An Experimental Study of Prospective Memory in Obsessive-compulsive Disorder

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An Experimental Study of Prospective Memory in Obsessive-compulsive Disorder

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Abstract

The aim of the present study was to investigate prospective memory (PM) function in patients with obsessive-compulsive disorder (OCD). An event-based PM task was administered to 30 OCD patients and 30 healthy adult subjects. For OCD patients, PM instruction produced significantly more cost in terms of reaction time (RT) during the ongoing task. A significant group-experimental condition interaction in ongoing task RTs was found, which suggests that PM instruction loaded an extra cost onto OCD patients' ongoing activities, and this was independent of the execution of the PM intention. Comparing the PM task RTs between patients and healthy adults also revealed a significant group difference. These results suggest that OCD patients experience difficulties during PM tasks, and these difficulties originate from over-monitoring the stimuli for PM cues.

Keywords: obsessive-compulsive disorder, intention maintaining, prospective memory, monitoring functions

1. Introduction

OCD is a psychiatric condition that is defined by the presence of either obsessions (intrusive, disturbing thoughts) or compulsions (repetitive, unwanted behaviors). OCD has been associated with various cognitive deficits. The clinical presentation of this disorder has prompted researchers to investigate the integrity of executive functions and controlled memory processes based mainly on frontostriatal and frontotemporal neural circuits (van den Heuvel et al., 2005). Although the results of neuropsychological studies of OCD are inconsistent, there is evidence suggesting that OCD patients have difficulties with tasks involving strategy planning, attentional shifting, inhibition of prepotent responses, and self-cued memory retrieval processes (Christensen, Kim, Dysken, & Hoover, 1992; Gambini, Abbruzzese & Scarone, 1993; Abbruzzese, Bellodi, Ferri, & Scarone, 1995; Rubin & Harris, 1999; Purcell, Maruff, Kyrios, & Pantelis, 1998; Greisberg & McKay, 2003). It was recently suggested that prospective memory (PM) is also impaired in OCD patients, and this PM deficit is a major contributor to the cognitive phenotype of this disorder. By involving subclinical checkers, Cuttler and Graf (2007) produced compelling evidence that a checking compulsion is associated with a deficiency in event-based PM tasks. Marsh et al. (2009) found that people with obsessive-compulsive tendencies (washing compulsions) manifest deficits in an event-based PM task for neutral intentions. This performance was ameliorated by giving the subclinical group an intention about a threat-related category. PM refers to the encoding, storage, and delayed retrieval of intended actions (Ellis, 1996; Einstein & McDaniel, 1996).

Several neuroimaging studies have found that the maintenance and execution of PMs prompt activation in a distributed network. This network includes structures within the rostral prefrontal cortex (PFC), parietal cortex, hippocampal complex, and right thalamus (Burgess,

Quayle & Frith, 2001; Burgess, Scott & Frith, 2003; Okuda et al., 1998; Okuda et al., 2007; West, 2008). Without intact PM functions, one would be unable to carry out long-term plans and intentions (as is the case following sustained damage to various frontal areas). In addition, such an individual would be situated in a condition that can be described as lacking a cognitive future (Burgess, 2000; Kliegel, Jager, Altgassen, & Shum, 2008). On the contrary, over-activated intentions in a PM system would cause persistent thoughts and actions. Without the proper cancellation of these intentions, one's cognitive system would become overwhelmed by future thoughts and acts. Experimental research on PM has identified a number of components of prospective remembering, such as formation, retention, execution, and evaluation or monitoring of intentions (Kliegel, Martin, McDaniel, & Einstein, 2002). Although monitoring has a long history in the memory retrieval field, it has only recently become a topic of interest in the event-based PM research field (Guynn, 2003). Three widely known monitoring theories have been developed in the last two decades, and all of these models describe monitoring as a strategic process.

The supervisory attentional system (SAS) model states that actions are controlled on two levels (Norman & Shallice, 1986; Burgess & Shallice, 1997). The first level, contention scheduling, is automatic and controls routine behaviors when environmental cues are sufficient to trigger appropriate behavior. The second level is the SAS biasing contention scheduling and monitoring the environment for target events that indicate when it is appropriate to execute the intended prospective performance.

