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Attention in sub-clinical obsessive-compulsive checkers

Metehan Irak *, Martine F. Flament

University of Ottawa Institute of Mental Health Research, Canada

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ABSTRACT

The aim of the study was to explore differential attention profiles, according to attention types, in sub-clinical obsessive-compulsive checkers compared to controls. To examine attention biases in obsessive-compulsive phenomena, we compared sub-clinical checkers to non-checkers on their recall and recognition performances, using neutral and threat-relevant stimuli in three attention paradigms: focused attention, divided attention, and passive attention. Forty-six volunteer university students participated in the study: 24 checkers (14 males, 10 females), and 22 non-checkers (15 males, 7 females). We found that the checkers' recall and recognition performances were higher than those of the non-checkers for threat-relevant stimuli. Even though instructions and tasks were different in each attention paradigm, the checkers showed similar attention biases in all paradigms. Results indicate that there is an attention bias in obsessive-compulsive checkers that is independent from the type of attention.

1. Introduction

Obsessive-compulsive disorder (OCD) is a psychiatric condition characterized by recurrent obsessions and compulsions that are perceived as irrational, and cause significant impairment and distress. Several theories have been proposed for the etiology and maintenance of the disorder, including psychogenetic and neurobiological theories (Eichstedt & Arnold, 2001; Flament & Cohen, 2005; Shafran, 2001). Difficulty inhibiting irrelevant information (e.g., obsessive thoughts and impulses), is an important concept of OCD (Cohen, Lachenmeyer & Springer, 2003). In general OCD patients' attentional resources or attention span are allocated to threat-relevant stimuli related to their concerns, thereof these patients are limited in their ability to selectively attend to relevant information while simultaneously ignoring irrelevant stimuli or information (Eichstedt & Arnold, 2001; van den Heuvel et al., 2005).

Previous studies (Diniz et al., 2004; Foa & McNally, 1986; Hartston & Swerdlow, 1999; Summerfeldt & Endler, 1998) have reported that attention biases in individuals with OCD might be specifically related to threat-relevant stimuli. One of the first studies addressing this issue used a dichotic listening task to demonstrate that threat-relevant stimuli were perceived more easily than neutral stimuli (Foa & McNally, 1986). Further studies indicated dysfunctional basic attention abilities, and impairment of attention span, sustained and selective attention (Kuelz, Hogan, & Voderholzer, 2004; Muller & Roberts, 2005). There is evidence for abnormal processing biases towards OCD-relevant stimuli on tasks such as dot-probe and directed forgetting. In patients with OCD, either checkers or washers, these biases are dependent on the relevance of the task stimuli to individual concerns (Diniz et al., 2004; Moritz et al., 2004; Muller & Roberts, 2005). In a study by Lavy, Van Oppen, and Van Den Hout (1994) three basic hypotheses, namely threat-relatedness hypothesis, the emotionality hypothesis, and the concern-relatedness hypothesis, for attentional bias effects in anxious individuals were tested in same OCD patient group using with emotional Stroop color-naming test. The results of their study indicated that patients selectively attend to threat-related words associated with their fears. They argued that reliable evidence is only found for threat-relatedness hypothesis (the basic argument of this hypothesis is that people selectively attend to threatening stimuli related to their fears).

Similar attention biases have been documented in a variety of anxiety disorders, including post-traumatic stress disorder (Buckley, Blanchard, & Neill, 2000; McNally, 1998a), social phobia (Heinrichs & Hofmann, 2001), and generalized anxiety disorder (McNally, 1998b). Anxious individuals may perform poorly on difficult tasks because their cognitive systems preferentially process task-irrelevant information related to threat. It has been found that clinically anxious patients display an increased ability to encode threatening information emotionally (Burgess et al., 1981; Muller & Roberts, 2005). Muller and Roberts (2005) argued that OCD patients might display a similar attentional bias for threatening information and specifically for stimuli that are personally threatening (e.g., contamination-related words). Furthermore, memory biases for threatening information among

* Corresponding author at: University of Ottawa Institute of Mental Health Research, 1145 Carling Avenue, Room#: 6428, Ottawa, ON, Canada K1Z 7K4. Tel.: +1 613 722 6521x7094; fax: +1 613 761 3614.
E-mail address: metehan.irak@rohcg.on.ca (M. Irak).

