

Can Patients With Obsessive–Compulsive Disorder Discriminate Between Percepts and Mental Images? A Signal Detection Analysis

Halle D. Brown, Stephen M. Kosslyn, Hans C. Breiter, Lee Baer, and Michael A. Jenike

Signal detection analysis was used to test three hypotheses for repetitive thoughts and behaviors characteristic of obsessive–compulsive disorder (OCD). Patients might have (a) low sensitivity for the difference between having seen something or having imagined seeing it, (b) a high criterion for this discrimination, or (c) difficulty associating context with information in memory. Subjects judged viewed words or imagined words and later indicated which were actually seen. Patients with OCD discriminated seen from imaged words significantly better than normal control subjects, as evidenced by higher d' scores on a recognition memory task. Groups did not differ in response criterion, β , used to decide whether words had been seen or imaged. Implications for the study of OCD from an information-processing perspective are discussed.

Many patients with obsessive–compulsive disorder (OCD) cannot be certain that they performed an activity safely or correctly, as opposed to merely imagining that they did so (Jenike, Baer, & Minichiello, 1990). Hence, these patients often engage in repetitive rituals. On the basis of their subjective reports, we hypothesized that patients with OCD have trouble distinguishing between a memory of something actually experienced and a memory of something that was only imagined. Specifically, we tested the hypothesis that patients with OCD have difficulty distinguishing previous visual percepts (representations of objects that arise during perception) from self-generated visual mental images (representations formed on the basis of previously stored information, not perception).

OCD is expressed in a wide variety of forms, with symptoms ranging from anxiety-provoking thoughts and impulses, which often involve vivid, troubling mental images (see Rachman & de Silva, 1978), to complex compulsive rituals (see Jenike et al., 1990). The two most common types of rituals are checking rituals, in which patients repeatedly check to determine whether they have correctly completed an activity, and cleaning rituals, in which patients wash repeatedly, never feeling certain that they are clean (Barlow, 1988; Jenike et al., 1990; Rachman, 1985; Rachman & Hodgson, 1980). The etiology of OCD is poorly understood at present, and treatment programs range from drug therapies to behavior therapies to traditional psycho-

therapies, none of which effectively treat all cases (see Jenike et al., 1990). However, one common thread through a majority of OCD cases is the repetitive nature of thoughts or behaviors, or both, which patients feel are out of their control. We used the methods of cognitive psychology to characterize OCD thought processes. Viewing the brain as an information-processing system, we studied how this system can be disrupted to produce repetitive thoughts and behaviors characteristic of OCD (for a similar approach, see Pitman, 1987).

This investigation relied on the theory of “reality monitoring” developed by Johnson and her collaborators (e.g., see Johnson, 1988). This theory has been used to explain the circumstances in which memories of previous experiences become confused with memories of experiences that were only imagined. According to Johnson and Raye (1981), one’s ability to discriminate past percepts from images is determined by two factors: (a) the nature of the memory representations being evaluated and (b) how one decides which representations arose from actual events. Johnson (1988) discusses the relevance of reality monitoring to clinical populations, especially schizophrenia, and other researchers have used reality monitoring tasks to study OCD (McNally & Kohlbeck, 1993; Sher, Frost, & Otto, 1983). We extend the previous literature by using the terminology and methodology of signal detection theory to specify a set of hypotheses, motivated by the reality-monitoring literature, about how an information-processing system could be disrupted to produce OCD behaviors.

Using an information-processing approach, we posit four distinct points at which reality monitoring could break down. Any of these information-processing dysfunctions could selectively occur in a patient with OCD. First, a patient could have trouble perceiving a stimulus, which would later result in a dim mental image; alternatively, he or she could form such vivid mental images that they were confused with previously encoded percepts. Second, the percept or image might be improperly stored in memory. Perhaps the representation is interpreted as a percept when it is an image, or vice versa. Third, the information could be stored properly, but retrieval processes are awry. In this case,

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information about the source of a memory might not be accessed, leading to confusion. Finally, the patient might have a bias in how he or she decides whether a memory reflects perception or imagery, inappropriately deciding that too many memories are the result of imagination.

In this study, we considered three reasons why patients with OCD might have difficulty distinguishing memories of visual percepts from memories of mental images, on the basis of the types of information processing outlined above. First, it is possible that these patients have a lower sensitivity to the difference between the visual memory of a percept and the memory of a previously formed mental image. Such a deficit could arise if the patient had very vivid images or very dim percepts. Normal people sometimes mistake an image for a percept (e.g., see Finke & Shepard, 1986; Kosslyn, 1980, 1983, for reviews), and patients with OCD may simply be more prone to this problem. Visual images typically are not recalled as vividly as percepts, yet the two may be difficult to distinguish if their representations in memory are similar. Indeed, Johnson, Raye, Wang, and Taylor (1979) found that normal subjects who were good imagers were more likely to confuse internally generated images with externally generated memory representations than subjects who were poor imagers.

Other researchers have considered the possibility that patients with OCD have overly vivid mental images (e.g., de Silva, 1986). However, a study conducted by Sher, Frost, Kushner, Crews, and Alexander (1989) did not support this hypothesis. Sher et al. tested psychiatric outpatients, some of whom scored high on the checking subscale of the Maudsley Obsessive Compulsive Inventory (MOCI; Hodgson & Rachman, 1977) and some of whom did not score high on this subscale and were classified as noncheckers. None of their subjects was formally diagnosed with OCD. Sher et al. assessed vividness of imagery by asking the subjects to rate the type and amount of imagery they experienced while recalling what they did on their last vacation. Sher et al. found a near-significant trend for checkers to report less vivid images than noncheckers, but how their imagery differed from that of nonclinical subjects could not be assessed because no control group was included.