The multiprocess model proposes that although PM is supported by automatic processes when there is a strong association between the PM target event and the intended actions, there are other circumstances when PM performance is mediated by more strategic monitoring processes (McDaniel & Einstein, 2000; McDaniel, Guynn, Einstein and Breneiser, 2004). There are situations when, for example, the PM target events are not salient, or there is

no strong association between target events and the intended action. Finally, the preparatory attentional and memory processes model (PAM) proposes that non-automatic attentional processes are always involved in PM retrieval (Smith, 2003; Smith & Bayen, 2004). One component of these preparatory attentional processes is monitoring for the PM target events that indicate the appropriate time for PM actions.

Although these influential models propose that monitoring is a strategic process, there is a recent concept that proposes that monitoring comprises two processes that demand resources: instantiating a PM retrieval mode and making periodic checks of the environment for an appropriate target to execute the intended action (Guynn, 2008). Based on these advances, PM research produced dependent measures that were developed to analyze the role of monitoring functions in PM responses. These measures are the accuracy and latency of the ongoing activities in which the PM task is embedded (Guynn, 2003; Kliegel, Martin, McDaniel, & Einstein, 2001; Kliegel, Martin, McDaniel, & Einstein, 2004). According to Guynn (2008), the principal way to measure monitoring in an event-based PM task is to compare the performance on an ongoing task, during which PM instructions or targets are embedded (experimental trials), with the performance on the same task when no PM instructions or cues are assigned (control trial). The lower accuracies or higher latencies on the experimental trials relative to the control trials provide evidence of monitoring activity (Guynn, 2003; Kliegel et al., 2001; Kliegel et al., 2004; Marsh, Hicks, & Cook, 2005). In a seminal paper, Burgess, Quayle and Frith (2001) adapted these methodologies for a positron emission tomography study. Healthy participants were instructed to perform one of four tasks under three conditions: a baseline condition where only the ongoing activities were performed, a prospective expectation condition where prospective cues were expected but never occurred, and an execution condition where prospective cues were presented. The researchers found activation in the frontal pole (middle frontal gyrus), right parietal lobe, and

precuneus region in both the expectation and the execution conditions relative to the baseline condition. This result was interpreted as evidence that the activated network supports the maintenance of intentions during the course of ongoing activity. The differences revealed by the comparison of the expectation and execution conditions - the activation of the right thalamus accompanied by decreases in the right dorsolateral prefrontal cortex (RDLPFC) - seemed to be associated with the realization of delayed intentions. An important conclusion of this study was that the activation of the rostral PFC reflects sustained processing related to checking for a prospective cue (West, 2008).

The aim of the present study was to investigate PM functions in obsessive-compulsive (OCD) patients, both in an expectation and execution condition. We applied one of the tasks from the Burgess et al. (2001) study (task 1) outlined above; this specific task was selected because of its relative ease, as indicated by the low rates of misses and false alarms in the original study. Furthermore, this task appeared suitable for an experimental study involving medicated patients. The specific design of the task allowed us to investigate the function of monitoring processes for PM cues in OCD patients. We hypothesized that PM instruction would cause an extra cost in ongoing activity for OCD patients, and this was expected to be independent of the execution of the delayed intention.

2. Method

2.1. Experimental design and procedure

We closely followed the protocol established by Burgess et al. (2001). An event-based PM task was administered to each participant under three conditions: (1) a baseline condition in

which there was no expectation that PM stimuli would occur, and no PM stimuli occurred; (2) an expectation condition in which participants were told that PM stimuli might occur, though none actually did; and (3) an execution condition in which participants were told that PM stimuli might occur, and stimuli did occur. This procedure allowed us to separate and compare the performances associated with intention maintenance and its realization.

Sixty stimuli were presented in the baseline and expectation conditions. The execution condition contained PM stimuli that were pseudorandomly distributed, amounting to 25% of the stimuli. In each condition, the first six stimuli were considered practice items and were not included in the analysis. The order of the conditions (baseline, expectation, and execution) was the same for all participants. Stimuli presentation strictly adhered to the Burgess et al. (2001) procedure and was subject-paced (i.e., the onset of the next stimulus was cued by the subject's response, and the stimuli remained visible until that response occurred). A 2000 ms blank white screen interval was inserted between presentations.

- Figure 1 -

In each trial, two arrows were presented on the display. One arrow was always black, and its position varied pseudorandomly. In both the baseline and expectation conditions, stimuli included 30 items in which the black arrow pointed to the left and an additional 30 items in which it pointed to the right. The ratio in the execution condition was 40/40. Two color bars also appeared on the screen and were located at equal distances above and below the arrows. The color of the horizontal bar was red, blue, green, yellow, or orange.

