilitation due to the influence of the initial processing of an item on its subsequent processing, without any conscious awareness of the initial episode (Hauptmann and Karni, 2002). Nevertheless, very few studies of perceptual–verbal learning skills have been carried out in AD (Deweer et al., 1993; Grober et al., 1992). In a first study, Grober et al. (1992) claimed that AD patients showed a repetition priming effect equivalent to healthy elderly subjects, but that they could not acquire the mirror-reading skill. However, Deweer et al. (1993), using the same paradigm, showed that both repetition priming and procedural learning were preserved in AD.

Both studies were based on the traditional mirror-reading paradigm proposed by Cohen and Squire (1980), in which participants have to read words in a mirror and are timed both at the initial presentation and in a later session. Some words from the first session are included in the second one, while other words are presented only during the second session. This division of words into repeated and non-repeated items is used to study procedural skill learning and repetition priming.

Procedural learning is demonstrated when subjects read non-repeated words faster in the second session than the original words in the first one. A reading improvement for repeated words could be sustained by different mechanisms that may be cumulative: the acquisition of the mirror-reading skill, a repetition priming effect and, possibly, an episodic memory effect for the words (Koenig et al., 1999). Repetition priming (and/or an episodic memory effect) is shown when repeated words in the second session are read faster than the same words in the first session and, because they also benefit from the procedural learning effect (if any), faster than non-repeated words in the second session.

However, an improvement in performance for non-repeated words in the second session compared to words in the first session is not so easy to interpret. The reading-time improvement for non-repeated words in the second session could be due to a repetition priming effect for the letters rather than to the learning of a procedural mirror-reading skill, as suggested by Cohen and Squire (1980). More specifically, because the same letters are presented throughout the task,

a repetition priming effect for the letters could be sufficient to explain the improvement in performance.

Masson (1986) had already expressed this hypothesis and sought to understand the real nature of this reading-time improvement for non-repeated words in the mirror-reading paradigm. He raised two possibilities: (1) subjects acquire a general procedural skill which is independent of the specific training items; (2) the improvement in their reading speed appears only for the specific items they had already encountered during training. If subjects acquired a general skill, they should be able to apply this skill to all items (i.e., letters), including those that had not been encountered during the initial training. On the other hand, if this skill was based on the memory of the specific items encountered during training, transfer of performance should be observed only for words which present some similarity to words presented during the training phase. In other words, in the latter case, no transfer of training should be observed if the new words are composed of letters that had not been practised during training.

Masson (1986) proposed a training phase that consisted of ‘mirror words’ constructed with only 13 letters of the alphabet, and a test phase in which three kinds of items were presented: (1) words read during training (old letters/old words), (2) new words formed with the same 13 letters used during training (old letters/new words), and (3) new words composed of letters that were not used during training (new letters/new words). These words were read from left to right as with normal typography, but each letter was a mirror image.

Masson (1986) administered this task to 24 young subjects. The subjects read the ‘old letters/old words’ and ‘old letters/new words’ in the test phase faster than words in the initial training phase. However, no improvement was observed for ‘new letters/new words’. Bondi and Kaszniak (1991) extended Masson’s approach and administered the same task to 16 Parkinson’s disease patients and to 16 healthy elderly subjects. Both the Parkinson’s disease patients and the healthy elderly subjects improved their performance in the retention test for the ‘old letters/old words’ and ‘old letters/new words’, but not for ‘new letters/new words’. This pattern of results suggests that the traditional mirror-reading paradigm evaluates a repetition priming effect for letters more than the real acquisition of a mirror-reading skill, because, in order to demonstrate a procedural learning effect, the authors should have found an improvement for ‘new letters/new words’ as well.

However, it is quite surprising that young and healthy elderly subjects did not acquire the mirror-reading skill. Masson (1986) hypothesized that, in his study, the subjects did not get enough practice to allow a procedural learning effect to appear. However, despite the addition of 168 practice trials (see Masson, 1986, Experiment 4), no evidence of procedural learning appeared in the young subjects.

Another explanation for this absence of any procedural learning effect could be that the mirror-reading task used by Masson (1986) and Bondi and Kaszniak (1991) was too complex for subjects to learn. In fact, several studies have already claimed that the complexity of the task is a restraint on the acquisition of a new procedural skill (e.g., Albaret and Thon, 1998). In the case of mirror reading, one reason for the absence of learning could be the use of lowercase letters in Masson’s

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