Chapter 4

Effects of Obsessive-Compulsive Disorder Symptom Intensity on Brain Electro-Cortical Activity Associated with Emotional Memory

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1. Introduction

Obsessive-Compulsive Disorder (OCD) consists of recurrent and persistent thoughts (**obsessions**), accompanied by the development of ritual and/or repetitive behaviors (**compulsions**). It has been widely suggested that these symptoms might be linked to different types of cognitive and cerebral impairments. More precisely, it has been shown that OCD patients present specific memory difficulties that could be related to a Cortico-Striato-Thalamo-Cortical (CSTC) loop dysfunction. Some research has further explained these memory problems as a result of poor confidence, along with affected emotional evaluation.

Numerous studies have undertaken the task to examine which specific aspect of memory processing might be affected in OCD patients. For instance, the California Verbal Learning Test (CVLT) was employed to assess verbal memory. Overall, findings have been mixed with poorer encoding, but intact delayed recall, impaired encoding and long delay recall, or completely intact encoding, recall and recognition memory. In contrast, there is a stronger support for the presence of a visual memory deficit in OCD. Several studies have reported impaired recall on the Rey Complex Figure Test (RCFT), as well as recall on other tests of non verbal memory.

In parallel, a general questioning regarding a possible relationship between emotion processing and OCD symptoms remains unresolved. From a psychological measurement standpoint, obsessive and compulsive symptom expressions could also be modulated by internal media-

ting factors like the emotional context, including the type of material presented, its emotional valence and its complexity. These examples of internal factors could likely influence performance behavior including the degree of avoidance, hesitation and difficulties in recall and memory. Thus, a potential candidate explanation for OCD patients' altered neuropsychological performances, may lie in emotionality and emotional stressors. More precisely, stimuli eliciting anxious over-concern, strong emotionality such as those perceived as threatening, may activate a differential performance. Some investigations have focused their attention on the relationship between emotion and cognition in order to explain and find what triggers OCD behaviors. For instance, OCD patients attended to negative words longer than controls in a modified Stroop test using neutral and emotional threatening word sets. It was proposed that OCD patients have a propensity to encode negative words. In the same line, another research group found that OCD patients exhibited deficits in the ability to forget negative material compared to controls. Concurrently, others found that OCD washers showed longer latency responses to contamination words than non-washers, but that in general, OCD participants showed a longer latency to threat words. Thereby, these findings suggest that a threat-related hypothesis might explain OCD's maladaptive behaviors rather than an anxious concern and emotionality hypothesis.

In addition, other studies have indicated that the apparent memory-deficit in OCD might be modulated by the emotional valence of the presented stimulus. assessed memory in people with OCD with fear for contamination and compared their memory capacities to healthy controls. They mainly found that the OCD group had better memory skills for contaminated objects than for clean ones. Furthermore, neuropsychological tests scores indicated that this bias was not the result of differences in general memory ability. However, another investigation showed that physiological emotional reactions to stimuli were appropriate in OCD, but that patients' facial expressions indicated more attempts to suppress emotion and fear. In other words, the OCD group reacted to their emotionality more censoriously. In certain context, superior memory performances can be found with OCD checkers but they were more dissatisfied with the vividness of their recall, than were the controls. This might constitute an important clue underlying OCD's difficulties in memory confidence. Additionally, recent research suggests that there is a positive memory bias for threatening information in compulsive cleaners. However, it was proposed that the relationship between OCD and memory is likely to be more complex when the compulsive behavior is checking in a context of high responsibility. explored this relationship in a clinical sample of compulsive checkers and found a positive memory bias for threat-relevant information. In this laboratory setting, when the responsibility was artificially inflated, they observed that this positive memory bias was concurrently amplified. As expected, under conditions of no responsibility, no memory bias was detectable. However, responsibility appeared to have had a greater impact on confidence in memory than on memory itself in OCD.

In sum, the memory deficit seems to be mediated by emotionality, the degree of investment in motivations and by the responsibility to threat-relevant stimuli. However, the link between memory and emotional dimensions were not investigated yet in the context of cognitive

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electrophysiology and Event-Related brain potentials (ERP), which might bring some essential insights regarding cognitive processes.

2. Event-related brain potentials in obsessive-compulsive disorder

The ERP technique represents the stimulus-locked average of the raw electroencephalographic (EEG) signals. A core feature of the ERP approach is its sensitivity to covert information processing, which may not be fully assessed with behavioral measures. By giving a particular instruction during recordings, such as categorizing a stimulus by a motor response, various ERP components are obtained. These are related to different levels of cognitive processes as well as early sensory processing. Early ERP components (P100, N100, N200) are predominantly related to basic cognitive functions such as selective attention and mismatch detection, whereas the middle and late components (P300) vary with higher order information processing, such as stimulus evaluation and working memory storage.