Participants were positioned with the forefinger, middle finger, and third finger of their right hand on the three arrow keys of a computer keyboard. They were told to press the key with their forefinger if the black arrow was pointing to the left, with their third finger if it was pointing to the right, and with their middle finger if the two color bars above and below the arrows were the same color. Written instructions were read to the participants immediately before each experimental block was administered. Participants were asked to press the key with their forefinger if the arrow was to the left of a fixation point and with their third finger if it was to the right. They were told to respond with their middle finger if the two color bars above and below the fixation point were the same color on any trial.

2.2. Participants

Thirty properly-diagnosed OCD patients were selected from the Nyírő Gyula Hospital, Department of Psychiatry I and II, Budapest, Hungary (mean age = 33.46, S.D. = 10.81; mean education = 12.86, S.D. =2.59). Patients were either being followed for OCD treatment or had been followed in the past. Individuals were included in the study if they had a DSM-IV diagnosis of OCD and were between 18 and 65 years old. A psychiatrist (A.H.) confirmed the diagnosis following the Structural Clinical Interview for DSM-IV Axis I Disorders (SCID-I) (First et al., 1997). Severity of OCD symptomatology was assessed with the Yale Brown Obsessive-compulsive Scale (mean=26.36; S.D.=7.37). We excluded subjects from the study who met the criteria for depression (Revised Hamilton Depressive Rating Scale, mean=10.5; S.D.=6.34); we also excluded subjects with any other current comorbid psychiatric diagnosis (Axis I or Axis II). Pariticipants completed a questionnaire about their drug use and those patients with a history of drug abuse in the last year were excluded.

All OCD patients received the following evaluations: a psychiatric interview by experienced clinicians (M.D.) and an assessment by trained raters that included the Structured Clinical Interview for DSM-IV (First et al., 1995) to confirm current Axis I DSM-IV disorders, the Y-BOCS (Goodman et al., 1989a, b), and the Hamilton Rating Scale for Depression (HAM-D, 17-item; Hamilton 1960).

Written informed consent was obtained prior to the study (see Table 1 for patient characteristics). The project was approved by the institutional ethical review board. After being given a detailed description of the investigation by the clinicians, patients were asked to sign an informed consent document. All patients were assured that participation in the study would not interfere with their clinical treatment. The healthy adult group was matched according to age and education (mean age = 33.03, S.D.=11.76; mean education = 13.5, S.D. =2.71).

- Table 1 about here –

3. Results

As in the Burgess et al. (2001) study, errors for non-PM and PM stimuli were rare (see Table 2). The mean percentages of errors for the ongoing task were analyzed in a Group (Patient, Healthy adult) X Condition (baseline, expectation, execution) mixed ANOVA. The same analysis was conducted on the mean percentages of the two types of errors (miss and false alarm) for the PM task. No significant differences were found.

Comparing patient and healthy adult group errors on the ongoing task baseline [$t(1, 58) = 0.85$, $p>0.05$, $r=0,11$], expectation [$t(1, 58) = 0.91$, $p>0.05$, $r=0,12$], and execution conditions [$t(1, 58) = 1.09$, $p>0.05$, $r=0,14$] revealed no significant differences.

We found the same results in the PM task execution condition with the miss type errors (not responding to a PM cue) [t(1, 58) = -0.18, p>0.05, r=0,02] and the false alarm type errors (responding to a PM cue when there should be no response) [t(1, 58) = -0.33, p>0.05, r=0,04].

- Table 2 about here -

Analysis of RTs was based on errorless trials. The Group (Patient, Healthy adult) X Condition (baseline, expectation, execution) mixed ANOVA for the participants' mean RTs in the ongoing task showed a significant main effect of group [F(1,58) = 17.6, p<0.01, Cohen's d=1,1] and condition [F(1,58) = 106.7, p<0.01, Cohen's d=2,71]. This analysis also produced a significant groupXcondition interaction, [F(2,116) = 7.3, p<0.01, (see Figure 2). Inspecting the data shown in Figure 2 it appeared to us that this interaction may be driven by an increase in RT of the execution condition in the healthy cohort. Therefore we carried out post-hoc comparisons (Bonferroni) of participants' RTs in the expectation and execution conditions in both groups to check this assumption. Bonferroni corrected post hoc tests showed no significant difference in RTs of the ongoing task between the expectation condition and the execution condition in the OCD sample (p>0.1). In contrast, the same comparison produced a significant difference within the healthy adult group (p<0.001). Comparison of patient and healthy adult group RTs on the ongoing task execution condition [t(1, 58) = 3.96, p<0.001, r=0,46] and on the PM task [t(1, 58) = 3.9, p<0.001, r=0,46] revealed significant differences (see Figure 3).