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OCD checkers appeared to be contingent upon patients' perceived responsibility for the outcome of a particular check (Radomsky, Rachman & Hammond, 2001).

According to Maki, O'Neill and O'Neill (1994) there are two important reasons that sub-clinical compulsive checkers (i.e., persons with symptoms similar to those of clinical subjects, but with less disabling checking rituals) have been studied extensively. First, sub-clinical checkers display behavioral, affective and cognitive characteristics which are similar to obsessive compulsive patients. Second, these characteristics that seem to distinguish them from noncheckers (see also, Frost & Sher, 1989; Sher, Martin, Raskin & Perigo, 1991).

Attention performance of sub-clinical OC checkers has been investigated in previous studies. Compared to normal controls, sub-clinical checkers showed impaired recall of their own actions, such as being unable to find an object they are looking for (Sher, Frost & Otto, 1983), lower performance on Wechsler Memory Scale Quotient (Frost & Sher, 1989; Sher, Mann & Frost, 1984), and slower performance on information processing speed (Frost, Lahart, Dugas & Sher, 1988). Also, Rubenstein, Peynircioglu, Chambless and Pigott (1993) found that as compared with normal controls, sub-clinical checkers remembered fewer actions, more often misremembered whether they performed and made more commission errors. On the other hand, these participants did not perseverate more than normal controls on the to-be-remembered words, and sub-clinical checkers recognition performance for words was higher than normal controls.

Cognitive dysfunction in compulsive sub-clinical checkers was investigated in a study by Sher et al. (1984). Using MOCI and Everyday Checking Behavior Scale, subjects were identified in four groups: frequent checkers, occasional checkers, infrequent checkers, and non-checkers. Checking status was found to be negatively correlated with memory functioning as measured by the Wechsler Memory Scale (WMS), but was not associated with attentiveness as measured by the WMS Digit Span subtest. Also, checkers showed poor performance on recalling details of meaningfully linked sequences, whether presented in narrative form or engaged in personally. Taken together, even though there are inconsistencies between the results of the studies discussed above, the results imply that similar to clinical OC checkers, sub-clinical checkers show poor performance especially on selective attention and memory for action tasks.

Since biases in selective attention have been consistently reported in individuals with OCD and sub-clinical checkers, the question of whether these biases and also these cognitive dysfunctions are depending on the type of attention solicited may help understand the process. The aim of the present study was to explore the differential attention profiles of sub-clinical obsessive-compulsive (OC) checkers compared to non-checkers, according to attention types. To investigate attention biases in OCD related phenomena, we tested sub-clinical checkers and non-checkers on their recall and recognition performances, using neutral and threat-relevant stimuli, in various attention paradigms.

2. Method

2.1. Participants

Volunteer university students ($n = 254$) completed the Maudsley Obsessive Compulsive Inventory (MOCI; Hodgson & Rachman, 1977; Sternberger & Burns, 1990). Following previous research (MacDonald, Antony, Macleod & Richter, 1997; Rubenstein et al., 1993), those who received a score of 4 or more on the checking subscale were classified as checkers, and those with checking scores of 0 or 1 as non-checkers. A total of 46 subjects participated in the study: 24 checkers (14 males, 10 females) and 22 non-checkers (15 males, 7 females). As shown on Table 1, independent sample t-tests showed that there was no significant difference between the checker and non-checker groups for age ($t = -0.693$; d.f. = 44; $p = 0.492$) or education level ($t = 0.675$; d.f. = 44; $p = 0.503$). All participants denied past diagnosis or treatment of any neurological or psychiatric disorders.

Table 1
Characteristics of the checkers and non-checkers groups.

Variable	Checkers (C)		Non-checkers (NC)		
	M	S.D.	*M*	S.D.	
Age (in years)	20.09	1.27	20.59	1.65	n.s.
Education (in years)	13.33	1.31	13.09	1.11	n.s.
MOCI-checking score	5.25	1.23	0.63	0.44	C > NC
MOCI-total score	16.42	3.73	7.69	2.04	C > NC
STAI-T score	47.82	6.23	38.65	14.78	C > NC
STAI-S score	39.45	13.65	35.12	13.31	C > NC
BDI score	16.85	7.75	6.93	5.77	C > NC

n.s.: non significant.

2.2. Psychological measures

In addition to the MOCI, all participants completed the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Luschene, Vagg, & Jacobs, 1983), and the Beck Depression Inventory (BDI; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961).