A second hypothesis is that patients with OCD may be able to discriminate between percepts and images, but may require much more information to be certain about the distinction. Perhaps they have a deficit in their "feeling of certainty," which results in an unusually high, or conservative, criterion for deciding that a stimulus had been seen rather than imaged. Such a problem would arise from a biased decision-making process. Previous studies of reality monitoring in OCD have found that some patients with OCD are less confident than control subjects about their memories, as assessed through confidence ratings (McNally & Kohlbeck, 1993) and subjective estimates of items correctly remembered (Sher et al., 1983). These measures are an indirect assessment of response bias because they are obtained by asking subjects to reflect on their performance. By using signal detection measures, in this study we provide a more rigorous measure of the subjects' response biases.

Third, patients with OCD might have trouble mentally tagging incoming information as having been derived from a particular modality. Such a difficulty would arise from trouble storing the source of information, or trouble retrieving information from memory. Patients with OCD may have difficulty associat-

ing the context of a representation with its content (cf. Anderson & Bower, 1973). Johnson, Raye, Foley, and Foley (1981) found that increasing the number of "cognitive operations" performed on a stimulus when it was encoded into memory increased the accuracy of reality monitoring. Informing subjects that they will later be asked to indicate which items were seen and which were imaged should increase the cognitive processing of those items when they are encoded into memory; therefore, such instructions should result in robust contextual tagging. Patients with OCD might not be able to engage in the type of cognitive operations necessary to associate the information with the source.

All three of these types of deficits could underlie the feeling of uncertainty that causes some patients with OCD to continue to engage in an activity for an abnormal amount of time. Moreover, these hypothesized deficits are not mutually exclusive; an individual with OCD may have one or more of these difficulties.¹

A signal detection analysis allowed us to distinguish between inherent ability to discriminate between alternatives and attitudinal or motivational variables that influence decision criteria. The two measures that are obtained in a signal detection analysis are d' and β . The first, d' , is a measure of "sensitivity," which depends on both the individual's inherent ability to discrimi-

¹ Many case descriptions of individuals with OCD indicate a problem discriminating memories for actual percepts or actions from imaginations (e.g., "Did I do something or only think it?" or "Did I turn off the stove or only intend to?"; see Anderson, 1984; Johnson, 1988). Difficulty with precisely this type of discrimination is one of the cardinal features of many patients with OCD. It leads to severe doubt and anxiety and usually to extensive compulsive rituals to provide reassurance. As an example, when a schoolteacher who had OCD for over 30 years became angry in the classroom, afterwards she could not be certain whether she had only imagined harming one of her students or had actually done so. As a result, after school and during weekends and school vacations she repeatedly telephoned the student's mother to be reassured that she hadn't harmed him. If she still was not reassured, she obsessed until she next saw the child safely in the classroom (Baer, Minichiello, & Jenike, 1989). Similarly, this same patient could not be certain that she had turned off gas jets, water faucets, and light switches before leaving her home. As a result, she spent hours checking before going out (Baer et al., 1989). Another man suffered for 25 years with obsessive worries that he had failed to perform (as opposed to only imagining that he had performed) some important task, with resulting compulsions to repetitively wash his hands and touch walls and doors (Jenike, Surman, Cassem, Zusky, & Anderson, 1983).

This difficulty in discriminating actions performed from actions imagined is reported most frequently by patients with checking rituals, who often remark to us that, even though they see themselves performing an action, "it just doesn't seem to register" that they have performed it correctly. They subsequently imagine having performing it incorrectly (Baer & Jenike, 1990). However, patients with cleaning rituals often report that they continually wash their hands and other objects but cannot be certain that they have actually cleaned them correctly. For example, one man suffered for 15 years with severe anxiety and compulsive rituals of washing his body, clothes, and shoes with cleansers and bleach up to five times daily to "wash off dirt," which he feared his father had brought home with him from working in a cemetery (Jenike, 1981). It is possible that these patients also have difficulty discriminating ongoing perception (e.g., "I am cleaning sufficiently") from ongoing imagination (e.g., "I am not cleaning sufficiently to remove contaminants").

nate between two alternatives and how effectively the material can be encoded into memory. In this study, d' is an index of the subject's ability to discriminate between words that were actually seen and words that were imaged during the experiment. The second measure, β , is an index of an individual's a priori sense of how likely particular events are and reflects the subject's bias toward certain kinds of decisions. Depending on where the criterion is set, subjects will be more or less conservative in deciding that an event with a given "strength" indicates a stimulus that was actually seen.

We asked our subjects to compare the heights of the first and last letters of words either written in or imagined in lowercase letters, which forced them to attend to visually or auditorily presented words. We later asked them to tell us which of the words had been presented visually. This task was performed twice, once when the subjects did not know about the impending recognition test and once when they were told in advance to prepare for the upcoming test (and thus could try consciously to tag the stimulus modality).

Our three hypotheses now can be stated more precisely. First, patients with OCD may have a relatively low d' , which would reflect decreased sensitivity to the aspects of internal representations that distinguish visual percepts and images. Second, these patients may set their decision criteria, β , at a high value for deciding between these two alternatives. A high β would correspond to a conservative decision strategy, with which few false alarms would be made. By contrast, a liberal response strategy would involve many false alarms. Third, patients with OCD may have difficulty associating information about modality with the content of a representation. If so, they will not improve (show an increase in d') when they know the nature of the test in advance, compared with when they did not have the opportunity to prepare for the memory test.

We also expected that signal detection measures might differ between patients with OCD who were primarily "checkers" and those who were primarily "cleaners." As noted by Rachman (1985), patients with OCD who have primarily checking rituals are more likely to be doubtful and indecisive than patients with cleaning rituals (but some researchers have not found such differences between checkers and cleaners; see Barlow, 1988). Because checkers often complain of having difficulty being certain (e.g., about whether or not they actually locked a door), we predicted that checkers will have a more conservative response criterion. Such a problem might manifest itself as a higher, or more conservative, β score if the individual were reticent to decide that a particular memory (e.g., of a locked door) represented something actually seen. A lower sensitivity to the difference between a memory of something seen versus imaged might also underlie greater feelings of uncertainty and doubt in checkers compared with cleaners.