Several ERP studies hypothesized over-focused attention in OCD, as manifested by shorter latency P300, particularly when task difficulty was increased. It has also been reported that during attention tasks, OCD was associated with larger processing negativity over the frontal area and a smaller P300 to attended target-stimuli, while the N200 was intact. Similar findings, specific to OCD patients, were reported with a visual Oddball task showing reduced P300 amplitude to target-stimuli particularly in the anterior region. Furthermore, specifically to OCD, while the P300 component appeared earlier, both N100 and P200 components oppositely showed a delayed latency. Together, these ERP findings suggest that in OCD, there is a misallocation of cognitive resources, particularly regarding memory updating and stimulus evaluation timing. However, no experiment was designed to assess episodic memory, in the context of emotional modulation.

3. Goal and hypotheses

Neuropsychological studies of OCD have most often reported minimal or no significant correlations between OCD symptom severity and cognitive functioning in general. Concurrently, some have effectively observed relationships, but more specific to certain memory or executive function tests. We propose that the discrepancy in past results could reside in part in the sub-optimal selection of OCD patients without taking into account the severity and the comorbid symptoms such as depression and anxiety. Thus, the current project mainly aimed to investigate the impact of OCD symptom severity and comorbidity on emotional memory and ERPs. Since the emotional influence on memory for OCD patients has never been explored with electrophysiological measures, our results might bring a more precise understanding of the phenomenon, especially regarding the temporal resolution of these memory stages. The use of pictures instead of words and separating the two groups by their symptom intensity constitute original ways to analyze memory processes in OCD. We also intend to assess

subjective memory confidence concurrently. Based on earlier studies of OCD participants, we predicted that emotions will impact on memory. The classical episodic memory (EM) effect will be less important in both patient groups than for the control group. In addition, severe OCD patients will show the most important impairments.

4. Methodology

4.1. Participants

Two OCD groups were separated based on their symptom severity (median split at 29) with the Yale-Brown Obsessive Compulsive Scale (Y-BOCS; Goodman, Price, Rasmussen, Mazure, Delgado, et al., 1989). Fourteen extreme OCD (OCD+) were compared to 15 less symptomatic OCD (OCD-), matched to 15 controls on age, sex, laterality, mother tongue and education (see table 1).

	OCD + (N=14)	OCD - (N=15)	CTRL (N=15)	sig
Age (Years)	38 (10)	39 (10)	35 (10)	ns
Sex (F/M)	9/5	8/8	10/5	ns
Laterality (L/R/A)	1/9/2	0/11/0	0/15/0	ns
Mother tongue (French/English/Other)	10/1/0	10/3/0	14/0/1	ns
Schooling (Years)	14	14	18	ns

Note. n: non significant OCD+: Obsessive-Compulsive highly symptomatic; OCD-: Obsessive-Compulsive low symptomatic; CTRL: non psychiatric control group.

Table 1. Mean and standard deviations (in parentheses) of demographic data

4.2. Clinical assessment

All groups completed the Beck Depression Inventory (BDI), the Beck Anxiety Inventory (BAI), the Y-BOCS and the Padua Inventory for OCD symptoms. The OC symptoms severity was evaluated with the self-rated Y-BOCS for all groups, while both self and clinician-rated Y-BOCS was administered in both OCD group. With our sample of OCD, the reliability between self and clinician-rated global scores were good (α = 0.71) with no statistical differences between both evaluations (p= .11). Only the self-rated Y-BOCS will be reported in the current study. Other studies confirm the validity and reliability of the scales (internal consistency = 0.91-0.94, r = 0.90). The self-rated Padua inventory was also administered to all groups and constitute a 60-item inventory of obsessions and compulsions. The total scale (α = 0.95) and the subscales (α = 0.75-0.91) are also reliable. The BAI was also administered and consist in a 21-item anxiety symptom checklist rating symptom intensity for the last week on a 0–3 scale

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(α = 0.91). To assess the presence of depression, the BDI was used, which consist in a 21-item questionnaire relative to depression (α = 0.91).

Our groups were significantly different on the Y-BOCS global score [F(2,42) = 496.99, p < 0.001] and the Padua inventory ([F(2,42) = 11.18, p < 0.001]. A post hoc Tukey revealed that the OCD + groups were different from the OCD- (p= .001) and the controls (p= .001). But OCD+ and OCD- were not statistically different on the Padua inventory global scale and three subscales (checking, precision and rumination). There was also significant differences on anxiety [F(2,42) = 5.16, p < 0.01] and depression [F(2,42) = 14.58, p < 0.001], revealing that both OCD groups were significantly different from the controls on these assessments (Table 2). Given the fact that significant scores were found in anxiety and depression, we will use these traits as covariates in the statistical analysis involving ERPs in order to partial out the effect of these comorbid variables (see statistical analysis).

