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The Role of Semantic Memory in Reducing Learning Disability in Multiple Sclerosis Patients

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Abstract

There is evidence of episodic memory as one of the mostly reported complaints among Multiple Sclerosis (MS) patients with impaired cognition, while their semantic memory remains relatively intact. In this regard, the present study aimed to highlight the benefits of interaction between semantic memory and episodic memory to reduce episodic verbal memory deficit in MS patients. Fifteen Relapsing-Remitting MS patients attended six sessions of verbal learning containing item-specific and relational information. The average of correct free recalls of item-specific and relational information was analyzed by paired sample t-test, and the result showed superiority of recalling relational information ($P<0.05$). It is concluded that semantic memory compensates episodic memory deficit in verbal learning, and semantic learning is an effective strategy for MS patients with episodic verbal memory impairment.

Keywords: Cognitive rehabilitation • Episodic memory • Multiple sclerosis • Semantic memory • Verbal memory impairment

Introduction

Multiple Sclerosis (MS) as a neurodegenerative disease affects the central nervous system (CNS). It is recognized with visual, sensory, motor, and bulbar symptoms as well as cognitive impairments [1]. Available evidence indicates that in 43% to 70% of MS cases, cognitive impairments are prevalent, affecting MS patients' occupational, social, and especially educational activities. A review article reported that cognitive processing speed and episodic memory are the domains that are affected more [2-6]. However, basic language, attention span, as well as semantic memory are reported to remain relatively intact. In another review, Greenberg and Verfaellie (2011) referred to Tulving's (1985) 'memory system' as a view about episodic memory system that is attributed to events (e.g., item-specific information) and semantic memory system which is attributed to general knowledge (e.g., relational information). They emphasized on the interdependency between these systems in the acquisition and retrieval of information [7]. Accordingly, by a computational model, Fang, Rüther, Bellebaum, Wiskott, and Cheng (2018) found that the interaction between semantic memory (dependent on distributed neocortical areas) and episodic memory (hippocampus-dependent) is beneficial for the latter [8,9]. On the other hand, among compensatory cognitive rehabilitation programs for MS patients, the modified Story Memory Technique (mSMT) provided class I evidence of efficacy in training patients to take advantage of context-building and imagery to retain more verbal information [10,11]. Despite the existence of various verbal materials for learning in the mSMT, it seems visualization has the prominent role in this regard, and a verbal context may facilitate learning via semantic relations. Regarding the verbal memory problem associated with episodic memory in people with MS, the present study aimed to evaluate the compensatory role of semantic memory in episodic memory deficit by applying item-specific information and relational information.

Methods

Participants

Following ethical approval by the Institute for Cognitive Science Studies (ICSS) with the ethical code of IR.UT.IRICSS.REC.1398.001, patients from the Multiple Sclerosis Research Center of Sina hospital were informed about the intervention program. Twenty one patients who had subjective complaints about cognitive problems announced their interest in participating in the project. Inclusion criteria were: patients with 20 to 50 years of age, having a university degree, patients with Relapsing-Remitting MS, and MS patients who have been diagnosed over3 months prior to the study with an Expanded Disability Status Scale (EDSS) score of 0 <x< 5. In addition, all patients must have had their recent exacerbation at least 3 months

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prior to the study and should be free of corticosteroid effect during cognitive assessment and intervention sessions. Furthermore, participants with severe psychiatric disorders who were diagnosed by a psychiatrist, and those who participated in other cognitive rehabilitation programs were excluded. Demographic data of participants, including age, gender, education, length, type of MS, and the EDSS scores were recorded by a neurologist.

Materials

Materials for memorizing consisted of 6 lists, 3 unrelated and 3 related commands containing 16 simple imperative action phrases. Each phrase was formed by one concrete noun and one action verb (for example, "take the pen" and "through the ball").There was no semantic relationship between items in the item-specific information (unrelated lists). In contrast, the commands in the relational information (related lists) were nouns and verbs relating to a specific activity, and items followed a common purpose (e.g., the procedures of flowering). The items in both lists were developed in Persian language based on Engelkamp, Seiler, Zimmer's (2004) study [12]. Unrelated and related lists and the item orders in each list were counterbalanced across the patients.

Procedure

The corresponded factors were item-specific information (commands with unrelated items) versus relational information (commands with related items) in a within-group design followed by a free recall. This study was planned for 7 weeks, and the participants had to attend the program individually. They were asked for demographical data, the BDI, and the BAI tests at the first session (1st week). Intervention program included 6 independent sessions once a week. Three sessions were considered for unrelated commands (sessions 1, 3, 5) and 3 sessions for related commands (sessions 2, 4, 6) to encode verbally. Each session lasted about 35 minutes. The participants were initially informed about the memorizing program and were asked to memorize as many items as they could, including nouns and verbs, together. A tape recorder presented the commands at a rate of about 6 seconds. A five second break was considered between each pair of items in the lists (3 seconds for repeating plus 2 seconds for the interval before starting the next item). Then, category fluency as an interpolation task was given to the participants [13]. They had to say as many names of members of categories such as foods, animals, boy's first name, etc., as possible during one minute. Interpolation tasks were counterbalanced across the patients. Afterward, the participants were asked to recall as many items as possible. By considering disability in writing in some MS patients, interpolation and free recall tasks were performed orally, and the examiner wrote the replies for all the participants.