Method

Subjects

We tested a total of 49 participants, including 28 patients with OCD currently undergoing treatment at the Massachusetts General Hospital (MGH) OCD Clinic and Research Unit and 21 participants without OCD. Data from two patients and one control participant were omitted from the analyses because the participants did not follow the instructions for the memory task. Data from two additional control partici-

pants were discarded because the participants had high scores on the MOCI and Yale-Brown Obsessive-Compulsive Scale (YBOCS) questionnaires. Thus, data from 26 patients and 18 control participants are discussed.

Participants with OCD were diagnosed using the *Diagnostic and Statistical Manual of Mental Disorders*, Third Edition, Revised (*DSM-III-R*; American Psychiatric Association, 1987) criteria through the Structured Clinical Interview for *DSM-III-R*—Outpatient Version (SCID-OP; Spitzer, Williams, Gibbon, & First, 1988). Exclusion criteria included the presence of concurrent schizophrenia or other psychotic diagnoses, eating disorder, or bipolar disorder. If patients were found to have concurrent major depression on the SCID-OP interview, it must have occurred after the onset of OCD. We compiled a list of patients meeting the above criteria who were currently enrolled in support groups at the MGH OCD Clinic. The order in which patients were solicited from this list was determined by a random number list. Each patient who agreed to participate was asked to try to bring a relative to the testing session to be tested as well; 12 control participants were obtained in this manner. Six additional control participants were obtained from sign-up sheets in the Psychology Department at Harvard University. All subjects volunteered to participate.

For the patients with OCD, the mean age of onset of OCD symptoms was 16.5 years ($SD = 12.1$). Nineteen patients were on medication for their OCD at the time of testing (13 on fluoxetine only, 1 on fluoxetine and phenylzine, 1 on fluoxetine and clomipramine, and 4 on clomipramine only), 4 patients were nonmedicated, and 3 were currently in a drug study at the MGH OCD Clinic and were receiving either placebo or one of the medications mentioned above. Fifteen of the patients were in behavior therapy at the time of testing.

All patients and control participants were between the ages of 18 and 65. The patient group consisted of 11 men and 15 women, with an average age of 38.7 years ($SD = 9.3$) and an average of 15.2 years of education ($SD = 2.3$). The control group consisted of 12 relatives of patients with OCD (5 husbands, 1 wife, 1 brother, 2 sisters, and 2 daughters, and 1 additional man whose relation to the patient was not recorded) and 6 people who were unrelated to the patients (4 men and 2 women). The average age of the control participants was 41.9 years ($SD = 16.1$), and they had an average of 15.6 years of education ($SD = 2.1$).

Patients and control relatives were tested at MGH. Control participants who were unrelated to the patients were tested in a psychology laboratory at Harvard University and were paid \$5 each for their participation.

Materials

Two lists of 24 words each were prepared (see Appendix). Each word was printed in lowercase letters (varying between 0.7 and 1.5 mm in height) on a 4 × 6-in. index card. For 12 of the words in each list, the fourth letter was taller than the first letter; for 8 words, the first and fourth letters were the same height (4 with both letters short and 4 with both letters tall); and for 4 words, the first letter was taller than the fourth letter. These index cards were placed in a wire-bound booklet with an equal number of interspersed blank cards. A tape recording in which a beep sounded every 5 s was also prepared. Each beep corresponded to a card in a booklet: If the card was blank, then a word was read aloud on the tape; if the card contained a word, then the tape was silent. Equal numbers of each type of word were presented visually and auditorily. The booklets and tapes were divided into two lists, each containing a total of 24 words. Four stimulus sets were prepared for counterbalancing purposes, allowing each list to appear first and second equally often and each word in each list to be presented visually and auditorily equally often. Stimuli were presented in a pseudorandom order, with the restriction that no more than three words from each category or from the same presentation modality appeared consecutively.

Procedure

Participants were tested individually. The testing procedure took approximately 20 min to complete, and was followed by an additional 15–45 min of filling out the questionnaires. Each testing session began with the experimenter reading aloud an informed consent form, which each participant then signed. Each participant was first presented with one randomized set of 24 words in the following manner: The participant and experimenter were positioned on opposite sides of a table with a set of wire-bound index cards and a tape player between them. As the tape was played, a beep sounded every 5 s that signaled the experimenter to flip over the next card. If the card had a word printed on it, the participant was instructed to decide as quickly as possible whether the fourth letter was higher than the first letter and to say “yes” if this was the case or “no” if it was not. If the card was blank, the participant would hear a word spoken aloud. The participant was instructed to visualize the word to make the letter-height judgment; thus, words in the auditory condition were evaluated using visual mental imagery (Weber, & Castleman, 1970). The experimenter recorded the accuracy of all oral responses.

After the 24 words were presented, participants were given an unanticipated recognition memory test: A list of the stimulus words was given to them on a sheet of paper, and they were asked to place a check mark beside the words that had been written on a card. They were given as much time as they desired to complete this checklist; during this time, the experimenter politely refused to respond to questions about the words (e.g., many participants asked whether all the words on the checklist had been presented during the letter-height judgment task).

Following this, we presented a new list of words and repeated the procedure, beginning with the letter-height judgments and ending with the presentation modality recognition test. This time, however, the participants were warned that a recognition test would follow.

Finally, we gave the participants five standardized questionnaires and a form on which they recorded their age and gender, the age of onset of their OCD symptoms (if applicable), and the medications or therapy methods (or both, if any) currently being administered to them. The five questionnaires were the MOCI (Hodgson & Rachman, 1977), the YBOCS and Symptom Checklist (Goodman et al., 1989), the Absorption scale of the Multidimensional Personality Questionnaire (MPQ; Tellegen, 1982), the Beck Anxiety Inventory (BAI; Beck, Epstein, Brown, & Steer, 1988) and the Beck Depression Inventory (BDI; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961). The MOCI consists of 30 true–false questions regarding the contents of potential obsessive thoughts and compulsive behaviors, which produces subscale measures of checking, cleaning, slowness, and doubting. The YBOCS includes a checklist of 58 potential OCD symptoms along with 10 questions used to assess severity of symptomatology. For each statement on the checklist (e.g., “I am bothered by sticky substances or residues”), the patient indicated whether the problem stated was absent, present but not a principal problem, or present and a principal problem. The absorption scale of the MPQ assesses whether thought patterns are heavily emotional, vivid, or imaginative by asking patients to indicate which of 34 statements describe their thought patterns (e.g., “When I listen to music I can get so caught up in it that I don’t notice anything else,” or “Some of my most vivid memories are called up by scents and smells”). This measure was included because we suspected it might reflect one’s ability to experience vivid mental images. The BDI and BAI were included to assess differences in depression and anxiety between the patient and control groups.