2.2.1. Maudsley Obsessive Compulsive Inventory (MOCI)

The MOCI is a 30-item self-report questionnaire that measures the severity of OCD symptoms on four subscales: cleaning, checking, slowness, and doubting. The MOCI has satisfactory internal consistency and test–retest reliability (Sternberger & Burns, 1990).

2.2.2. State-Trait Anxiety Inventory (STAI)

A self-report measure, the STAI consists of 40 items that assess anxiety. Two separate total scores are computed, one for state anxiety and one for trait anxiety. The scales have high reliability and validity (Spielberger et al., 1983).

2.2.3. Beck Depression Inventory (BDI)

Beck Depression Inventory (Beck et al., 1961) is a 20 items self-report measure assessing the level of depressive symptomatology. The BDI has high reliability and validity.

Mean scores (and standard deviations) on those widely used measures of OC, anxiety and depressive symptoms, respectively, are shown in Table 1 for the two groups. Although none of the means were in the clinical range, the checkers scored significantly higher than the non-checkers on all measures.

2.3. Attention paradigms

Three different attention paradigms were used to assess attention performances: focused attention (FA), divided attention (DA), and passive attention (PA).

2.3.1. Focused attention paradigm

In this experiment, 40 words (word list A) were presented by headphones to the participants. Twenty of the words were neutral (e.g., book, table), and the other 20 words were threat-relevant (e.g., iron, door). Duration between presentation of two words was 2 s. A randomization technique was used for ordering of the words. Before the experiment began, the participants were instructed that they would be assessed on their attention regarding these words.

After the experiment, the participants were informed about an upcoming cued-recall test. Then, the first letter of a word was presented, and participants were asked to remember the letters that would complete one word of the list correctly. After completion of the cued-recall test for all words on the list, participants were given a recognition test, in which all cue words plus 40 unrelated words (80 words in total) were presented one at a time in a randomized order. For each word, participants had to decide whether or not they recognized it as having been presented before, with marking a 'YES' or 'NO' option. Performance for FA was determined by the number of correctly remembered neutral and threat-relevant words (between 0 and 20 for each type of words) on both the recall and recognition tests.

2.3.2. Divided attention paradigm

In this experiment, participants simultaneously attended to tasks involving auditory and visual stimuli. Forty words (word list B; 20 neutral and 20 threat-relevant) were presented by headphones (auditory stimuli). Duration between presentation of two words was 2 s. Simultaneously, a 100-s amateur silent movie, consisting of footage videotaped at a zoo, was presented for visual stimuli. Before the experiment began, the participants were instructed that they would be assessed on their attention regarding both these words and the movie. After viewing the film and hearing the words, the participants were informed about upcoming cued-recall test and recognition test for auditory stimuli, which had the same content as in the FA paradigm. Then, they were administered a questionnaire consisting of 20 multiple choice questions regarding the movie (e.g., 'what was the color of the parrot?', or 'how many tigers did you see?'). Three clinical experts had evaluated the movie and concluded that it did not contain any threat-relevant stimuli for OC checkers. Performance for DA was determined by the numbers of correctly recalled neutral and threat-relevant words (between 0 and 20 for each type of words) on both the recall and recognition tests for auditory stimuli, and the number of correct answers (between 0 and 20) on the questionnaire for visual stimuli.

2.3.3. Passive attention paradigm

In this experiment, visual (irrelevant) and auditory (target) stimuli were presented at the same time; however participants were instructed to ignore auditory (target) stimuli and that they would be assessed on their attention regarding the movie only. Forty words (word list C; 20 neutral and 20 threat-relevant) were presented through headphones, and duration between presentation of two words was 2 s. Another 100-s amateur silent movie was used for visual stimuli, this one consisting of videotaped footage of children playing in a daycare center. After the experiment, participants were informed about upcoming cued-recall test and recognition test for auditory stimuli, which were similar to those in the FA and DA paradigms. Then, a questionnaire consisting of 20 multiple choice questions about the movie (e.g., 'how many girls were playing around the water pool?', or 'how many children were playing around the sand pool?) was administered to the participants. Three experts had evaluated the movie and concluded that it did not contain any threat-relevant stimuli for OC checkers. Performance for PA was determined by the numbers of correctly recalled neutral and threat-relevant words (between 0 and 20 for each type of words) on both the recall and recognition tests for auditory stimuli, and the number of correct answers (between 0 and 20) on the questionnaire for visual stimuli.