Results

During the study procedure, 6 patients were excluded from the study, 4 due to medication side-effects and 2 due to relapsing course of the MS disease. Finally, data of 15 patients was reported. Demographic data, including age, gender, education, type of MS, length of disease, performance in Beck Depression/Anxiety Inventory, and EDSS score of patients are presented in Table 1. The average group age was about 38 years of age, and the group was educated. The female participants were more than males and the average disease duration of the group was more than 6 years. The group did not show severe depression and anxiety. The free recalls of correct responses for item-specific information and relational information were compared by paired sample t-test. The results are indicated in Table 2.

Variables	Verbal encoding (n=15)
Age	38.6 ± 7.4
Education	15.2 ± 2.1
Female	13
Male	2
Disease type	RR
Disease duration	6.4 ± 5.1
BDI	13.9 ± 9.0
BAI	13.8 ± 10.0
EDSS	2.53 ± 1.3

Table 1. Demographic characteristics of the samples.

Variables	Item-specific info.	Relational info.	T-test	p value	Correlation	Correlation
Free recall correct responses	4.13 + 2.56	6.29 + 3.32	-4.223	0	0.345	0.02

Table 2. Free recall correct responses comparison between item-specific and relational information.

Pairwise comparison for the main effect of 2 types of information using Bonferroni adjustments indicated a significant difference (P<0.05) between recalling item-specific information and relational

information. Relational information was retrieved more. Finally, the average of correct responses among free recalls during 6 sessions was considered, as shown in Figure 1. Figure 1 demonstrates an incremental improvement incorrect answer among free recalls during 6 sessions of verbal learning.

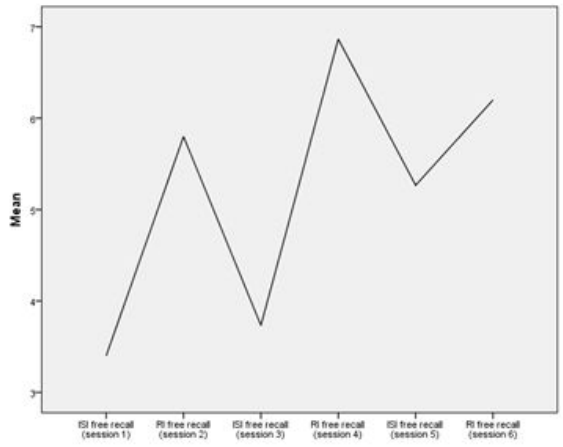

Figure 1. The increasing number of free-recall correct answers during six sessions. ISI: Item-specific information; RI: Relational information.

Discussion

This study aimed to highlight the role of semantic memory in compensating episodic memory deficit in MS patients with verbal memory problems. The intervention group was more successful in recalling relational information (Table 2) and indicated a relative improvement in verbal learning during 6 sessions (Figure 1). There was no semantic relationship between commands in the item-specific information (unrelated lists of commands). In contrast, the commands in the relational information (related lists) were nouns and verbs relating to a specific activity, and all the commands followed a common purpose. Based on the working memory model by Baddeley, noun and verb binding involves the phonological loop as well as the information from semantic memory for encoding a sentence such as commands [14-16]. Therefore, the superiority of relational information over item-specific information during encoding and retrieval may be due to relying more on semantic memory information. Fang et al. (2018) studied the relationship between episodic memory and semantic memory via computational modeling. They confirmed that individuals retrieve some aspects of episodes of information more easily when they are familiar with them compared to the episodes of information involving unfamiliar objects. They concluded that the interaction between semantic and episodic memory systems plays an essential role in episodic memory. Moreover, Greenberg and Verfaellie (2011) summarized the interdependency between episodic and semantic memories based on related studies as following:

Semantic memory facilitates the acquisition of new episodic memories, and episodic memory facilitates adding new information to the semantic store. Similarly, episodic memories facilitate retrieving information from semantic memory, and semantic memories are the basic material from which complex and detailed episodic memories are constructed. As Greenberg and Verfaellie (2011) stated, these findings can be applied in rehabilitation programs for individuals with memory disorders. For example, in patients with episodic memory disorders, the evidence suggests that the success of rehabilitation programs will depend not only on the severity of the episodic deficit but also on the semantic knowledge integrity and the extent of the integrity of novel information with already existing knowledge. In conclusion, considering episodic memory impairment as a prevalent cognitive problem in people with MS, the evidence confirms that semantic memorizing, semantic encoding, and semantic retrieval could be effective strategies to compensate for episodic memory deficit. In addition, as Figure 1 indicates, 6 sessions of encoding and retrieval training of verbal material could enhance patients' verbal memory, which draws attention to the rehabilitation role of verbal tasks in MS patients. The small sample is considered a limitation for the present study. Moreover, in order to study semantic learning in MS patients with learning difficulties, it is better to extend texts to various sentence types, while in the present study verbal material was limited to simple and concrete sentences.

Declaration of Interest

None.

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