Results

The within-subject independent variables were presentation modality (visual or auditory) and presentation block (first or second), and the between-subjects independent variables were group (patients with OCD or control participants), age, gender,

Table 1

Differences Between Patients With OCD and Control Participants for Demographic and Questionnaire Variables

Variable	<i>M</i>		<i>t</i>	<i>df</i>	<i>p</i>
	Patients	Controls			
Age	38.69	41.89	−0.83	42	.4099
Sex ^a	0.58	0.39	1.22	42	.2295
Education ^b	15.20	15.56	−0.52	39	.6089
Checking ^c	4.14	0.59	6.60	37	.0001
Cleaning ^c	3.14	1.00	3.60	37	.0009
Slowness ^c	2.50	0.18	5.16	37	.0001
Doubting ^c	4.27	1.59	4.53	37	.0001
Overall ^c	12.01	3.57	6.00	37	.0001
YBOCS	15.14	0.29	8.85	37	.0001
MPQ	10.18	9.35	0.32	37	.7468
BAI	8.86	2.00	3.72	37	.0007
BDI	8.14	4.35	1.90	37	.0647

Note. YBOCS = Yale–Brown Obsessive–Compulsive Scale; MPQ = Multidimensional Personality Questionnaire; BAI = Beck Anxiety Inventory; BDI = Beck Depression Inventory.

^a Coded as male = 0, female = 1.

^b Education background was not available for one patient and two control subjects.

^c From the Maudsley Obsessive–Compulsive Inventory.

and measures obtained from the questionnaires to assess OCD symptomatology. Participants whose age fell above the mean age (40 years) were classified as *older* ($n = 9$ patients with OCD and 8 control subjects), and those whose age fell below the mean were classified as *younger* ($n = 17$ patients with OCD and 10 controls).

The dependent measures were the number of correct responses (hits) and incorrect responses (false alarms) on the two recognition memory tests. These values were converted into signal detection measures, d' and β (see McNicol, 1972).

Group Differences

We began by examining group differences on the demographic measures and the questionnaire data and by examining the distributions for the signal detection measures.

Preliminary analyses. Initial analyses (unpaired t tests with two-tailed probabilities) were conducted to assess the overall differences between the patient and control groups on each of the measures except those for the memory task. As is evident in Table 1, the groups did not differ in age, sex, or educational background. The groups did differ on the questionnaire scores assessing OCD symptomatology, as expected. There was no group difference on the Absorption scale of the MPQ, which may suggest that the patients with OCD tested for this study did not characteristically experience more vivid mental images than the normal control participants. Thus, vividness of mental imagery, as measured by self-reports on the MPQ, was not a factor contributing to group differences in task performance for this study.

Patients with OCD did score higher than control participants on the BDI and the BAI. As will be described later in the Results and the Discussion sections, however, it is unlikely that group

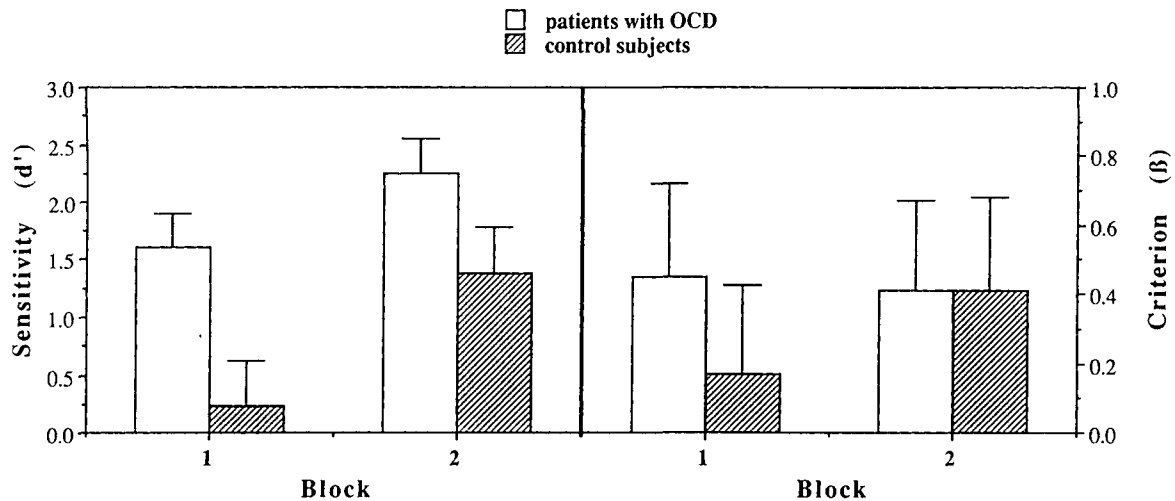


Figure 1. Sensitivity and criterion scores on the first and second recognition memory test blocks for patients with obsessive-compulsive disorder (OCD) and normal control participants. In Block 1 participants were not informed about the memory test, but in Block 2 participants were told that there would be a memory test after the letter-height judgment task.

differences in depression and anxiety were responsible for the group differences we found with our signal detection measures in our memory task. For both groups, d' scores were normally distributed, but β scores for both patients and control participants were highly skewed, with the majority of scores falling within a narrow range. Rather than omitting outliers, we took the logarithms of the β scores for both patients and control subjects for each administration of the memory task. This transformation succeeded in normalizing the distributions of β scores for both groups, and thus we analyzed these scores instead of the raw β scores. In general, log β scores less than zero reflect a more liberal decision criterion and scores greater than zero reflect a more conservative decision criterion. Liberal response bias is the tendency to check off many items as having been seen, thus running the risk of making many false alarms. Conservative response bias is the tendency not to check off many items, minimizing the likelihood of making false alarms.

