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EXECUTIVE FUNCTIONS, PROSPECTIVE MEMORY AND RETRIEVAL – CONTRIBUTION OF EXPERIMENTAL COGNITIVE PSYCHOLOGY TO THE UNDERSTANDING OF OBSESSIVE COMPULSIVE DISORDER

PhD thesis booklet

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Introduction

Obsessive-compulsive disorder (OCD) is a highly debilitating neuropsychiatric condition characterized by intrusive unwanted thoughts (obsessions) and/or repetitive, compulsive behaviors, or mental rituals (compulsions) (American Psychiatric Association, 1994). The prevalence of the disorder is between 2-3% in the general population and can occur concomitantly with other disorders: depression, anxiety, Tourette's disorder, panic disorder, phobias, tricotilomania, bulimia, anorexia (see e.g., Fineberg, Marazziti, & Stein, 2001).

We know from previous research that in OCD there is an executive function deficit, but its exact nature is still unclear, and the results are contradictory (for reviews see Chamberlain, Blackwell, Fineberg, Robbins, & Sahakian, 2005; Greisberg & McKay, 2003; Kuelz, Hohagen, & Voderholzer, 2004; Olley, Malhi, & Sachdev, 2007). In an early neuropsychological model Savage (1998) considered that the fronto-striatal dysfunction leads to impaired executive functioning, which manifests in: difficulty in appreciating the larger context, difficulty in prioritizing and planning behavior, difficulty initiating strategic action and difficulty in monitoring and shifting. These problems contribute to the observed clinical symptoms sustained and altered by the possible memory problems, which are a secondary result of the existing executive function deficits. According to Chamberlain et al. (2005) not all aspects of the executive system are injured in OCD. The appearance of the relevant clinical symptoms and the main cognitive deficits – *inhibition of*

prepotent responses, set shifting and strategy use in memory probes – could be explained by failures of cognitive and behavioral inhibition. The neuroimaging studies support the involvement of the lateral and medial orbitofrontal cortex, the dorsal anterior cingulated cortex and the amygdale in OCD symptomatology (for review see Milad & Rauch, 2012).

We think that executive functions play an important role in the realization of delayed intentions, in prospective memory (PM) performance. Many factors – such as motivation, stress, the properties of the PM cues, the characteristics of the ongoing task, planning and individual differences – influence the successful performance on PM tasks. In case of memory retrieval there is an impressive amount of data demonstrating that *interference* also plays an important role in forgetting (see e.g., Anderson & Neely, 1996). According to Anderson (2003) the need to resolve interference during retrieval induces executive control processes that overcome interference through inhibition of the interfering non-target memory.

Executive function is an umbrella term and during our studies we focus on two main components that we consider critical in OCD: *set shifting* and *inhibition.* We want to find and answer to the questions: "If there is an executive function impairment regarding these main components, how is its pattern of distribution in the clinically impaired ranges and how does the severity of symptoms relate to the different neuropsychological scores?"

As far as we know, we are the first group trying to connect executive impairment with PM function deficits in a clinical sample

of OCD patients in a series of experimental studies. Our second main question refers to this topic: "Is there a PM deficit in OCD and if so how can we interpret the findings and connect them to symptomatology?" We hypothesize that OCD patients will manifest extra monitoring activity in event-based PM tasks due to the overactivity of the PM system. This will result in increased reaction times in the ongoing and PM tasks and more false alarm type errors on the PM task.

Our third guiding question group is related to the topic of episodic memory retrieval using the retrieval practice procedure: "Is the retrieval induced forgetting (RIF) a short or a long term effect, and what factors modulate its persistence or diminishment?; "Is this effect present in OCD?"; "How is affected by symptom severity, working respective short term memory capacity and anxiety?". We hypothesize that if there is no active rehearsal the RIF effect will persist also after 12 hours and that sleep may play a critical role here. The diminished RIF effect in OCD could be attributed to the dysfunction of conflict detection processes observed in this disorder.

The thesis tries to find answers to the above questions in four main thesis points: thesis I is related to executive functions, thesis II to PM and theses III and IV to episodic memory retrieval.

Main goals

1. To assess the level of short term memory and executive functions in OCD compared to healthy control subjects.

2. To describe the distribution of patients in different impairment ranges regarding short term memory, shifting and inhibition.

3. To clarify the relationship between symptom severity and cognitive impairments in OCD.

4. To demonstrate PM impairment in a series of event-based PM tasks compared to healthy control subjects.

5. To clarify the relationship between symptom severity, subjective evaluation of memory performance and error patterns during event-based PM tasks in OCD.

6. To demonstrate the long term effect of selective retrieval practice in normal population.

7. To compare OCD patients and normal subjects' performance in a modified retrieval practice paradigm.

New scientific results

Thesis I: Impaired executive functions in OCD

OCD patients show impaired performance on the shifting and inhibition component of the executive system measured by the Wisconsin Card Sorting Task (WCST) respective Stroop Task. Patients with more severe symptoms committed significantly more perseverative errors on the WCST.

