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Executive functions and updating of the contents of working memory in unipolar depression

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Abstract

Background: Depression is characterized by cognitive impairments, including executive dysfunctions. These executive deficits could reflect impairments of more basic executive processes, such as updating, set shifting and inhibition. While shifting and inhibition impairments are often reported, studies on depression have been somewhat obscure about specific deficits of the updating process. The main goal of that study was to assess the updating process in young in-patients with depression.

Methods: We used a verbal *n*-back task to assess updating process. Load and mental manipulation within working memory (WM) were incremented by using three different levels of complexity (1,2,3-back). Neuropsychological tests and an attentional task (0-back) were also administered to subjects. Twenty-two individuals meeting DSM-IV criteria for Major Unipolar Depression and 22 healthy control subjects, matched on age, verbal IQ and education, were included in the study.

Results: Subjects with depression showed significant deficits at the *n*-back task compared to control subjects. They were normal in tasks assessing the short-term maintenance in WM and attention. This suggests that depressed patients exhibit impairment in the updating process. Depressed patients also showed set shifting and inhibition deficits. Only the *n*-back task was correlated with the number of hospitalizations and the longitudinal course of the illness.

Conclusions: Our results suggest that young depressed in-patients have widespread executive dysfunctions, including updating, shifting and inhibition processes. We also found a correlation between a longitudinal measure of depression severity and an updating task performance. We suggest that using multiple executive tasks gives the opportunity to distinguish the specific influence of various executive processes on clinical dimensions in depression.

Keywords: Unipolar depression; Executive functions; Updating process; Longitudinal severity; *n*-back task

1. Introduction

In addition of mood alteration, depression is also characterized by cognitive deficits, mainly involving memory and executive functions. Executive functions include integration of multimodal sensory input, generation of multiple response alternatives, maintenance of set and goal-directed behaviours, adaptation to changes in environment, planning abilities and self-evaluation (Stuss and Benson, 1984; Dubois et al., 1994). Several neuropsychological studies in depression showed executive deficits in young, middle-aged (Elliott et al., 1996; Fossati et al., 1999, 2003) or elderly depressed patients (Beats et al., 1996; Lockwood et al., 2002). However, executive tasks often used in neuropsychological studies involve many functions, making it difficult to tease out the primary functional deficit associated with impairment on any one complex task (such as Wisconsin Card Sorting Test). Indeed, major executive functions may depend on the effectiveness of more basic executive processes. In a recent study in normal subjects, Miyake et al. (2000) used latent vari-

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able analysis to determine to what extent different executive processes can be considered to be unitary (in the sense that they are reflections of the same underlying mechanism or ability) or non-unitary. They focused on the following three basic executive processes: (1) shifting between tasks or mental sets, (2) inhibition of dominant or prepotent responses, and (3) updating and monitoring the contents of working memory (WM). Confirmatory factor analysis indicated that these three executive processes, although moderately correlated with one another, are clearly separable. Miyake et al. (2000) suggested that set shifting, inhibition and updating could contribute differently in the execution of more global executive functions like planning or problem-solving.

Many studies in depression have identified specific deficits with tasks mainly requiring set shifting processes – i.e., WCST or Trail Making Test – (Austin et al., 1999; Beats et al., 1996; Merriam et al., 1999; Franke et al., 1993; Purcell et al., 1997). For instance, Merriam et al. (1999) evaluated 79 depressed patients with WCST. Patients with depression clearly did more perseverative errors and perseverative responses, thus suggesting set shifting impairments. Deficits in inhibition have also been identified in depressed patients, with tasks like Stroop colour-word tests (Lemelin et al., 1996; Trichard et al., 1995) or with other tasks. For instance, MacQueen et al. (2000) used a computerized negative priming task in which colour, identification and location features of a stimulus and distractor were systematically manipulated across successive prime and probe trials. Their results showed a reduction of distractor inhibition in depressed patients.

While shifting and inhibition impairments are often reported, neuropsychological studies on depression have been less clear about potentially specific deficits of the updating process, which is closely linked to WM (Smith and Jonides, 1997). WM is a limited-capacity mental workspace involving both the short-term storage of information and the simultaneous manipulation of the contents of this store by executive processes. One of these processes, the updating, goes beyond the simple maintenance of task-relevant information in its requirement to monitoring and coding incoming information for relevance to the task at hand and appropriately revisiting the items held in WM by replacing old, no longer relevant information with newer, more relevant information (Morris and Jones, 1990). Updating is an important executive process and might be related to more complex executive functions like goal management, planning and adaptation to changes in environment. Some studies have found WM deficits in depressed patients (Beats et al., 1996; Channon et al., 1993; Elliott et al., 1996; Landro et al., 2001; Nebes et al., 2000; Porter et al., 2003) but those results are still inconsistent with other studies (Barch et al., 2003; MacQueen et al., 2000; Purcell et al., 1997, 1998; Zakzanis et al., 1998). Furthermore, authors who found WM deficits in depression have not clearly associated those deficits to an updating process dysfunction. Landro et al. (2001) used a variant of The Paced Auditory Serial Addition Test (PASAT), a task that needs to continually refresh the content of the store and thereby also discard the information after it is used. Even if PASAT seems to involve updating process, the interpretation of a specific updating deficit for depressed patients is unclear because that task contains an addition part that probably requires more executive resources than a single comparison task (subject is asked to add every pair of successive numbers and give the answer immediately). Nebes et al. (2000) used an auditory *n*-back paradigm to test WM on elderly depressed patients. *n*-Back is a WM task mainly involving updating process that offers the opportunity to test the impact of different workload levels on performance. Although in their paradigm Nebes et al. (2000) used five different workload levels (1 to 5-back), they did not analyse these levels separately. Subjects had a global WM score that included the performance for all levels of complexity. Then, it was impossible in that paradigm to differentiate updating process impairment from high workload management (including maintenance and strategies) deficit. Taken together, these data do not permit to conclude on the existence of an impairment of the updating process in depression.

Table 1
"Miyake-based" executive processes involved in our executive tasks

	Set shifting	Updating	Inhibition
TMT B	+++		+
Modified WCST	+++		+
Stroop-interference	+		+++
n-Back task	+	+++	+
Verbal fluency	++	+	+

The main goal of this study was to assess updating process and executive functions in young in-patients with depression. A verbal *n*-back task with three different workload levels was used to evaluate updating process in depressed patients. Patients were also tested with a battery of executive tasks assessing shifting and inhibition (see Table 1). Our main hypothesis was that young depressed patients would have a poorer performance at the *n*-back task compared to controls, and would also show set shifting and inhibition deficits.

2. Material and methods

The study was approved by the Ethics Committee for Biomedical Research of the Salpêtrière Hospital.