	OCD + (N=14)	**OCD - (N=15)**	**CTRL (N=15)**		
Clinical scales	**A**	**B**	**C**	**ANOVA**	**Tukey**
Y-BOCS global scale	33 (3)	24 (4)	0.60 (1)	***	A > B > C
Obsessions	16 (2)	11 (4)	0.20 (1)	***	A > B > C
Compulsions	17 (2)	13 (3)	0.40 (1)	***	A > B > C
Padua Inventory	85 (60)	65 (28)	20 (13)	***	A >C B > C
Checking	19 (13)	14 (8)	3 (3)	***	A > C B > C
Precision	10 (7)	6 (4)	1 (1)	***	A > C B > C
Rumination	32 (22)	27 (11)	7 (6)	***	A > C B > C
Washing	15 (16)	15 (9)	7 (5)	ns	…
Beck Anxiety	17 (17)	14 (10)	4 (3)	***	A > C B > C
Beck Depression	22 (16)	17 (6)	3 (3)	***	A > C B > C

Note. ***: p < 0.001 Y-BOCS: Yale-Brown Obsessive-Compulsive Scale. OCD+: Obsessive-Compulsive high symptomatic; OCD-: Obsessive-Compulsive low symptomatic; CTRL: non psychiatric control group. ns: non significant.

Table 2. Add a space or tabulation before Checking, Precision, Rumination and Washing. They are subscales of the Padua Inventory.

4.3. Stimuli selection

The emotional materials were constituted by photographic images from the International Affective Picture Systems, a standardized collection of images gathered from a wide variety of emotional and semantic categories. A total of 150 photographic images were chosen and classified into three groups, based on the arousal and valence estimation from the IAPS normalization (50 unpleasants, 50 neutrals and 50 pleasants). The stimuli for the study phase

included a total of 75 images. For the test phase, the list included the 75 images of the study phase (old), plus 75 images that had not been presented (new) before. The selected images were classified into three basic categories based on the IAPS female ratings of valence [unpleasant = 1-3; neutral = 4-6; pleasant = 7-9]. These 150 images [25 trials by 2 response types (old/new) by 3 valence categories (pleasant/unpleasant/neutral)] were presented in different orders to counterbalance potential effects due to sequence. In addition, for half of participants, the old/new order of presentation was inverted. There were no significant differences between old and new categories across valence or arousal values (all p's > .36). In each emotional category, the images contained the same basic attributes (scenes including humans, animals, inanimate objects or landscapes) across old and new category in order to preserve coherence across recall conditions.

The images were presented one at a time on a 17'' SVGA monitor (Viewsonic), for a fixed duration of 4000 ms, at a distance of 90 cm calculated from the nose to the center of the computer screen with a 5 degrees angle. They were presented at a resolution of 640 x 480 pixels in 256 colors. The inter-trial interval (ITI) was fixed at 2000 ms during which a red and white checkerboard image appeared (IAPS #7182). This red and white checkerboard image informed the participant to fixate their gaze on a point between picture presentations and reduce the eye movements. This procedure also helped to reduce the after image effect, which occurred during presentation of a blank background in our previous pilots.

4.4. Experimental procedure

The experimental session began with a **study phase** during which the participants were instructed first to fix their gaze on a red and white checkerboard screen while waiting for the next images to appear. At that point, participants were told that a series of images would be presented and that they should attend to each picture the entire time it appeared on the screen without giving any response. A short retention interval of 10 minutes was allowed between the study and the test phase. In the **test phase**, images were projected for the same duration and ITI as for the study phase. The participants were instructed to detect the images that had been already presented (*old*) during the study phase by a button press and also to identify the images that had never been present (*new*) during the study phase by pressing another button. The reaction times were obtained with a three-button device placed in front of the subject. They were instructed to emphasize both speed and accuracy in their responses. The emotional evaluation based on the Self Assessment Manikin (SAM) was administered after the ERP experimentation and the participants rated, by a paper and pencil response, each of the 150 images presented in a booklet. Previous brain imaging studies using emotional photographic images have shown that task instructions, prompting preparation for the processing of the evocative images, are susceptible to affect neural activity. Thus, for both study and test phases, participants were not informed about the emotional value of the images beforehand in order to minimize emotional expectancy. The emotional evaluation of images was done post-test in order to keep the emotional nature of the task implicit during the experimentation.