Earlier neuropsychological studies with tasks tapping short term memory and executive functions in OCD have produced inconsistent results (for reviews see Chamberlain et al., 2005; Greisberg & McKay, 2003; Kuelz et al., 2004; Olley et al., 2007). This could be attributed to the facts that the executive system is not unitary and the different methods used to evaluate executive functions require different cognitive processes. According to Miyake and collaborators (2000) traditional neuropsychological executive tasks load on three main central executive components: *inhibition*, *modality specific updating-monitoring* and *shifting*.

In our study (Study 1) the OCD group performed within the range for healthy adults in the short term memory tasks (Digit Span Forward and Backward Tasks, Corsi Block Tapping Task), while they produced severely impaired performance in executive tasks assessing shifting (WCST) and inhibition (Stroop Task). The increased reaction times on the interference condition in the Stroop task as well as the higher number of perseverative errors in WCST could be interpreted as a consequence of impaired inhibitory

mechanisms. We argue that set-shifting also requires the ability to inhibit previously acquired rules, a process mediated by the orbitofrontal cortex (Chamberlein et al., 2005). There is also a relation between symptom severity and performance scores, patients with more severe symptoms committed more perseverative errors on the WCST. Our findings support the view that the updating component of the executive system seems to be intact in OCD while the inhibition and shifting components are altered.

Thesis II: Impaired PM functions in OCD

OCD patients PM function is impaired compared to healthy subjects. PM instruction produced a significantly cost effect in OCD patients during the ongoing task due probably to an extra over-monitoring activity for PM cues.

OCD patients commit significantly more false alarm type errors in a modified event-based PM task compared to healthy controls probably due to an overactivity of the PM system and the desinhibition of the activated inadequate responses. The patients who consider their PM performance poorer commit significantly more false alarm type errors.

There are just a few studies with OCD patients or with subclinical groups characterized by dominant checking symptoms or obsessive tendencies in the domain of PM research (see e.g., Cuttler & Graff, 2009; Harris, Vaccaro, Jones, & Boots, 2010; Jelinek, Moritz, Heeren, & Naber, 2006; Marsh, Jameson, Cook, Amir, &

Hicks, 2009). In two consecutive experiments (Study 2 and Study 3) we have demonstrated the impairment of PM functions in event-based task in OCD, and contrary to previous interpretations we argue by an overactivity of the PM system.

In our first experiment (Study 2) we found that OCD patients slowed down on the ongoing task in both the expectation condition (in which participants were told that PM stimuli might occur but none actually did) and execution condition (in which participants were told that PM stimuli might occur and they did) compared to baseline. We propose the occurrence of extra monitoring activity as probable cause for this finding. The PM instruction produced an extra monitoring activity for OCD patients that resulted in a more active search for PM cues. The higher latency and lower accuracy scores in the experimental trials compared to the control trials are evidence of monitoring activity (see Guynn, 2003; Kliegel, Martin, McDaniel, & Einstein, 2004).

In our second experiment (Study 3) a modified PM task was used with minimal memory load suitable for patients under medication and with the goal of simulating a real life situation, where following a successful response to a relevant target, the response must be inhibited for the same target on the next encounter with it. This task compared to our previous experiment required a more intense monitoring activity from subjects concerning their own actions, making it appropriate for analyzing the monitoring activity through reaction times and errors made. We have found not just similar data regarding reaction times with our previous experiment,

but also significant differences in error patterns. The significantly higher rate of false alarm type errors may reflect the overactivity of the PM system and also a response inhibition deficit (Chamberlain et al., 2005). We argue that overactivated PM intentions go together with a response inhibition deficit, and that these two factors together contribute to the higher rate of false alarms. Another important result supporting our view is that patients who achieved higher scores on the PM subscale of the Prospective and Retrospective Memory Questionnaire (PRMQ) made significantly more errors on the PM task. Taking together the hit rates on the PM task and the reaction time scores on the ongoing task in the execution condition, it can be concluded that OCD patients' performance can be explained by over-monitoring for PM cues.

Thesis III: Long-term effects of retrieval practice

Retrieval practice effects were found to persist over a 12 hour retention interval when the items were maintained in memory by frequent rehearsal or when a period of nocturnal sleep occurred during the retention interval. When rehearsal was reduced or did not occur, long-term RIF was present only following a full period of sleep. It is proposed that consolidation processes occurring during sleep, possibly featuring off-line elaborative rehearsal, mediate this long-term effect of retrieval practice.