- Figures 2 and 3 about here-

To further analyze the data, a "cost of PM instruction" was calculated for both the expectation (ongoing task RT in expectation condition – ongoing task RT in baseline condition) and execution (ongoing task RT in execution condition – ongoing task RI in baseline condition) conditions. Comparison of patient and healthy adult group expectation cost revealed a significant difference [t(1, 58) =3,59 p<0.01, r=0,43], as did comparing the patient and healthy adult group execution cost [t(1, 58) =3,07, p<0.01, r=0,37] (see Figure 4).

- Figures 4 about here-

4. Discussion

The present study involved the investigation of PM functions in OCD patients using an event-based PM experimental paradigm, and the study revealed some important differences between OCD patients and healthy adults. We found that OCD patients had longer reaction times during the ongoing task for all three conditions. While OCD patients had longer RTs than the healthy adult participants, the two groups performed similarly in terms of hits and misses. There was a significant group-experimental condition interaction for the ongoing task RTs, which suggests that PM instruction loaded an extra cost onto the ongoing activities of the OCD patients. This was independent of the execution of the PM intention, as there was no difference between the expectation and execution conditions. Patients were also significantly slower at the PM task, which indicates that their extra effort in searching for PM cues did not result in a better performance when PM cues appeared. Based on these results, we conclude that this interaction in the ongoing task RTs originated from OCD patients over-monitoring stimuli for PM cues following PM instruction.

5. Conclusion

The present study investigated PM function, a subcomponent of the executive system, in OCD patients using an event-based PM procedure. The performance of the OCD patients was impaired on the PM tasks, which suggests that this impairment originates from the over-monitoring of stimuli for PM cues. Previous findings are controversial concerning the relationship between OCD symptoms and prospective memory, as Cuttler & Graf (2007) found impaired PM functions in subclinical checkers, while Jelinek et al. (2006) found no PM impairment in OCD patients. The present paper is the first experimental study that showed differences in PM functions in OCD patients compared to healthy adults.

One way to explain these results is to assume that OCD patients produce a type of overactivation in monitoring for PM cues following PM instructions. This assumption would be consistent with some recent data suggesting that patients with OCD produce overactive performances in action-monitoring tasks (Johannes, 2001; Ursu, Stenger, Shear, Jones, & Carter, 2003). As Guynn (2008) pointed out, lower accuracies or higher latencies on the experimental trials relative to the control trials provide evidence of monitoring activity (Guynn, 2003; Kliegel et al., 2001; Kliegel et al., 2004; Marsh, Hicks, & Cook, 2005). Based on these findings, it seems plausible that PM instruction prompted extra monitoring performance for PM cues in the OCD group, which interfered with the performance of the ongoing activities in both the expectation and execution trials relative to the baseline. Interpreting these results from a neuroscientific point of view, it is critical to investigate the results of Burgess et al (2001) in detail, who applied the same procedure for healthy participants using positron emission tomography (PET). They found increased regional cerebral blood flow (rCBF) in the frontal pole (BA10) bilaterally, and also in the right lateral prefrontal cortex, inferior parietal cortex and the precuneus in the expectation and execution

conditions relative to the baseline condition These rCBF increases were accompanied by significant rCBF decreases in the insula of the left hemisphere. Importantly, they found decreased rCBF in left fronto-temporo networks (insula gyrus, precentral gyrus) when participants expected PM stimuli relative to the baseline (minus execution, see Burgess et al., 2001). Finally, the direct comparison of the execution and expectation conditions (execution minus expectation) revealed the activation of the right thalamus accompanied by decreases in the right dorsolateral prefrontal cortex (RDLPFC). In the present study we found that PM instruction in the expectation and execution conditions produced the same amount of increase in RTs of the ongoing activity in the OCD group. Based on this, a plausible assumption would be that the activation of thalamus and DLPFC in OCD patients is at the same level when they only expect a PM cue and when they execute a PM action. Although there is no way to say more on this issue without neuroimaging investigations, it is an interesting assumption that OCD patients may produce a thalamic hyperactivation and DLPFC hypoactivation relative to healthy adults in PM expectation conditions. Thalamus is implicated in anticipatory attentional processes and in the monitoring of self-generated actions (Blakemore et al., 1998; Portas et al., 1995). Recent neuroimaging studies found increased glucose metabolism in the thalamus, orbitofrontal cortex (OFC), caudate, prefrontal cortex,and anterior cingulate in patients with OCD as compared with healthy participants (Baxter et al., 1988; Nordahl et al., 1989; Swedo et al., 1989). These findings speak to the assumption that fronto-thalamic circuits may be overactivated in OCD patients in prospective memory task situations. This overactivation will result in an intensive monitoring performance for prospective cues. The smaller the probability of prospective cues is, the more maladaptive this monitoring behavior will be by slowing down ongoing behavior.