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4.5. EEG recordings and ERP extraction

The EEG was recorded from 28 tin electrodes mounted in an elastic nylon cap (Electro-Cap International Inc) only during recall (test phase). The scalp electrodes were placed according to the guidelines for standard electrode position by the at F3, FT7, FC3, T3, C3, F4, FC4, FT8, C4, T4, TP7, CP3, T5, P3, O1, CP4, TP8, P4, T6, O2. All electrodes were referenced to linked mastoids and their impedances were kept below 5 KΩ. The Electro-oculograms (EOG) was recorded using four 9-mm tin external bi-polar electrodes for horizontal and vertical movements. For the horizontal EOG, electrodes were placed at the outer canthus of each eye and for the vertical EOG at infra- and supra-orbital points at the left eye, aligned with the pupil looking straight. A bioelectric analog amplifier model ISS3-32BA (SAI-InstEP) amplified electrical signals (EOG gain = ±10000 and EEG gain = ±20000) with a band-pass between .01 and 30 Hz. The EEG was recorded continuously at a sampling rate of 250 Hz and averaged offline in a time-window beginning at 100 ms before and until 1900 ms after picture onset. The EOG artifact contained in the EEG were corrected with a dynamic multiple regression in the frequency domain. The regressions were applied using the horizontal and the vertical EOG activity subsequently. After EOG corrections, all remaining epochs with a voltage exceeding ±100 uV and clippings due to saturation or blocking of the amplifiers were eliminated automatically during the averaging procedure. On average, 2.5 trials per condition were rejected, after EOG corrections, because of the remaining artifacts (range = 0-5 trials). An analysis of variance (ANOVA), applied to the number of artefact rejected, failed to show any significant effect across response type and emotional valence conditions (all p's over .30). A second ANOVA applied on the two EOGs separately also failed to reach any statistical significance according to response type or valence (all p's > .10). A minimum amount of 16 trials free of both errors (false alarms and misses) and artifacts were included in the ERP averaging, which is comparable to the criteria used in similar ERP experiments. All ERP data were extracted for two time-windows (300-500ms and 500-1000ms). These two windows allowed us to study the EM effect, which usually appear between 300 and 800 ms after the stimulus presentation. The EM effect was first depicted by as a representation of recollection processes associated with medial temporal lobe structures. Our experimental hypotheses were tested using the mean amplitudes of the ERP detected within the temporal windows as defined in previous recognition memory research.

4.6. Statistical analysis

Several ANOVAs were performed on age, education and non-verbal intelligence (Raven matrices), as well as for BDI, BAI, Padua and Y-BOCS scores. Gender was analyzed using the Kruskall-Wallis, non-parametric test.

EM effect amplitude was analyzed separately using multivariate repeated-measures analyses of variance (MANOVA-RM). Subsequently, a separate multivariate analysis of covariance (MANCOVA) was applied on ERP amplitude data considering BDI and BAI as covariates. The analysis comprised a between-groups factor including three levels (OCD+, OCD- and control groups), and the following within-groups factors: Memory, with two levels (old, new); Emotion, with three levels (positive, neutral, negative); Hemisphere, with two levels (left,

right); Region, with two levels (anterior, posterior) and Electrodes, with the five remaining levels. The electrodes were divided in four quadrants as left anterior (F3, FT7, FC3, T3 and C3), left posterior (TP7, CP3, T5, P3 and O1), right anterior (F4, FC4, FT8, C4 and T4) and right posterior (CP4, TP8, P4, T6 and O2).

5. Results

5.1. Subjective evaluation of emotional images

Activation and valence evaluation: On one hand, a non-significant memory factor indicated that memory showed no impact on the subjective evaluation of activation. On the other hand, the emotional valence influenced the subjective evaluation of activation [$F(2,38) = 151.17$, $p < 0.001$]. Thus, the subjective evaluation of activation was higher for positive (6.79/9) and negative (5.61/9) emotional valence stimuli than for neutral ones (3.82/9). Furthermore, we found a significant memory by emotion interaction [$F(2,38) = 25.50$, $p < 0.001$], indicating that the emotional valence effect was more important for the previously seen images. However, there was no group effect since participants from both OCD groups (OCD+ and OCD-) gave a subjective evaluation of activation that was equivalent to the control participants.

Dominance evaluation: The level of subjective confidence in participants' respective responses was also affected by the emotional valence of stimuli [$F(2,38) = 7.24$, $p < 0.005$]. We effectively observed that the dominance level was significantly higher for responses to positive images (7.93/9) compared to negative (7.53/9) and neutral ones (7.51/9). Additionally, a significant interaction between memory and emotions [$F(2,38) = 7.55$, $p < 0.005$] indicated that the subjective dominance level was greater only for responses to old positive images. Regarding the comparison group, there was a trend suggesting a lower subjective confidence level for both OCD groups when compared to the control group [$F(2,39) = 2.96$, $p = 0.06$].