2.4. Procedure

All participants were tested individually in the same testing room. Each was exposed to all paradigms and related procedures within a single session. A full balancing technique was used, so that the order of the attention experiments differed between participants. Threat words were chosen on the basis of previous research (Radomsky & Rachman, 1999). A total of 132 words (3 word lists: A, B and C; 72 neutral and 60 threat-relevant words) were used for all experiments, and different words were used in each experiment. To minimize primacy and recency effects, four neutral words were added to each experiment (two at the beginning, and two at the end). These neutral words (12 in total) were not included in the statistical analyses. A 21″ color monitor was used for visual stimuli presentation. Total duration of the experiments was 25–30 min for each participant.

3. Results

The design was a $3 \times 2 \times 2$ mixed factorial design, where attention paradigm type (FA, PA and DA) and word type (neutral, threat-relevant) were within-subject variables. Group status (checker, non-checker) was the between-subject variable. Statistical analyses were applied to all of the variables of interest regarding recall and recognition. Before the statistical analyses, data were screened for missing values, univariate and multivariate outliers (Tabachnick & Fidell, 2007). In these data, no univariate or multivariate outliers were found.

The auditory stimuli were the target stimuli for the study, therefore related results are presented in most detail. Only the main results regarding the visual stimuli are presented, at Section 3.3. A 3 (paradigm type) $\times$ 2 (word type) $\times$ 2 (group) repeated measures multivariate analysis of variance (MANOVA) was carried out for recall and recognition performances (for auditory stimuli). The mean scores and standard deviations for the checker and non-checker groups, according to attention paradigms and word types are shown on Table 2. According to MANOVA results, all main effects and binary interaction effects were significant for all recall and recognition performances, but the triple interaction effect was not significant.

3.1. Recall performance

According to MANOVA results, the group effect $F(1, 44) = 15.93$, $p < 0.001$, $\eta^2 = 0.27$, and the paradigm effect was significant, $F(1, 44) = 1622.14$, $p < 0.001$, $\eta^2 = 0.97$, and post-hoc HSD test showed that the recall performance of all participants for FA ($M = 15.42$) was significantly ($p < 0.01$) higher than those for DA ($M = 10.86$)

Table 2
Means (and standard deviations) for recall and recognition performances according to group status, attention paradigm, and word type.

Group	Word type	Focused attention		Divided attention		Passive attention	
		Recall	Recognition	Recall	Recognition	Recall	Recognition
Checkers	Threat	17.67 (1.55)	18.76 (1.55)	13.83 (0.70)	14.83 (0.72)	15.38 (0.70)	16.83 (0.72)
	Neutral	11.17 (1.0)	12.17 (1.01)	6.67 (1.20)	8.71 (1.19)	5.29 (1.37)	6.29 (1.36)
Non-checkers	Threat	14.41 (1.71)	15.14 (1.51)	6.27 (1.41)	7.72 (1.24)	4.82 (0.85)	5.82 (0.80)
	Neutral	18.45 (0.74)	19.54 (0.79)	16.68 (1.0)	18.68 (0.99)	5.91 (1.15)	6.91 (1.51)

and PA ($M = 7.96$). The paradigm $\times$ group interaction was significant $F(1, 44) = 391.78$, $p < 0.001$, $\eta^2 = 0.89$. Post-hoc *t*-tests were performed for all significant interaction effects, and an alpha level of 0.01 was used for all comparisons. Although the checkers' recall performance for FA ($M = 28.84$) and for DA ($M = 20.50$) was lower ($p < 0.01$) than those of the non-checkers ($M = 32.86$ vs. $M = 22.95$) in the PA paradigm, the checkers' performance was higher ($p < 0.01$) than that of the non-checkers ($M = 21.12$ vs. $M = 10.73$). In addition for both the checkers' and the non-checkers' recall performance in the FA paradigm, significantly ($p < 0.01$) higher than PA and DA paradigms. The word type main effect was significant $F(1, 44) = 124.92$, $p < 0.001$, $\eta^2 = 0.74$, and the recall performance for threat-relevant words was higher than that for neutral words ($M = 12.14$ and $M = 10.70$, respectively). The word type $\times$ group interaction effect was significant $F(1, 44) = 2630.58$, $p < 0.001$, $\eta^2 = 0.98$, and the recall performance of the checkers was higher ($p < 0.01$) than that of the non-checkers for threat-relevant stimuli ($M = 15.78$ and $M = 8.50$, respectively), whereas the checkers' ($M = 7.71$) recall performance was lower ($p < 0.01$) than the non-checkers' ($M = 13.68$) recall performance for neutral stimuli (see Table 2).