Although this is a plausible interpretation of our data, there are some limitations in our study design. First, we only used an event-based task and not a time-based PM task, and a time-based PM task would have allowed us to directly measure monitoring activity in terms of checking behavior (see Mackinlay, et al., 2009). Second, we only found group differences in RTs and not in hits and misses, so a possible explanation of our data is that the group differences are the consequence of general inattention and not PM dysfunction. For example, Jelinek et al. (2006) found no PM impairments in OCD patients using the Rivermead Behavioural Memory Test. However, the major dependent variable in this study are the correct responses of the individuals in these simple tasks. We think that the reaction time data are more informative/sensitive in this case than the errors, which were almost zero in our study as a consequence of the construction of our task. In our opinion the overactivity of the PM system results in an over-monitoring activity in OCD patients, and the consequence of this over-monitoring is a slower reaction time in the ongoing task and in the PM task compared to healthy adults. We think that these results could outline a new aspect of the treatment of OCD, as well. Considering that prospective memory deficit could contribute to both treatment adherence and many everyday difficulties in this disorder, including a prospective memory training in cognitive-behavioural therapy protocols of OCD seems a reasonable suggestion. Further experimental and neuroimaging work is needed to confirm the outlined assumptions.

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REFERENCES

Abbruzzese, M., Bellodi, L., Ferri, S., & Scarone, S. (1995). Frontal lobe dysfunction in schizophrenia and obsessive-compulsive disorder: a neuropsychological study. *Brain and Cognition, 27,* 202–212.

Baxter Jr., L.R., Schwartz, J.M., Mazziotta, J.C., Phelps, M.E., Pahl, J.J., Guze, B.H., Fairbanks, L. (19889 Cerebral glucose metabolic rates in nondepressed patients with obsessive–compulsive disorder. American Journal of Psychiatry 145, 1560–1563.

Blakemore S.J,. Rees G., Frith C.D. (1998) How do we predict the consequences of our actions? A functional imaging study. Neuropsychologia, 36, 521–9.

Burgess, P. W. (2000). Strategy application disorder: The role of the frontal lobes in human multitasking. *Psychological Research, 63,* 279-288.

Burgess, P. W., & Shallice, T. (1997). The relationship between prospective and retrospective memory: Neuropsychological evidence. In M. A. Conway (Ed.), *Cognitive models of memory* (pp. 247–272). Cambridge, MA: MIT Press.

Burgess, P. W., Quayle, A., & Frith, C.D. (2001). Brain regions involved in prospective memory as determined by positron emission tomography. *Neuropsychologia, 39,* 545-555.

Burgess, P. W., Scott, S. K., & Frith, C. D. (2003). The role of the rostral frontal cortex (area 10) in prospective memory: a lateral versus medial dissociation. *Neuropsychologia, 41,* 906-918.

Chamberlain, S. R., Blackwell, A. D., Fineberg, N. A, Robbins, T. W., & Sahakian, B. J. (2005). The neuropsychology of obsessive compulsive disorder: the importance of failures in cognitive and behavioural inhibition as candidate endophenotypic markers. *Neuroscience and Biobehavioral Reviews, 29,* 399-419.

Christensen, K. J, Kim, S. W., Dysken, M. W., & Hoover, K. M (1992). Neuropsychological performance in obsessive-compulsive disorder. *Biological Psychiatry, 31,* 4 –18.

Cuttler, C., & Graf, P. (2007). Sub-clinical compulsive checkers' prospective memory is impaired. *Journal of Anxiety Disorders, 3,* 338-352.

Cuttler, C., & Graf, P. (2009). Sub-clinical compulsive checkers show imaired performance on habitual, even- and time-cued episodic prospective memory tasks. *Journal of Anxiety Disorders, 23,* 813-823.