5.2. Performance and reaction times

Reaction times: New images elicited a delayed reaction time (1329 ms) in comparison to old ones (1205 ms) [*Memory*: $F(1,42)$ 26.45, $p < 0.001$]. Likewise, reaction times to negative images (1307 ms) were significantly delayed when compared to positive (1249 ms) and neutral (1247 ms) ones [*Emotion*: $F(2,41) = 16.65$: $p < 0.001$]. As exposed before, we noticed differences between response times to old and new images. Thus, a significant memory by emotion interaction [$F(2,41) = 6.72$: $p < 0.005$] showed that these old-new differences were larger when a response was required for stimuli of negative emotional valence (158 ms) compare to positive (137 ms) and neutral (75 ms) ones (see Figure 1). Additionally, we have noticed that both OCD groups showed delayed reaction times than controls to the negative condition [*Group by emotion:* $F(2,42) = 3.84$, $p < 0.05$].

Analysis of correct responses (hits): The novelty aspect affected the amount of correct responses as indicated by a significantly greater amount of hits for new images than for old ones [*Memory:* $F(1,42) = 19.67$, $p < 0.001$]. As well, emotions also showed an impact on performances

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[*Emotion:* $F(1,42) = 19.67$, $p < 0.001$], since negative images (24) elicited more hits than the neutral (23) and the positive (22) ones. Similarly, the emotional valence of images has also showed an impact on memory performances since a memory by emotion interaction was significant [$F(2,41) = 27.99$, $p < 0.001$] only in positive and neutral conditions. As for the reaction times analyses, a significant group by emotion interaction [$F(4,84) = 3.34$, $p < 0.05$] was found. This indicates that negative images evoked better performances for the control and OCD- groups, as represented by a higher number of hits.

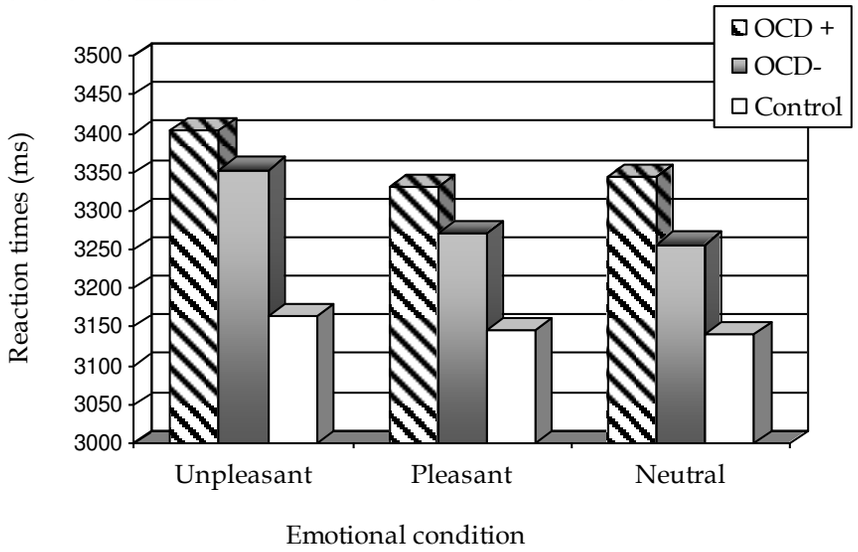

Figure 1. Illustration of the group by emotion interaction on the reaction times (RT) in function of the three emotional conditions for the three groups. The RTs were delayed more dramatically in the unpleasant condition for both OCD groups compared to the control group.

5.3. Electrophysiological data

300 ms to 500 ms post-stimulus window: The topographic distribution of ERPs revealed greater amplitudes in the posterior comparatively to the anterior area [$F(1,42) = 49.28$: $p < 0.001$]. As well, emotional valence impacted electrophysiological data as shown by more salient ERPs in response to positive and negative images than those for the neutral ones [Emotion: $F(2,41) = 16.95$: $p < 0.001$]. Similarly, memory also influenced 300-500 ms brain activity as suggested by significantly larger ERPs for old images than for new ones [$F(1,42) = 30.34$: $p < 0.001$], thus attesting for the early EM effect. Additionally, a complex interaction between memory, emotion and regions reached significance [$F(2,41) = 3.57$: $p < 0.05$]. Accordingly, specifically over the anterior region, the EM effect was more important to positive and neutral emotions than to negative ones. Furthermore, no effect of memory or emotions was evident over the posterior region and importantly, no group difference was found for this time-window.

