INHIBITION AND EXECUTIVE FUNCTIONING IN TRICHOTILLOMANIA

A Comparison With an Obsessive-Compulsive Disorder Group and a Healthy Control Group

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Antje Bohne

aus Gütersloh

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Zusammenfassung

Einleitung

Trichotillomanie (TTM) ist gekennzeichnet durch repetitives Ausreißen der eigenen Haare, das beträchtliches Leiden hervorruft oder zu einer signifikanten Einschränkung der Funktionsfähigkeit eines Menschen führt. Trotz geschätzter Prävalenzraten von 1-3 Prozent und schwerwiegender körperlicher und/oder psychischer Auswirkungen des Haareausreißens ist diese Störung bis heute unzureichend wissenschaftlich erforscht. Bisherige Studien zur TTM haben sich im wesentlichen auf Beschreibungen des Erscheinungsbildes und Krankheitsverlaufs sowie der phänomenologischen und neurobiologischen Ähnlichkeiten mit anderen psychischen Störungen konzentriert. Therapiestudien sprechen für unbefriedigende (sowohl pharmakologische als auch psychotherapeutische) Behandlungsergebnisse, insbesondere mit Blick auf die Beständigkeit eines Therapieerfolgs.

TTM gilt als eine Störung der Impulskontrolle, ist aber aufgrund von phänomenologischen und neurobiologischen Ähnlichkeiten auch dem Spektrum der Zwangsstörungen zugeordnet worden. Zwangsstörungen sind durch aufdringliche, ängstigende bzw. quälende Gedanken (Zwangsgedanken) geprägt, die durch exzessives Ausüben von motorischen oder gedanklichen Handlungen (Zwangshandlungen) zu kontrollieren versucht werden. Bei Zwangsstörungen, die im Gegensatz zur TTM bereits intensiv erforscht worden sind, deuten Ergebnisse zahlreicher Studien auf kognitive Funktionsstörungen hin. Zu den charakteristischen Defiziten bei Menschen mit einer Zwangsstörung scheinen Beeinträchtigungen in der intentionalen Hemmung von Gedanken und Störungen in exekutiven Funktionen zu gehören.

Die Erforschung kognitiver Funktionen hat wesentlich zur Identifizierung von Mechanismen beigetragen, die der Entstehung und Aufrechterhaltung von psychischen Störungen zugrunde liegen, und dieses Wissen konnte gewinnbringend für die Entwicklung

von effektiven Therapiekonzepten (u.a. für Angst- und Zwangserkrankungen) genutzt werden. Kognitive Funktionen bei Trichotillomanie, die zur theoretischen Erklärung der Entstehung und Aufrechterhaltung der Störung und damit letztendlich zur Ableitung funktionaler Behandlungsstrategien hilfreich sein könnten, sind jedoch bislang kaum untersucht worden. Die vorliegende Forschungsarbeit geht daher der Frage nach, ob TTM durch Auffälligkeiten in kognitiven Funktionen gekennzeichnet ist und ob diese gegebenenfalls störungstypisch sind.

Aufgrund des Störungsbildes erscheint es naheliegend, die Fähigkeit zur intentionalen Impulskontrolle bei TTM zu untersuchen. Zudem erscheint es auf der Grundlage der vermuteten Ähnlichkeiten zwischen TTM und Zwangsstörungen sinnvoll, eben jene kognitiven Funktionen bei Personen mit TTM zu untersuchen, die zuvor bei Zwangspatienten als beeinträchtigt identifiziert wurden. In der vorliegenden Untersuchung werden deshalb folgende kognitive Funktionen bei Personen mit TTM im Vergleich zu Personen mit einer Zwangsstörung und gesunden Kontrollpersonen untersucht: (1) die Fähigkeit zur intentionalen Hemmung von motorischen Impulsen, (2) die Fähigkeit zur intentionalen Hemmung von Kognitionen und (3) die Integrität exekutiver Funktionen (i.e. die Fähigkeit zur Organisation von komplexem Stimulusmaterial, die Fähigkeit zum Planen und Problemlösen sowie die Fähigkeit zum Aufbau, zur Aufrechterhaltung und zum flexiblem Wechsel eines mentalen Sets). Die charakteristischen Symptome der TTM (wiederholtes Ausreißen der Haare) könnten, ähnlich wie bei den Zwangsstörungen, auf Defizite in diesen Bereichen zurückgehen.

Methode

Es wurden 35 Personen mit TTM, 26 Personen mit einer Zwangsstörung und 33 gesunde Kontrollpersonen am Massachusetts General Hospital in Boston, USA, rekrutiert. Klinische Probanden durften weder eine neurologische Störung, Psychose, Substanzabhängigkeit oder signifikante Kopfverletzungen in der Vorgeschichte noch eine Komorbidität von TTM und

Zwangsstörungen aufweisen. Die gesunden Kontrollpersonen durften keinerlei neurologische oder psychische Störung aufweisen. Auf der Grundlage dieser Kriterien wurden 21 rekrutierte Personen von der Teilnahme an der Studie ausgeschlossen. Einige der verbleibenden Versuchspersonen waren mit einzelnen Tests vertraut. Die entsprechenden Testdaten wurden in diesem Fall von der Auswertung ausgeschlossen.

Eine Testsitzung hatte im wesentlichen folgenden Ablauf: Zunächst wurde jeder Teilnehmer über die Studie aufgeklärt, und es wurde eine schriftliche Einverständniserklärung unterzeichnet. Anschließend wurde ein strukturiertes diagnostisches Interview (SCID) von etwa 45 Minuten Dauer durchgeführt. Es folgte eine etwa zweistündige Testphase, die sich aus einem 'GoNogo'-Experiment, einem 'Directed Forgetting'-Experiment und einer neuropsychologischen Testbatterie zusammensetzte. Zum Abschluß wurden die Teilnehmer gebeten, mehrere Fragebögen zu Symptomen psychischer Störungen (TTM, Zwangsstörungen, Depression und Angst) auszufüllen, was weitere 30 Minuten in Anspruch nahm. Die Testabfolge wurde variiert und balanciert, um möglichen Reihenfolgeeffekten zu begegnen.