Ellis, J. (1996). Prospective memory or the realization of delayed intentions: A conceptual framework for research. In. M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications.* (pp. 1-22). New York: Lawrence Erlbaum Associates.

Einstein, G. O., & McDaniel, M. A. (1996). Retrieval processes in prospective memory: Theoretical approaches and some new empirical findings. In. M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications.* (pp. 115-141). New York: Lawrence Erlbaum Associates.

First, M.B., Spitzer, R.L., Gibbon, M. and Williams, J.B.W. (1995). Structured Clinical Interview for DSM-IV, Patient Edition (SCUD-P). Biometrics Research Department, New York State Psychiatric Institute, New York.

First, M.B., Spitzer, R.L., Gibbon, M., & Williams, J.B.W. (1997). Structured Clinical Interview for DSM-IV Axis I Disorders-Clinician Version (SCID-CV)., American Psychiatric Press, Washington, DC.

Gambini, O., Abbruzzese, M., & Scarone, S. (1993). Smooth pursuit and saccadic eye movements and Wisconsin Card Sorting Test performance in obsessive-compulsive disorder. *Psychiatry Research*, *48,* 191–200.

Goodman, W. K., Price, L. H., Rasmussen, S. A., Mazure, C., Fleischman, R. L., Hill, C. L., et al. (1989a). The Yale-Brown Obsessive Compulsive Scale: I. Development, use, and reliability. *Archives of General Psychiatry 46,* 1006–1011.

Goodman, W. L., Price, L. H., Rasmussen, S. A. & Mazure, C. (1989b). The Yale-Brown Obsessive Compulsive Scale (YBOCS): validity. *Archives of General Psychiatry 46,* 1012–1016.

Greisberg, S., & McKay, D. (2003). Neuropsychology of obsessive-compulsive disorder: a review and treatment implications. *Clinical Psychology Review*, 23, 95–117.

Guynn, M. J. (2003). A two-process model of monitoring in event-based prospective memory: Activation/retrieval mode and checking. *International Journal of Psychology, 38,* 245-256.

Guynn, M. J. (2008). Theory of monitoring in prospective memory: Instatiating a retrieval mode and periodic target checking. In. M. Kliegel, M. A. McDaniel, & G. O. Einstein (Eds.), *Prospective memory: Cognitive, neuroscience, developmental, and applied perspectives* (pp 53-76). New York: Lawrence Erlbaum Associates.

Hamilton, M. (1960). A rating scale for depression. *Journal of Neurology, Neurosurgery & Psychiatry, 23*, 56-62.

Jelinek, L., Moritz, S., Heeren, D., & Naber, D. (2006). Everyday memory functioning in obsessive-compulsive disorder. *Journal of the International Neuropsychological Society, 12,* 746-749.

Johannes, S., Wieringa, B. M., Nager, W., Rada, D., Dengler, R., Emrich, H. M., et al. (2001). Discrepant target detection and action monitoring in obsessive compulsive disorder. *Psychiatry Research, 108,* 101–110.

Kliegel, M., Martin, M., McDaniel, M. A., & Einstein, G.O. (2001). Varying the importance of a prospective memory task: Differential effects across time- and event-based prospective memory. *Memory, 9,* 1-11.

Kliegel, M., Martin, M., McDaniel, M. A., & Einstein, G.O. (2002). Complex prospective memory and executive control of working memory: A process model. *Psychologische Beiträge, 44,* 303–318.

Kliegel, M., Martin, M., McDaniel, M. A., & Einstein, G.O. (2004). Importance effects on performance in event-based prospective memory tasks. *Memory, 12,* 553-561.

Kliegel, M., Jager, T., Altgassen, M., & Shum, D. (2008). Clinical neuropsychology of prospective memory. In. M. Kliegel, M. A. McDaniel, & G. O. Einstein (Eds.), *Prospective memory: Cognitive, neuroscience, developmental, and applied perspectives* (pp 283-308). New York: Lawrence Erlbaum Associates.

Mackinlay, R. J., Kliegel, M., & Mäntylä, T. (2009). Predictors of time-based prospective memory in children. *Journal of Experimental Child Psychology, 102,* 251-264.

Marsh, R.L., Brewer, G.A., Jameson, J.P., Cook, G.I., Amir, N., & Hicks, J.L. (2009). Threat-related processing supports prospective memory retrieval for people with obsessive tendencies. *Memory, 17,* 679-686.