Analyses of variance. We next conducted repeated measures analyses of variance (ANOVAs) to compare the sensitivity and criterion scores from both groups. Group (patient or control), age (young or old), and sex (male or female) were the three between-subjects variables for each analysis, and task block (first or second administration) was the within-subject variable. Separate ANOVAs were conducted for sensitivity (d') scores and criterion (β) scores. As illustrated in Figure 1, the mean d' score for the patient group (1.93) was actually higher than that for the control group (0.81), $F(1, 36) = 14.11$, $p < .001$, $MS_e = 2.37$, for the main effect of group. Thus, the patients with OCD were better able to discriminate between previously seen and previously imagined items than were the control participants. Also, the mean d' score on the second block (1.89) was higher than the score on the first block (1.05), $F(1, 36) = 6.24$, $p = .02$, $MS_e = 1.87$, for the main effect of block; this result indicates that subjects generally had greater discrimination sensitivity on the second administration of the recognition test. However, the interaction of group with block was nonsignificant ($p > .30$); there

was no difference between patients with OCD and control participants in the extent to which they used the instructions to improve their performance on the second recognition memory test.

We conducted a second ANOVA to examine β scores. There were no significant main effects or two-way interactions for these scores. For this and all other analyses reported here, results not mentioned were nonsignificant, $p > .10$ in all cases.

Group differences in anxiety and depression. To rule out the possibility that our results were an artifact of group differences in anxiety and depression, additional ANOVAs were conducted to examine the effect of group differences in BDI and BAI scores on the d' and β measures. A participant was classified as having high levels of depression if his or her BDI score was above the mean score for all participants, and was classified as having low levels of depression if his or her score fell below this mean. By this criterion, 19 participants had relatively high levels of depression (14 patients with OCD and 5 normal controls), and 22 participants had relatively low levels of depression (10 patients and 12 controls). We used the mean as the dividing line between groups, rather than the median, because scores tended to be either very low or very high. Moreover, many more participants had low scores, and thus the median would have been misleading. In a repeated measures ANOVA with group and depression level as between-participants variables and d' scores as the within-subject variable, there was no significant interaction between group and depression level. That is, having a relatively high or low depression score did not affect d' scores differently for patients versus controls. However, we did find that high levels of depression were associated with lower sensitivity scores ($M = 1.24$) than were low levels of depression ($M = 1.61$), $F(1, 37) = 4.62$, $p = .04$, $MS_e = 2.77$.

Similarly, level of depression did not differentially affect the β scores for patients with OCD compared with normal control participants. In a separate ANOVA with β scores as the within-subject variable, there was no interaction between depression

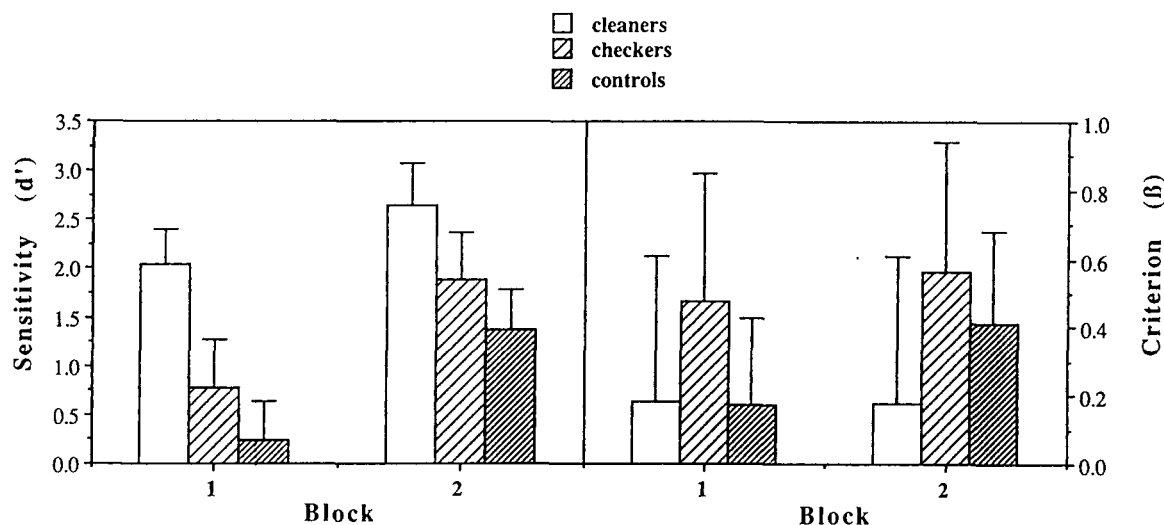


Figure 2. Subtypes of patients with obsessive-compulsive disorder compared with normal control participants on sensitivity and criterion measures.

level and group. We did find, however, that participants who had a high level of depression had a relatively liberal response criterion ($M = -0.01$), and participants with a low level of depression had a relatively conservative response criterion ($M = 0.58$), $F(1, 37) = 4.60$, $p = .04$, $MS_e = 1.91$.

Additional ANOVAs were conducted with group and anxiety level as the between-subjects factors. As before, we classified a participant as having high or low anxiety by comparing his or her score with the mean of all participants on the BAI. By this measure, 10 patients with OCD and 15 control participants had low levels of anxiety, and 14 patients and 2 controls had high levels of anxiety. There were no significant main effects or interactions involving the level of anxiety factor for either the d' or β scores, all F s < 1 .

Subtypes of OCD

We conducted two additional ANOVAs to consider possible differences among subgroups of OCD patients. We first divided the patient group into separate subgroups of checkers and cleaners. Our patient group was not large enough to compare pure cleaners and pure checkers, and most of our patients experienced both types of symptoms to some degree. We classified 13 patients with OCD as checkers because their MOCI checking subscale score was higher than their MOCI cleaning subscale score, and we classified 9 patients as cleaners because they showed the opposite pattern. The 4 remaining patients were not classified as checkers or cleaners because they did not complete the questionnaires. The ANOVAs were conducted with participant type (checker, cleaner, or normal control) as the between-subjects variable and the sensitivity or criterion scores (depending on the analysis) as the within-subject variable.