500 ms to 1000 ms post-stimulus window: The emotion factor remained significant in our second time-window [$F(2,41) = 16.31$: $p < 0.001$]. The ERPs to positive and negative images were significantly larger compared to those in response to neutral ones. Additionally, a complex

interaction between memory, emotion and hemispheres was present [F (2,41) = 4.14: $p < 0.05$]. When taking into account the memory factor, ERPs in response to neutral images were larger in the left hemisphere comparatively to the right hemisphere. Hemispheric lateralization of the memory effect as observed in the left hemisphere was also noted for the negative images (without being as important as for neutral and positive images). Similarly to the first time-window, the ERPs scalp distribution revealed larger amplitudes in the posterior region comparatively to the anterior area [F (1,42) = 13.38: $p = 0.001$]. A memory by region interaction [F (1,40) = 7.87: $p < 0.01$] indicated that the amplitudes differences between old and new images were greater in the posterior region than in the anterior area. Additionally, OCD+ participants showed reduced amplitudes in comparison to controls and OCD- groups particularly in the posterior region, as suggested by a significant region and group interaction [F (2,42) = 5.49: $p < 0.010$]. Moreover, the group by memory interaction remained significant after covarying for anxiety scores [F (2,40) = 3.78: $p < 0, 05$].

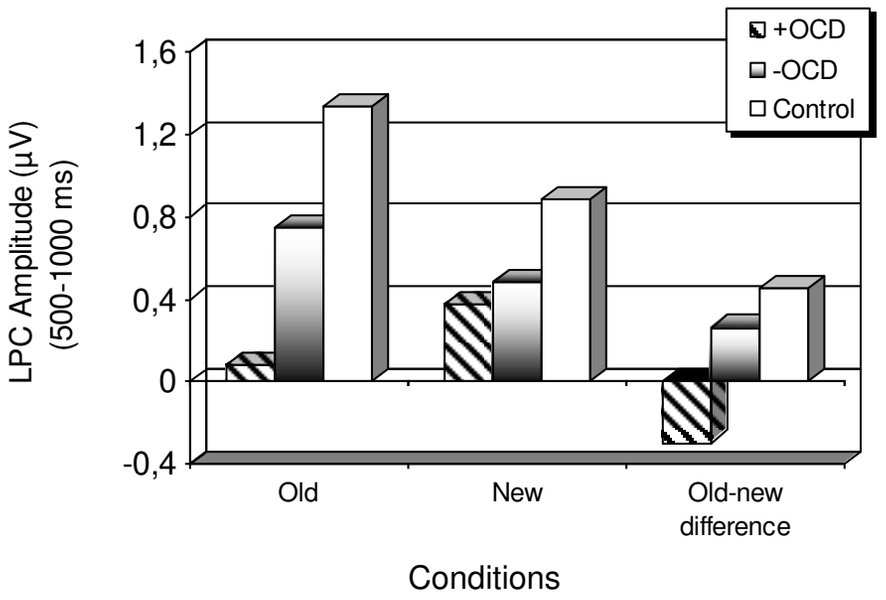

Figure 2. Illustration of the group by memory interaction with the LPC amplitude in function of old-new memory condition for the three groups.

The EM effect reflected by the difference between old and new stimuli was significantly smaller for OCD- and OCD+ respectively than for the control group, as shown in Figure 2. Also, a four-way complex interaction between groups, memory, emotions and regions has been noticed [F(2,40) = 3.57, $p < 0.05$].

6. Discussion

Globally, analyses suggested that old pictures triggered faster reaction times and that OCD groups were characterized by delayed reaction times and less correct responses comparatively