Marsh, R. L., Hicks, J. L., & Cook, G. I. (2005). On the relationship between effort toward an ongoing task and cue detection in event-based prospective memory. *Journal of Experimental Psychology: Learning, memory, and Cognition, 31,* 68-75.

McDaniel, M. A., & Einstein, G. O. (2000). Strategic and automatic processes in prospective memory retrieval: A multiprocess framework. *Applied Cognitive Psychology, 14,* S127–S144.

McDaniel, M. A., Guynn, M. J., Einstein, G. O., & Breneiser, J. (2004). Cue-focused and reflexive-associative processes in prospective memory retrieval. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 30,* 605–614.

Nordahl, T.E., Benkelfat, C., Semple, W.E., Gross, M., King, A.C., Cohen, R.M. (1989) Cerebral glucose metabolic rates in obsessive compulsive disorder. Neuropsychopharmacology 2, 23–28.

Norman, D. A., & Shallice, T. (1986). Attention to action: Willed and automatic control of behavior. In R. J. Davidson, G. E. Schwartz, & D. Shapiro (Eds.), *Consciousness and self-regulation: Advances in research and theory* (Vol. 4 pp. 1–18). New York: Plenum.

Okuda, J., Fujii, T., Yamadori, A., Kawashima, R., Tsukiura, T., Fukatsu, R., et al. (1998). The participation of the prefrontal cortices in prospective memory: Evidence from a PET study in humans. *Neuroscience Letters,* 253, 127-130.

Okuda, J., Fujii, T., Ohtake, H., Tsukiura, T.,Yamadori, A., Frith, C.D. et al. (2007). Differential involvement of regions of prefrontal cortex (Brodmann area 10) in time- and event-based prospective memory. *International Journal of Psychophysiology,* 64, 233-246.

Portas C.M., Rees G., Howseman A.M., Josephs O., Turner R, Frith C.D. (1995) A specific

role for the thalamus in mediating the interaction of attention and arousal. Journal of Neuroscience, 18, 8979–8989

Purcell, R., Maruff, P., Kyrios, M., & Pantelis, C. (1998). Cognitive deficits in obsessive–compulsive disorder on tests of frontal–striatal function. *Biological Psychiatry, 43,* 348–357.

Rubin, R. T., & Harris, G. J. (1999). Obsessive-compulsive disorder and the frontal lobes. In B. L. Miller, & J. L. Cummings (Eds.), *The human frontal lobes: functions and disorders* (pp. 522–536). New York: Guilford.

Smith, R. E. (2003). The cost of remembering to remember in event-based prospective memory: Investigating the capacity demands of delayed intention performance. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29,* 347–361.

Smith, R. E., & Bayen, U. J. (2004). A multinomial model of event-based prospective memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 30,* 756–777.

Swedo, S.E., Schapiro, M.B., Grady, C.L., Cheslow, D.L., Leonard, H.L., Kumar, A., Friedland, R., Rapoport, S.I., Rapoport, J.L.(1989) Cerebral glucose metabolism in childhood-onset obsessive– compulsive disorder. Archives of General Psychiatry 46,518– 523.

Ursu, S., Stenger, A., Shear, M. K., Jones, M. R., & Carter, C. S. (2003). Overactive action monitoring in obsessive-compulsive disorder: Evidence From Functional Magnetic Resonance Imaging. *Psychological Science, 14,* 347-353.

West, R. (2008). The cognitive neuroscience of prospective memory. In. M. Kliegel, M. A. McDaniel, & G. O. Einstein (Eds.), *Prospective memory: Cognitive, neuroscience, developmental, and applied perspectives* (pp 261-282). New York: Lawrence Erlbaum Associates.

van den Heuvel, O.A., Veltman, D.J., Groenewegen, H.J., Cath, D.C., van Balkom, A.J.L.M., van Hatskamp, J., et al. (2005) Frontal-striatal dysfunction during planning in obsessive-compulsive disorder. *Archives of General Psychiatry, 62,* 301-310.

Figure legends

Figure 1 Description of the tasks:

a) Ongoing Task: press the key (left or right) in the direction of the black arrow.

b) PM Task: if the color bars are the same color, press the up-arrow key.

Figure 2 Mean RTs (S.D.) by condition for the ongoing task.

Figure 3 Mean RTs (S.D.) for the ongoing and PM tasks in the execution condition.

Figure 4 Mean RTs (S.D.) for the expectation and execution costs in the OCD and the healthy adult groups.