The paradigm $\times$ word type interaction effect was significant $F(1, 44) = 93.92$, $p < 0.001$, $\eta^2 = 0.70$. Post-hoc *t*-tests for this interaction effect showed that the recall performance was higher for threat-relevant words than for neutral stimuli, in all attention paradigms ($p < 0.01$). In the recall performances for threat-relevant words, the mean differences between the FA ($M = 16.04$) and the DA paradigms ($M = 10.05$), and between the FA and PA paradigms ($M = 10.33$) were significant ($p < 0.01$), but the difference between DA and PA performances was not. For neutral words, the differences between FA ($M = 14.81$), DA ($M = 11.67$) and PA ($M = 5.60$), all were significant ($p < 0.01$). Consequently, the checkers' and non-checkers' recall performance was affected by word types and attention paradigms. Although the checkers' recall performance was lower than that of the non-checkers in two out of three attention paradigms for neutral stimuli, for threat-relevant stimuli, the recall performance was higher the checkers than for the non-checkers in all attention paradigms.

Using only two options to measure recognition may have lead to some bias (e.g., tendency to say yes). To investigate this bias, measures of accuracy or sensitivity (d') was calculated based on detection theory (Macmillian & Creelman, 2005). In these calculations the D-Prime program (Creelman, 2008) was used, and hit and false alarm rates were calculated for each response. The results showed that all hit rates were higher than false alarm rates, that the lowest d' index was 1.43 (± 0.308), and the bias index (c) was 0.040 (± 0.077). Finally, these calculations indicated that a bias for measure of recognition was not an issue in our study.

3.2. Recognition performance

The recognition performance was higher than the recall performance in all attention paradigms. According to the MANOVA results, the group effect $F(1, 44) = 16.41$, $p < 0.001$, $\eta^2 = 0.27$, and the paradigm effect was significant $F(1, 44) = 1719.93$, $p < 0.001$, $\eta^2 = 0.98$, and post-hoc HSD tests showed that the recognition performance of all participants in the FA paradigm ($M = 16.42$) was higher ($p < 0.01$) than their performance in the DA ($M = 12.37$) and PA paradigms ($M = 8.96$). The paradigm $\times$ group interaction was also significant $F(1, 44) = 401.97$, $p < 0.001$, $\eta^2 = 0.90$. Although the checkers' recognition performances in the FA ($M = 30.83$) and DA paradigms ($M = 23.54$) were lower than those of the non-checkers ($M = 34.86$ and $M = 25.95$, respectively; $p < 0.01$), in the PA paradigm, the checkers' performance ($M = 23.1$) was significantly higher than that of the non-checkers ($M = 12.74$).

The word type main effect was significant $F(1, 44) = 72.65$, $p < 0.001$, $\eta^2 = 0.62$, and the recognition performance was higher for threat-relevant than for neutral words ($M = 13.14$ and $M = 12.04$, respectively). The word type $\times$ group interaction effect was significant $F(1, 44) = 2613.23$, $p < 0.001$, $\eta^2 = 0.98$. Post-hoc *t*-tests showed that the recognition performance of the checkers was higher than that of the non-checkers for threat-relevant stimuli ($M = 16.78$ and $M = 9.50$, respectively), whereas the checkers' recognition performance ($M = 9.10$) was lower than that of the non-checkers ($M = 15.02$) for neutral stimuli ($p < 0.01$).

The paradigm $\times$ word type interaction effect was significant $F(1, 44) = 90.91$, $p < 0.001$, $\eta^2 = 0.67$. Post-hoc *t*-tests showed that the recognition performance for threat-relevant words was higher than that for neutral stimuli in all attention paradigms ($p < 0.01$). In the recognition performances for threat-relevant words, the mean differences between the FA ($M = 17.04$) and DA paradigms ($M = 11.05$), and between the FA and PA paradigms ($M = 11.33$) were significant ($p < 0.01$), but the difference between DA and PA performances was not. For neutral words, the differences between FA ($M = 14.81$), and DA ($M = 11.67$), and between FA and PA ($M = 5.60$), and between DA and PA were significant ($p < 0.01$). Consequently, the checkers' and non-checkers' recognition performance was affected by word types and attention paradigms. Although the checkers' recognition performance was lower than that of the non-checkers in two out of three attention paradigms for neutral stimuli, for threat-relevant stimuli the recognition performance was higher for the checkers than the non-checkers in all attention paradigms.