The ANOVA of d' scores revealed that there were differences among the groups, $F(2, 37) = 6.35$, $p < .01$, $MS_e = 2.80$. As shown in Figure 2, cleaners had higher d' scores than checkers, who in turn had higher d' scores than normal control participants. Analyses of simple effects were performed for each of the

d' scores. For the first block, the mean d' score for cleaners was higher than the mean d' score for the control participants, $F(1, 37) = 10.48$, $p < .01$. Cleaners tended to have higher d' scores than checkers, $F(1, 37) = 3.61$, $p = .06$, but checkers did not differ from the control participants ($p > .4$). For the second block of d' scores, the mean d' score for cleaners was again higher than the mean d' score for control subjects, $F(1, 37) = 4.55$, $p = .04$, but cleaners did not differ from checkers ($p > .3$), and checkers did not differ from control participants ($p > .4$). There were no differences in criterion scores between participant groups.

Checkers tended to have higher BAI and BDI scores than cleaners. For the BDI scores, the means for checkers, cleaners, and controls, respectively, were 10.0, 6.8, and 4.3. These overall differences did not reach the .05 level of significance, $F(2, 36) = 2.54$, $p = .09$, nor did post hoc tests of the significance of the differences between pairs of means. Three comparisons were possible, so the Bonferroni-adjusted level of significance was .017. A post hoc contrast testing the difference between the means for checkers and controls did not reach this adjusted level of significance, $F(1, 36) = 5.01$, $p = .03$, $MS_e = 37.43$.

In contrast, there were clear group differences in the BAI scores, $F(2, 36) = 8.61$, $p < .001$, $MS_e = 31.16$. Checkers and cleaners did not differ from each other, but both groups scored higher than the control group, as evidenced by contrasts. Cleaners scored higher than control subjects (7.2 vs. 2.0), $F(1, 36) = 6.47$, $p = .02$, $MS_e = 31.16$, and checkers scored higher than controls (11.2 vs. 2.0), $F(1, 36) = 16.06$, $p < .001$, $MS_e = 31.16$.

Demographic Variables

Given that previous studies found age differences in reality monitoring (Hashtroudi, Johnson, & Chrosniak, 1989), we wanted to control for this factor, as well as any sex differences, in our analysis of group differences. In so doing, we found age and sex differences in both d' and β scores. As is evident in Fig-

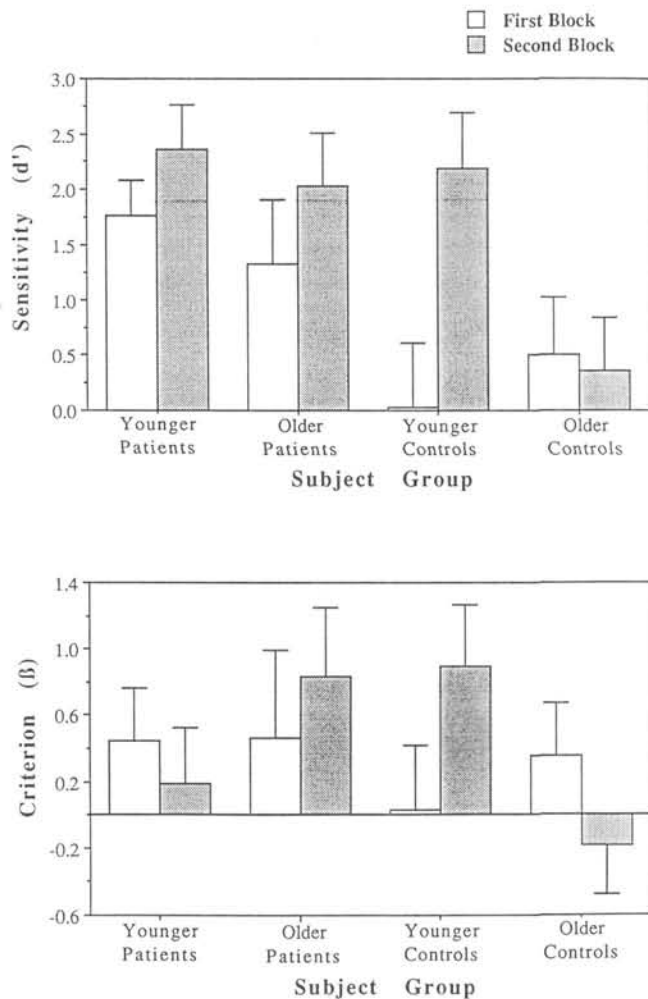


Figure 3. Sensitivity and criterion measures for younger and older participants.

Figure 3, younger participants tended to improve at tagging the encoding modality of the words, as indicated by larger d' scores on the second than on the first presentation block, whereas there was no such trend for older participants; this tendency was evident in a trend toward an interaction of age and block, $F(1, 36) = 3.35, p = .08, MS_e = 1.87$.

In addition, younger patients with OCD used a more liberal criterion on the second test, whereas older patients used a more conservative criterion. Control participants showed the opposite pattern: Younger controls became more conservative, and older controls became more liberal. This pattern, as shown in Figure 3, was documented by a three-way interaction between group, age, and block, $F(1, 36) = 5.06, p = .03, MS_e = 0.99$.

We also found trends toward sex differences in sensitivity, but not criterion, scores between the first and second blocks. We found a tendency for female patients to have higher sensitivity scores than male patients (2.19 vs. 1.58), but for female control participants to have lower sensitivity scores than male control participants (0.06 vs. 1.28), $F(1, 36) = 3.76, p = .06, MS_e = 2.37$, for the interaction between sex and group. We also found that men tended to have higher sensitivity scores than women in

the first block (1.26 vs. 0.84), but women tended to have higher sensitivity scores than men for the second block (2.18 vs. 1.60), as suggested by a marginal interaction between sex and block, $F(1, 36) = 3.54, p = .07, MS_e = 1.87$.