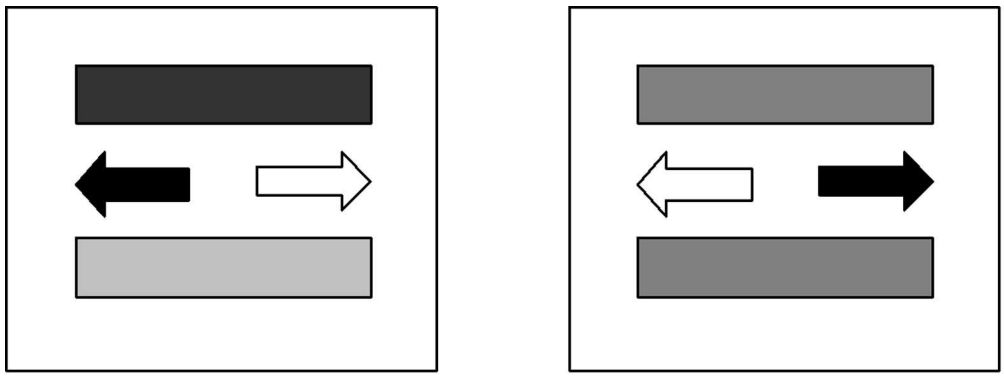

Figure 1 Description of the tasks:
a) Ongoing Task: press the key (left or right) in the direction of the black arrow.
b) PM Task: if the color bars are the same color, press the up-arrow key.

398x146mm (300 x 300 DPI)

Figure 2 Mean RTs (S.D.) by condition for the ongoing task.
173x97mm (120 x 120 DPI)

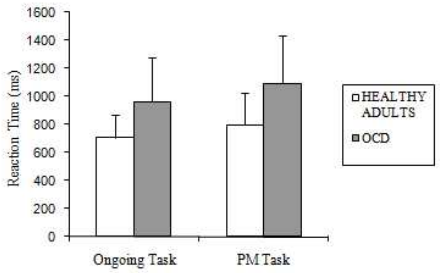

Figure 3 Mean RTs (S.D.) for the ongoing and PM tasks in the execution condition.
173x97mm (120 x 120 DPI)

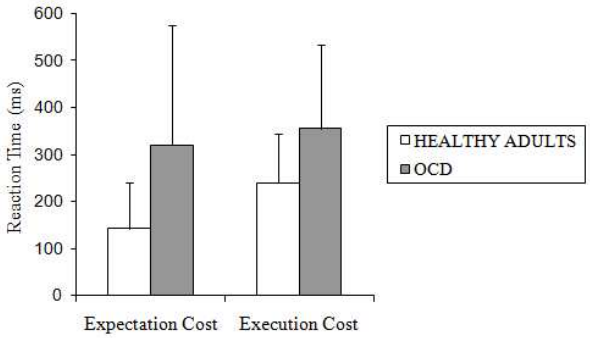

Figure 4 Mean RTs (S.D.) for the expectation and execution costs in the OCD and the healthy adult groups.
173x97mm (120 x 120 DPI)

Table 1

Sample Demographics

Characteristics	OCD (*n*=30)		Healthy Adults (*n*=30)		ANOVA	
	Mean	S.D.	Mean	S.D.	F	p
Age (years)	33.46	10.81	33.03	11.76	0.022	0.882
Education (years)	12.86	2.59	13.50	2.71	0.853	0.359
Sex (M/F)	20/10		21/9			
Y-BOCS Total	26.36	7.37				
HAM-D	10.5	6.34				

Note. OCD, obsessive-compulsive disorder; M, male; F, female; Y-BOCS, Yale-Brown Obsessive Compulsive Scale; HAM-D, Hamilton Rating Scale for Depression

Table 2

Hit Rates in the Three Experimental Conditions

Hit rate (% correct)	OCD (*n*=30)		Healthy Adults (*n*=30)		ANOVA	
	%	S.D.	%	S.D.	F	p
Baseline condition – Ongoing Task	98.83	4.87	99.61	0.97	0.735	0.395
Expectation condition – Ongoing Task	98.83	3.69	99.66	0.67	1.479	0.229
Execution condition – Ongoing Task	99.44	1.87	99.72	0.77	0.563	0.456
Execution condition – PM Task	90.66	13.11	89.5	9.03	0.161	0.690

Note. OCD, obsessive-compulsive disorder; PM task, prospective memory task