3.3. Some important results for visual stimuli

In this study, two visual stimuli were used, in the DA and PA paradigms. Performance was determined by the number of correct answers (between 0 and 20) on the questionnaires for visual stimuli. In the DA paradigm, subjects simultaneously attended to and carried on tasks with auditory and visual stimuli. The checkers' performance ($M = 5.17$; S.D. = 1.40) was lower than that of the non-checkers ($M = 10.27$; S.D. = 1.45) for visual stimuli, and this difference was significant ($t = -12.21$; d.f. = 44; $p < 0.001$). In the PA paradigm, visual (irrelevant) and auditory (target) stimuli were presented at the same time, but the participants were asked to ignore auditory stimuli. In this experiment, the checkers' performance ($M = 5.04$; S.D. = 1.23) was also lower than the non-checkers' performance for visual stimuli ($M = 11.32$; S.D. = 1.78), and this difference was significant ($t = -13.98$; d.f. = 44; $p < 0.001$). In sum, these results indicate that in spite of instructions to ignore one of them, the checkers were less successful than the non-checkers at simultaneously attending to two stimuli. In the DA paradigm, the checkers attended especially threat-relevant auditory stimuli. Further, in the PA paradigm, they failed to ignore threat-relevant auditory stimuli, as instructed.

3.4. Relationships between psychological measures and attention performances

In order to explore the relationship between psychological measures (STAI-Trait, STAI-State and BDI) and attention performances (recall and recognition) in the checkers group, Pearson product–moment correlations (Pearson's r) were computed. Results showed that there were significant correlations between the BDI total score and the recall and recognition performances (for both, $r(24) = -0.42$, $p < 0.05$) for threat-relevant stimuli in the FA paradigm, while all other correlations were not significant (all other correlations $r(24) < 0.36$, $p = 0.86$ or larger). When Pearson's r were computed for all participants together, the relations between attention performances and psychological measures were negatively significant for threat-relevant stimuli, and positively significant for neutral stimuli (for all correlations, $r(46) \geq 0.35$, $p = 0.017$ or smaller). Due to those relations, we then performed a multivariate analysis of co-variance (MANCOVA), in which BDI and STAI scores were the covariates. According to MANCOVA results, there were no changes in the results when the contributions of these scores were removed (all $ps > 0.05$). Thus, the group differences reported above could not be attributed to higher levels of depression or anxiety in the checkers group.

In order to control for the effects of other OC symptoms on the recall and recognition performance, three additional MANCOVAs were carried out for each MOCI subscale separately, namely; washing, slowness, and doubting. In these analyses washing, slowness, and doubting subscales were covariates. Results indicated that there were no changes in the results when the contributions of these scores were removed (all $ps > 0.05$). Finally, the group differences reported above was not affected by other OC symptoms.

4. Discussion

The present study explored differential attention profiles, according to attention types, in sub-clinical OC checkers compared to non-checkers. We compared the checkers and non-checkers' attention performances using threat-relevant and neutral words in three attention conditions. Our results indicate that, compared to non-checkers, the checkers showed an attention bias for threat-relevant stimuli, and these biases were observed in all attention paradigms. In addition, while the checkers' recall and recognition performances were higher than those of the non-checkers for threat-relevant stimuli, the non-checkers' performances were higher than those of the checkers for neutral stimuli.

Many studies (e.g., Chamberlain, Blackwell, Fineberg, Robbins & Sahakian, 2005; Kuelz et al., 2004; Muller & Roberts, 2005; Wood, Vevea, Chambless, & Bayen, 2002) have reported that patients with OCD are characterized by a bias in selective attention for threat-relevant information. According to Muller and Roberts (2005), it is likely that these biases in selective attention might contribute to the maintenance or worsening of intrusive obsessive thoughts in OCD. Also, they might explain why such threat-relevant information is especially hard to ignore for these individuals.