Inhibition could explain why we forget previously studied items while we retrieve some items from memory, a phenomenon

known as the RIF (Anderson, Bjork, & Bjork, 1994). This phenomenon was often studied with the *retrieval practice paradigm* (Anderson, et al., 1994). In today's memory research there is still an active debate about how we can overcome interference and resolve competition between similar traces when retrieving specific target memories (see e.g., Anderson, 2003; Camp, Pecher, & Schmidt, 2007). Researchers consider the retrieval practice effect a short rather then a long term effect (see e.g., Saunders & MacLeod, 2002). We know that the operation processes operating during sleep play a crucial role in the consolidation of episodic memories (see e.g., Conwey, 2009) but it is still unclear if the suppression effects due to selective practice are lasting for seconds, creating just a short term reduction in the activity level of competing responses or are long term effects, which determines the durable accessibility of items from memory. We think that this is an important aspect in the understanding of OCD symptomatology.

We have demonstrated that the RIF effect persists in long term in healthy subjects after 12 hours if there is no active rehearsal and a period of nocturnal sleep is included before the surprise delayed recall (Experiment 1, Study 4). In the absence of rehearsal the retrieval-practice effects began to dissipate after a retention period of just 1 hour (Morning no-sleep group, Experiment 2, Study 4). In one experiment just mentioned in our study we found that if there is rehearsal during the retention interval, then retrieval practice effects will be present also after 12 hours (with no period of sleep). According to the *episodic inhibition account* (Racsmány & Conway,

2006) in the retrieval practice paradigm the study of item pairs gives rise to the formation of an episodic memory and the practice phase establishes a pattern of activation and inhibition over these memories. On the final recall then this pattern of activation-inhibition will mediate access to memories. It seems likely that the opportunity for interference by new memories was greater in our no-sleep than in our sleep-groups, and, consequently, integration may have been attenuated in the no-sleep relative to the sleep groups. We can conclude that the greater degree of integration of memories in the sleep groups underlies the observed retrieval practice effects.

Thesis IV: No retrieval induced forgetting (RIF) in OCD

OCD patients didn't show the RIF effect which could not be explained by working memory deficit or increased anxiety. The lack of RIF effect might be explained by the dysfunction of conflict detection processes observed in OCD.

For the cognitive profile of OCD it seems essential the overactiveted mechanism involved in conflict detection, monitoring and inhibition of competing information. The OCD patients do not show the RIF effect, whereas we found similar practice effects in both the control and the OCD group. According to our findings this is not affected by the level of anxiety, symptom severity, working and short term memory capacity.

Contrary to the findings of Koessler, Engler, Riether, and Kissler (2009) who argue that stress might eliminate RIF in healthy

adults by temporary suspending the inhibitory mechanism involved, we haven't found relations between RIF and trait or state anxiety measured by the STAI (State and Trait Anxiety Inventory) in the OCD group. Aslan and Bäuml (2010) argue that there is a connection between working memory capacity and RIF. We haven't found significant difference between the two groups regarding the hit rates on the N-back tasks (updating) and on the Digit Span Forward and Backward Tasks (short term memory span). There was no significant correlation between RIF and working, short term memory scores in either of the groups.

The different pattern regarding the recall of NRP- (control items for Rp- items) and NRP+ in the two groups could mean that the patients are not sensitive for output interference. Most probably, the lack of RIF might be explained by the dysfunction of conflict detection processes observed in OCD maintained by the constant hyperactivity of anterior cingulated cortex and prefrontal structures.

Conclusions and further directions

Our data support the executive system deficit in OCD and we argue that this impairment could contribute to the overactivity and cancellation deficits observed in the PM system and to the altered recall of episodic memories.

The studies focusing on the first degree relatives and on the identification of *endophenotipic markers* represent a great step forward. We think that the development and use of paradigms that can discriminate and measure the different PM phases and the functions involved could be a great interest here. According to the *gateway hypothesis* (Burgess, Scott, & Frith, 2003) we think that is possible that in OCD the maintenance of the intention requires extra stimulus independent (SI) attentional processes which impairs the execution of the ongoing activities (stimulus oriented attending, SO). It is possible that different subgroups of OCD patients will manifest different performance patterns on PM paradigms and this kind of further research could contribute to the findings of endophenotypic markers in OCD.

This clinical domain combined with experimental cognitive psychology methodology offers a lot of open and exciting questions and further research is needed to clarify it and to integrate main findings in the cognitive psychotherapy of the disorder.

List of publications related to thesis

1. Demeter, Gy., Racsmány, M., Csigó, K., Harsányi, A, Döme, L. & Németh, A. (2012). Intact short term memory and impaired executive functions in obsessive compulsive disorder. *Ideggyógyászati Szemle - Clinical Neuroscience* (accepted publication).
2. Demeter, Gy. (2010a). A kényszerbetegség neuropszichológiai jellegzetességei. In. A. Harsányi, K. Csigó, & Demeter, Gy. (Eds.), *Kényszerbetegség: Elmélet, kutatás, terápia* (pp. 137–153). Budapest: Oriold és Társai Kiadó [Hungarian].
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