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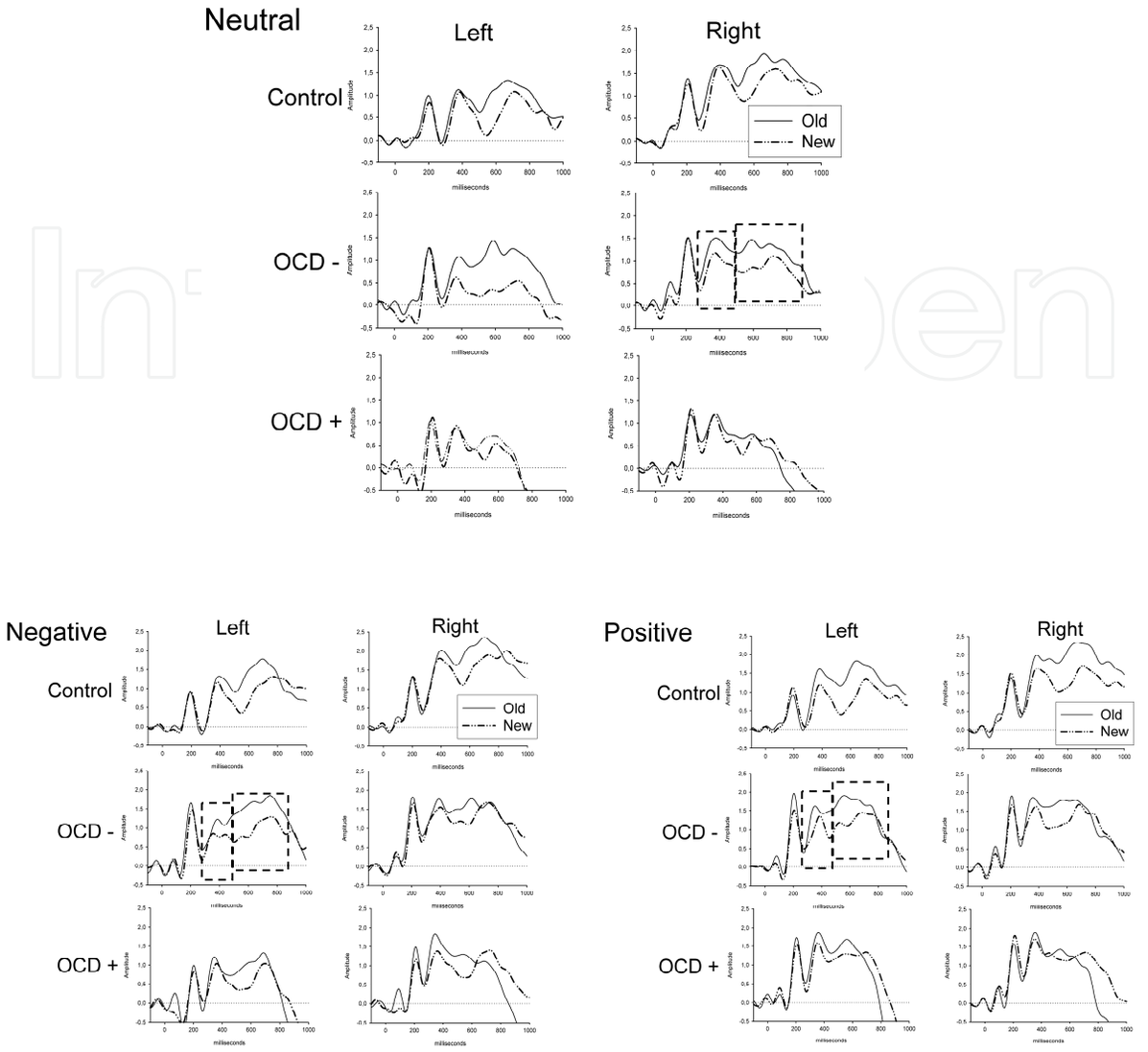

Figure 3. Illustration of the stimulus-locked ERP amplitudes to old (solid lines) and new (dotted lines) images for all groups in neutral, negative and positive valence conditions. The left column represent ERPs of the left posterior parietal region and the right column refer to ERPs of the right posterior parietal region. The dotted squares represent the two time windows of interest (300-500 ms and 500-1000 ms post-stimulus). The OCD+ showed a reduced old-new effect compared to the OCD- and to the controls.

to healthy participants. These observations are consistent with current and past research investigating anxious and depressive patients who showed similar phenomena. Additionally, the pictures' emotional valence influenced all participants' episodic memory processing. As well, the EM effect was smaller for all OCD patients, and even more particularly for the most severely affected group. The severity of OCD symptoms seems to affect brain activity related to memory processing and this could be, at least in part, explained by a dysfunction in the CSTC. Moreover, emotional pictures elicited a reduced anterior EM effect among severe OCD patients. Additionally, the insertion of depressive or anxious symptoms as covariables did not influence the results, suggesting that the presence of significant comorbid symptoms were not related to the altered emotional memory effect observed in OCD patients.

6.1. Emotional memory performances and behavior

In general, performances and response times were delayed and the number of correct responses was higher for new images. Similarly, it has been shown that new words elicit delayed reaction times than old ones. Likewise, in a study investigating episodic memory accounting for emotional factors of Gilles de la Tourette syndrome and OCD (SGT-OCD) patients, also found that old words, that were presented only once, elicited shorter reaction times. Conversely, found that depressive patients presented delayed reaction times for old words. Unlike, we found that the emotional valence did in fact, influenced reaction times. Indeed, our results showed that overall, negative images were those that elicited the fastest reaction times. Additionally, participants were faster to detect old negative and positive images comparatively to new positive and negative images. Using words rather than photographs, also reported the same findings in depressive patients.

Analogously, the amount of correct responses was also influenced by the emotional valence of images, especially for newly presented neutral and positive ones. This suggests that emotional valence influences performance and modulates memory processes. Additionally, we observed a trend toward longer reaction times for OCD patients when compared to controls. Consistently, observed the same phenomenon in different OCD patients. Likewise, when they compared moderately symptomatic OCD patients to controls, they showed significantly delayed reaction times. These results coincide with those found by during an implicit memory task that was part of an experiment assessing OCD patients' memory using words. It is interesting to note that the OCD patients included in that study were comparable to our less symptomatic patients (OCD-) and that similar results were found (i.e. patients and controls showed delayed reaction times for old words. Moreover, we also found that, for images of the same emotional category, OCD+ participants showed a delayed response when compared to controls. Additionally, our more symptomatic OCD patients tended to be less confident in their responses to negative images compared to controls. These group difference could be explained by a different recall strategy aiming to compensate the difficulties experienced by more severe OCD symptoms. From past results, we also know that checker OCD patients have a poorer perception of their memory capacity and that they lack confidence in their recognition capabilities.