Results of the present study conducted in sub-clinical OC checkers indicate a similar attention bias towards threat-relevant material, which is independent from the type of attention solicited. In other words, threat-relevant stimuli in the environment of OC individuals are always foremost or dominant, since, in OC checkers, the attention process ignores other factors such as conditions, instructions or tasks. Macleod, Mathews and Tata (1986) found that anxious subjects shifted their attention toward emotionally threatening stimuli in their environment, whereas healthy controls tend to shift attention away these stimuli. Following this result, it may be that sub-clinical subjects process both the neutral and the threat-related material to the same degree, but due to a bias in the allocation of attentional resources toward mood congruent material, it may simply reflect a mood-dependent response bias. Interestingly Lavy et al. (1994) found that patients with OCD (washers and checkers) did not show an attentional bias for positive OC related words (e.g., tidy, safe), but these patients selectively attended to negative OC related words (e.g., dirty, fatal).

Furthermore, the checkers were less successful than the non-checkers in simultaneously attending with two stimuli together (in the DA paradigm), and the checkers failed to ignore threat-relevant stimuli when this was explicitly requested (in the PA paradigm). A possible explanation may be that threat-relevant or anxiety-provoking words activated more affective, perceptual and semantic associations in OC checkers than neutral words, even during passive, automatic attention. There is clear evidence that both clinical and sub-clinical obsessive-compulsive checkers have selective attention bias. Consistent with previous results our sub-clinical checkers showed selective attention bias for threat-relevant words in the FA paradigm. These subjects' recall and recognition performances were higher than normal controls for these words. As discussed above, our results indicated that like patients with OCD, sub-clinical checkers shift their attention toward emotionally threatening stimuli.

The divided attention task requires the maintenance and processing of two mental task sets at the same time, and these processes relate to task-switching and executive control functions (ECF) (Verhaeghen & Cerella, 2002). ECF has been separated from the specific cognitive domains such as, memory and language (Royall et al., 2002). The executive mechanism allocates between the two tasks and manages flow of input and output from the two tasks (Pashler, 1998). To our knowledge the DA paradigm has not been used in previous obsessive-compulsive studies. On the other hand and consistent with previous studies, results showed that patients with OCD have executive control deficits (e.g., also for review, Bannon, Gonsalvez, Croft & Boyce, 2006; Cox, 1997; Moritz et al., 2002; Kuelz et al., 2004; Otto, 1992), and our results indicated that sub-clinical checkers had poor performance on the executive control.

The PA paradigm of the present study represents a failure of inhibition or response inhibition (in our task, inability to stay focused on the visual stimuli). Response inhibition or cognitive inhibition has been extensively investigated in OCD through the negative priming paradigm (e.g., adaptation of Stroop color-naming task). Response inhibition refers to how an organism narrows down incoming information in order to selectively attend to the stimuli that are most related, and minimize the processing of unrelated information. Muller and Roberts (2005) argued that OCD patients have problems in controlling unwanted intrusive thoughts, and deficits in attentional inhibition may play an important role in this clinical condition. Many studies demonstrated that patients with OCD exhibited specific deficits in response inhibition abilities or reduced levels of cognitive inhibition. Our results demonstrated that in spite of thorough instructions, the sub-clinical checkers found difficulty ignoring irrelevant stimuli, which is consistent with general findings of response inhibition deficits in OCD patients.

Taken together, although conceptually three types of attention were discussed, our results indicate that functionally the cognitive and behavioral aspects of these three attention paradigms are related in sub-clinical checker populations. Similar to patients with OCD, sub-clinical checkers show selective attention bias and dysfunction in executive control and response inhibition. It might be speculated that due to a bias in the allocation of attentional resources toward mood congruent materials, sub-clinical checkers display such dysfunctions. Another explanation as argued by Williams, Watts, MacLeod and Mathews (1988), in comparison to non-anxious, anxious individuals more willingly perceive threat-related information (or stimuli) and spend more cognitive effort and more cognitive capacity to process such information.