Finally, the female patients had higher sensitivity scores than female controls, regardless of age; only the older male patients, however, had higher sensitivity scores than male controls. In contrast, younger male controls showed higher sensitivity than younger male patients. This pattern was documented by a three-way interaction of group, age, and sex for the sensitivity scores, $F(1, 36) = 4.56, p = .04, MS_e = 2.37$ (see Figure 4). There were no main effects of age or sex for either d' or β .

Discussion

The principal question addressed in this study was whether the repetition of thoughts and behaviors experienced by patients with OCD is related to difficulty distinguishing between a memory of a visual percept and a memory of a self-generated visual mental image. We hypothesized that patients with OCD might differ from normal control participants in three possible ways: in their ability to discriminate between a percept and a mental image, in their criterion for deciding that an item had been perceived and not imaged, or in their ability to appropriately tag the modality of a stimulus. We found that, in fact, some patients with OCD demonstrated a greater ability than control participants to discriminate between percepts and mental images. The patients in our sample who showed this pattern were apparently more aware of the difference between what they had seen and what they had imaged; they may even have had a heightened attentiveness (compared with control subjects) to the modality in which information had been originally encoded. There were no differences between patients and control participants in setting a criterion for deciding that a word had actually been seen rather than imaged. In addition, both patients and controls were able to tag the modality of the words, as evidenced by their improved sensitivity scores when the memory task was administered a second time.

Unlike Sher, Frost, and Otto (1983), who did not find a significant difference in d' between checkers and cleaners, the checkers in our study did have a lower d' than the cleaners, as we predicted, even though patients with OCD as a group had higher d' scores than normal control participants. Sher et al. gave a reality-monitoring task to normal subjects who had scored highly on a checking questionnaire, but it did not involve imagery. Participants were presented with a series of word pairs. For half of them, the second word in the pair was printed in full, and for the other half, only the first letter was printed and the participants had to generate the word. Then subjects were asked to distinguish words printed in full from words they had generated. Checkers did not differ from noncheckers in this type of reality-monitoring ability. Similarly, McNally and Kohlbeck (1993) did not find a significant difference between checkers and cleaners in a reality-monitoring task, nor did they find a difference between patients with OCD and control participants. Their study involved actual versus imagined performance of an action (tracing a line-drawn picture or a printed word; see Anderson, 1984). These studies collectively refute the hypothesis that patients with OCD, and checkers in particular, have a reality-monitoring deficit relative to non-OCD subjects. However,

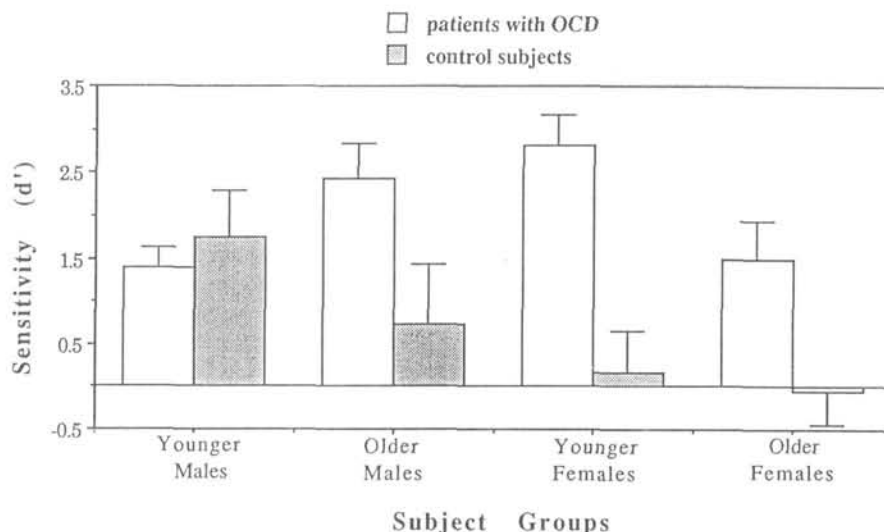


Figure 4. Group, age, and sex differences on sensitivity scores. OCD = obsessive-compulsive disorder.

with signal detection analysis we can be more precise in our characterization of cognitive differences between patients with OCD and normal control participants, and also between subtypes of patients. We found that checkers differed from cleaners in sensitivity, but not criterion; the cognitive ability to discriminate percepts from images stored in memory is very different from the cognitive ability to set a criterion by which to make this distinction.

In this study, we focused on the processes used to retrieve and evaluate information from memory. However, these may not be the processes disrupted by OCD. According to Reed (1983), the pervasive doubt characteristic of OCD arises from difficulty making "decisions about decisions":

Indeed, obsessionals often "know" the answer to a problem at an abstract, intellectual level. They are unable to implement the decision because they find themselves unable to internalize it, and thus cannot experience conviction and a sense of completion. (p. 173)

This characterizes the performance of patients with OCD in our study: They were very good at discriminating items previously seen from those previously imaged. However, they were not required to evaluate this information against any additional criteria. It may be that repetitive thoughts and behaviors arise only when the individual has constructed an elaborate set of criteria that need to be satisfied before a behavioral goal has been reached. As described by Reed (1983),

to the casual observer, the behaviour of a compulsive hand-washer may appear to be merely a protracted string of lathering and rubbing movements. Closer examination will usually reveal, however, that a complex hierarchy of rigidly determined acts has been prescribed; at each level, spatial, coordinative, and often temporal criteria must be achieved. Any perceived "error" involves going back to the beginning of the stage in question and achieving criterial performance seven times, for example. Thus the activity is infinitely more complex than the simple repetition of actions in a replicative manner. (p. 173)

Our results have led us to consider how our hypotheses fit into a broader range of possible information-processing impair-

ments that could lead to repetitive thoughts and behaviors in OCD. Two alternatives are that OCD is related to problems making decisions about memories ("Did I do it or did I only imagine doing it?") or that OCD is related to problems making decisions about ongoing behaviors ("Have I satisfied enough criteria to decide that a behavioral goal has been met?"). Either alternative could involve a sensitivity or a criterion deficit. For decisions about memories, sensitivity is the ability to discriminate previously perceived from imagined information, and one's criterion is how conservative one is when making that decision. For decisions about ongoing behaviors, sensitivity is the ability to detect the difference between the goal state and the current state, and one's criterion is how liberal one is in allowing an error signal to be generated when these states do not match (i.e., how rigidly the behavioral goal is held). For decisions about memories, behaviors are repeated if one is unable to make the decision (because of poor sensitivity, or low d' , for detecting the difference between current and goal state, or because of a liberal criterion, or high β , for deciding that the current state meets the goal state). For decisions about ongoing behaviors, behaviors are repeated if an error signal, indicating mismatch between current and goal state, is continuously generated (because of good sensitivity, or high d' , or because of a conservative criterion, or low β).