6.2. The influence of OCD symptoms on episodic memory and ERPs

Between 300 and 500 ms post-stimulus, old images elicited larger ERP amplitude than new images. Our results strongly resemble those of, which demonstrated that ERPs were more positive for repeated words (i.e. old words). This old/new effect has been shown to be reflected by episodic memory and is sensitive to conscious recollection. In our second time-window (500-1000 ms post-stimulus), we also found that OCD+ participants showed significantly smaller ERPs for old images. Moreover, this result remained significant even after covarying for anxiety level.

Conversely, Kim et al. (2006) found no difference between their OCD patients and controls for the EM effect with words. However, their OCD patients were moderately symptomatic (Y-

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BOCS = 25), and resembled more to our OCD- patients (Y-BOCS = 24) than our OCD+ patients (Y-BOCS = 34+). In fact, our OCD- group revealed no significant differences compared to the control group regarding the magnitude of the EM effect. These results suggest that only highly symptomatic OCD patients may recollect information differently. Indeed, it has been found that people suffering from OCD may feel the need to adopt a sequential rather than a comprehensive approach to recognition and organization when performing even a simple memory task. A possible explanation regarding the results discrepancies between different studies may lie in the severity of OCD symptoms.

Another interesting finding is that ERPs remained more important in the posterior region compared to the anterior area. This could indicate the presence of a late positive component (LPC) associated with episodic memory. The EM effect is associated with the conscious recollection processes that occur primarily in the left parietal scalp region, normally between 400 and 800 ms. Interestingly, we observed, comparatively to OCD- and controls, that highly symptomatic OCD+ patients showed smaller EM effects, particularly in the posterior region. Likewise, performed a similar study, comparing severe and moderate OCD patients to control participants. They studied the EM effect after presenting new and old words, while recording ERP signals. Although our OCD+ group (mean Y-BOCS = 33) was more symptomatic than their severe group (mean Y-BOCS = 27), they also observed a diminution of the late EM effect (450-650 ms). This reduction was specific to the severe OCD group compared to moderate OCD and controls and was also more prominent in the parieto-temporal region. This could indicate that severe OCD symptoms impact on processes mediated through the right prefrontal cortical regions, which are hypothesized to be involved in memory inhibition mechanisms.

6.3. The influence of OCD on episodic memory and the influence of emotions on ERPs

With our participants, we noted that positive and negative images evoked the largest ERPs. As well, numerous researchers have also reported that they observed increased ERPs' amplitudes when presenting stimuli with an emotional component. Moreover, added that emotions might modulate recognition processes. Thus, it is possible that ERPs reflect, in part, the activity of the anterior cingulate cortex, which has connections with cortico-frontal regions and limbic system. Additionally, found a decrease of the EM effect when they presented words with positive and negative connotations to SGT-OCD patients. In parallel, for our first-time window (300-500 ms post-stimulus), neutral images triggered larger EM effects and positive ones elicited even larger ERPs. Analogously, reported similar conclusions following their SGT-OCD study, where ERPs were larger particularly in the frontal and central regions.

Regarding our second time-window, the memory effect was linked to larger ERPs in the left hemisphere particularly for neutral and negative images. This result seems consistent with other findings with verbal stimuli. Recognition information that has no emotional component might be related to more limited cerebral regions while information with emotional factors might be related to other structures. found a smaller EM effect for positive images for SGT-OCD patients comparatively to control participants. While covarying for anxiety levels, we have observed the same phenomenon more particularly over the posterior region for OCD+

and controls. Our results lead us to the same hypothesis articulated by: patients showed diminished capacities for conscious recollection than healthy controls, especially in an emotionally charged context.

7. Conclusion

Our findings highlighted the influence of severe OCD symptoms on processes mediated through the right prefrontal cortical regions, which are hypothesized to be involved in memory inhibition mechanisms. Indeed, it has been found that people suffering from OCD may feel the need to adopt a sequential rather than a comprehensive approach to recognition and organization when performing even a simple memory task. Anomaly in certainty or memory inhibition mechanisms could influence information processing and working memory updating processes, as reflected by an anterior P300 amplitude attenuation. Thus, our findings support the importance of selecting more symptomatic participants in order to study differences in emotional memory processes. This might explain why a relatively important part of the literature often failed to notice any significant difference between OCD and control participants.

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