Our findings showed that, compared to non-checkers, the OC checkers' recall and recognition performances were lower in the FA and DA paradigms, but higher in the PA paradigm. The source of these differences was the checkers' attention bias towards threat-relevant stimuli. Although our results showed that people with sub-clinical OCD have no memory impairment, empirical data on the relationship between compulsive symptoms (either clinical and/or sub-clinical) and memory problems have been inconsistent. A few investigators have reported that patients with OCD showed poorer memory (e.g., semantic, episodic, implicit memory) than normal controls (e.g., Savage et al., 2000; Tallis, Pratt, & Jamani, 1999; Zitterl et al., 2001). In a study by Singh, Mukundan, and Khanna (2003), OCD subjects aged 16–45 years performed more poorly than controls on a verbal working memory and a visuospatial working memory task. Some studies (e.g., Deckersbach, Otto, Savage, Baer, & Jenike, 2000; Sher et al., 1984; Zitterl et al., 2001) reported that individuals with high levels of checking symptoms were relatively impaired in their memory for complex verbal information, immediate and delayed free recall, but had preserved verbal memory recognition. Other studies found positive memory biases (better recall in OCD patients than controls) for threat-relevant information (e.g., Constans, Foa, Franklin, & Mathews, 1995; Radomsky & Rachman, 1999; Radomsky et al., 2001).

In an experimental study by Maki et al. (1994) sub-clinical checkers showed similarly to non-checkers inhibitory control of cognition. The sub-clinical checkers and non-checkers did not differ in performance on tasks involving attentional distraction, suppression of unrelated information, and intentional forgetting. In light of these results the authors pointed that cognitive deficits in sub-clinical checkers are not big and stable, but appearing only specific situations. They also argued that the basic differences between checkers and non-checkers are level of anxiety they have regarding their making mistakes, but not in frequency and severity of cognitive dysfunctions. A study by Rubenstein et al. (1993) showed that general recognition performances of sub-clinical checkers were better than those of normal controls. When comparing OCD checkers, non-checkers and normal controls, MacDonald et al. (1997) found no group differences in recall and recognition performances. In Wood, Vevea, Chambless and Bayen's (2002) meta-analysis on checking and memory, checkers were impaired on a number of memory tasks, including verbal free recall, verbal cued recall, and recall of actions, but not recognition. Also, studies (Frost & Sher, 1989; Sher et al., 1983, 1984) with sub-clinical groups showed that memory deficits may play a role in perpetuating and maintaining checkers' repetitive behaviors. Thus, evidence from existing studies suggests that memory dysfunction in OCD patients does not result from memory impairment per se, but rather from an impaired ability to apply efficiently elaborated strategies. Ability to store new memories seems to be preserved in OCD patients, whereas they are impaired when it comes to encoding and recalling information, due to strategic dysfunction. Strategic aspects of memory are closely related to executive functioning (Savage, 1997) and attention.

Our results are different from other studies mentioned before, where no difference was reported in between sub-clinic checkers' and normal controls' recall and recognition performances. Except the PA paradigm, even though non-checkers' recall and recognition performances were higher than checkers, these differences were not significant. On the other hand these differences were significant when analyses were carried out according to word type. Consequently, our results indicated that the checkers' and non-checkers' recall performances were affected by word types. In detail, while the checkers' recall and recognition performances were higher than those of the non-checkers for threat-relevant stimuli, the non-checkers' performances were higher than those of the checkers for neutral stimuli. Other possible reason for the difference between our results and previous result is this may be due to a ceiling effect observed in these studies (Tuna, Tekcan, & Topcuoglu, 2005). Our tests did not give rise to such ceiling effects and thus, a difference appeared between checkers and non-checkers. Our cued-recall test findings concur with some primary studies (e.g., Kuelz et al., 2004; Muller & Roberts, 2005; Wood et al., 2002) which report medium effect sizes for verbal free and cued recall.

Although no relationship has been found between level of education and cognitive impairment in OCD, general links have been reported between years of education and cognitive functions (Kuelz et al., 2004). Consequently, a potential confounding variable in our study should be mentioned. Participants were university students, and they may have had previous experience with memory and attention experiments and with learning new material. However, there were no statistical differences between the checkers and the non-checkers for age or years of education, and still recall and recognition performances differed between the two groups on a number of tests. Thus, we believe the results to be valid despite this potential confounding variable.

Our study was done in a community population, and not a clinical sample. We found that the checkers' recall and recognition performances were higher than those of the non-checkers for threat-relevant stimuli, even though instructions and tasks were different in each attention paradigm. We would expect that patients with full-blown OCD would show similar attention biases towards threat-relevant stimuli that are independent from the type of attention solicited. This should be confirmed using a clinical OCD group in a future study.

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