We tested only the possibility that OCD is related to problems making decisions about memories. We focused on a particular feature of obsessional thought that Reed (1983) called "mnemonic brooding" (e.g., asking oneself, "Are my recollections sufficient and correct?"). Our results do not support this possibility; in fact, they suggest that patients with OCD are very good at making decisions about their memories. However, our results do not speak to the issue of whether this type of decision making improves with treatment, because our study did not include a nonmedicated patient group. In addition, we do not know whether patients with OCD would have reality-monitoring difficulties while experiencing stress or in an obsessional state.

Alternatively, the central problem in OCD may be an inabil-

ity to use information in memory to guide behavior (e.g., one knows that he or she did lock the door but still does not feel secure). This would support the possibility that OCD is related to difficulty making decisions about ongoing behaviors (in the example above, knowledge about the locked door is the current state and the feeling of security is the goal state). If this were more characteristic of OCD symptomatology than a reality-monitoring impairment, then normal or better-than-normal encoding of certain types of information in memory might be related to the problem: If much information about the current state were available but for some reason an error signal were still being generated, anxiety would surely result—as would repeated attempts to retrieve even more information from memory to satisfy the goal state criterion.

The theory that OCD is related to difficulty making decisions about ongoing behaviors is similar to Pitman's theory of OCD as a control system dysfunction (Pitman, 1987). The crux of Pitman's approach is that behavior is controlled by the process of matching perceptual input to internal reference signals, generating an error signal that represents the degree of mismatch, and then adjusting behavior to reduce the error signal. Obsessive or compulsive behaviors arise when the system breaks down so that error signals cannot be reduced; hence, thoughts or behaviors are repeated in a vain effort to bring the system to equilibrium. Pitman suggested that the inability to reduce error signals could have three different causes. First, error signals could be unusually high when a patient is trying to choose between two alternatives, which would lead him or her to have trouble deciding on a single course of action. Second, a faulty comparison mechanism could generate an error signal regardless of the perceptual input. If so, the repetitive behavior of patients with OCD would occur because the external input would never match the desired internal reference point. Such a faulty comparator presumably would be reflected in a very conservative criterion. Third, patients with OCD may not shift their attention away from discrepant or irrelevant perceptual input, which presumably would cause an error signal to persist. One possible explanation for our finding of superior reality monitoring ability in some of our OCD patients stems from Pitman's hypothesis. If OCD is related to an inability to shift attention away from a certain input, then when attention is locked on to that input it may be processed more deeply and hence remembered better. Thus, the same mechanism that might lead to persistent, repetitive, unwanted thoughts or behaviors in some circumstances (by causing error signals to persist) would improve cognitive abilities in others.

Our study also revealed some unexpected age and sex differences in the subject sample as a whole. We found that the greater sensitivity of patients with OCD, relative to control participants, in discriminating between percepts and mental images was common to all patient subject groups except younger men. Younger male control participants had higher d' scores than younger male patients. In addition, the effects of forewarning were different for subjects of different age and sex groups. Younger subjects showed much greater improvement in sensitivity on the second recognition test than did older participants. In a study of source monitoring in young and elderly participants, Hashtroudi, Johnson, and Chrosniak (1989) found poorer performance for older participants only when they were asked to discriminate items in memory from the same class (internally

generated or externally generated). They concluded that source monitoring deficits were not generally a problem for the elderly. In our study, older participants showed greater impairment than younger participants only when they were informed of the upcoming recognition test; the two groups' scores did not differ on the initial incidental memory task, as evidenced by the Age \times Block of Sensitivity Scores interaction described in the Results section. We also found that female participants showed greater improvement in sensitivity than male participants on the second recognition test, as evidenced by a marginal Sex \times Block of Sensitivity scores interaction.

The higher levels of depression and anxiety in our OCD patients (compared with our normal control participants) did not influence the group differences on sensitivity and criterion scores. Although higher levels of depression in general were associated with lower d' scores and lower β scores (i.e., a liberal response bias), there was no interaction between level of depression and group for either the sensitivity or criterion measures.

In short, OCD does not arise because of confusion about the original source of representations already stored in memory. The patients we tested had neither less sensitivity to the distinction between stored percepts and images nor a more conservative response bias for making that distinction. Rather, OCD may be related to how information is initially perceived and encoded into memory or later selected from memory for further processing. If patients with OCD are so sensitive to perceptual input that responses are evoked on the basis of minimal input, then repetitive thoughts or behaviors could occur because the input from perceptual systems continually reactivates stored representations in memory. Alternatively, patients with OCD may have difficulty using information stored in memory to guide behavior or to make decisions about ongoing behavior.

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Appendix

Word Stimuli Used for Letter-Height Judgment Task

Yes		No ^a		No ^b		No ^c	
Set 1							
coat	girl	soap	star	bird	fork	face	hair
meat	wall	corn	nose	desk	bush	deer	bike
rock	card						
crab	seed						
park	nail						
suit	wood						
Set 2							
comb	road	cane	ears	book	leaf	fire	lion
mint	part	shoe	wing	fish	belt	door	lady
post	seat						
cart	sand						
sled	raft						
path	salt						

^a First and fourth letters are both short. ^b First and fourth letters are both tall. ^c First letter is taller than fourth letter.

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