GoNogo-Experiment. Das GoNogo-Experiment wurde durchgeführt, um die Fähigkeit zur intentionalen Hemmung von motorischen Impulsen zu untersuchen. Auf einem Computerbildschirm wurden dazu in pseudo-randomisierter Abfolge zwei Arten von Stimuli präsentiert. Auf die Präsentation des einen Stimulus ('GO'-Signal) sollten die Patienten mit einem möglichst schnellen Tastendruck reagieren, bei Präsentation des anderen Stimulus ('NOGO'-Signal) sollte kein Tastendruck erfolgen. In einer Testphase wurden insgesamt je 240 GO- und 80 NOGO-Stimuli präsentiert. Falsch-positive Reaktionen (Tastendruck bei Präsentation des NOGO-Signals) gelten als Ausdruck beeinträchtigter motorischer Impulskontrolle.

Directed Forgetting-Experiment. Zur Überprüfung der Fähigkeit zur intentionalen Hemmung von Kognitionen wurde ein Directed Forgetting-Experiment durchgeführt. Bei

diesem Experiment wurde der Gedächtnisabruf von Wörtern, die explizit erinnert werden sollten ('REMEMBER'-Wörter), verglichen mit dem Gedächtnisabruf von Wörtern, die nach vorheriger Enkodierung absichtlich vergessen werden sollten ('FORGET'-Wörter). REMEMBER und FORGET Wortlisten bestanden jeweils aus sieben negativ-valenten Wörtern aus der Kategorie 'TTM' (z.B. "balding"; dt.: 'Haare verlieren') und sieben neutralen Wörtern aus der Kategorie 'Kochen' (z.B. "boiling"; dt.: 'kochen'). Im Falle einer unbeeinträchtigten Fähigkeit zur intentionalen Hemmung von Kognitionen sollten beim freien Gedächtnisabruf ('Free Recall') mehr REMEMBER- als FORGET-Wörter erinnert werden (sogenannter 'Directed Forgetting-Effekt').

Neuropsychologische Testbatterie. Eine neuropsychologische Testbatterie wurde eingesetzt, um grundlegende verbale Fähigkeiten, räumlich-konstruktive Fähigkeiten, verbale und nonverbale Gedächtnisleistungen und die Integrität exekutiver Funktionen zu untersuchen. Die Testbatterie umfasste Subtests der 'Wechsler Adult Intelligence Scale-Revised' und der 'Wechsler Memory Scale' sowie den 'Rey-Osterrieth Complex Figure Test', 'California Learning Test', 'Tower of Hanoi', 'Object Alternation Task' und 'Wisconsin Card Sorting Test'.

Ergebnisse

Zwischen den drei Versuchsgruppen (TTM, Zwangsstörungen und gesunde Kontrollpersonen) bestanden weder hinsichtlich des Alters noch hinsichtlich der Anzahl der Schul- bzw. Ausbildungsjahre signifikante Unterschiede. Die klinischen Gruppen zeigten jedoch auf der Grundlage von Fragebogendaten ('Beck Depression Inventory' und 'State-Trait Anxiety Inventory') signifikant höhere Depressions- und Angstwerte als die gesunde Kontrollgruppe. Der Anteil an Frauen war - entsprechend des vermuteten Geschlechterverhältnisses in der jeweiligen Gesamtpopulation - in der TTM-Gruppe signifikant höher als in den anderen beiden Gruppen.

GoNogo-Experiment. In der Fähigkeit zur intentionalen Hemmung motorischer Impulse zeigten sich signifikante Gruppenunterschiede. Bei der Gruppe der Zwangspatienten und der gesunden Kontrollgruppe standen Reaktionszeit und Gesamtfehlerzahl in einem positiven Zusammenhang, was darauf hindeutet, dass diese Personen das GoNogo-Experiment entweder schnell und fehlerarm (i.e. kompetent) oder langsam und fehlerreich (i.e. inkompetent) ausführten. Im Gegensatz dazu wies die TTM-Gruppe einen negativen Zusammenhang zwischen Reaktionszeit und Gesamtfehlerzahl auf. Außerdem zeigte sich in dieser Gruppe ein signifikant negativer Zusammenhang zwischen Reaktionszeit und Zahl der falsch-positiven Reaktionen. Beides deutet darauf hin, dass die TTM-Personen das GoNogo-Experiment entweder schnell und fehlerreich (i.e. impulsiv) oder langsam und fehlerarm (i.e. vorsichtig) ausführten. Der Korrelationskoeffizient von Reaktionszeit und Gesamtfehlerzahl der TTM-Gruppe unterschied sich signifikant von dem in der gesunden Kontrollgruppe und dem in der Gruppe der Zwangspatienten.

Die Ergebnisse deuten auf ein heterogenes Leistungsprofil in der TTM-Gruppe hin, wobei eine Subgruppe durch Schwierigkeiten in der intentionalen Kontrolle von motorischen Impulsen gekennzeichnet ist. Post hoc-Analysen sprechen dafür, dass die Subgruppe der TTM-Probanden mit einer extrem 'impulsiven' GoNogo-Bearbeitung signifikant früher an TTM erkrankt ist als die Subgruppe der TTM-Probanden mit einer extrem 'vorsichtigen' Bearbeitung.

Directed Forgetting-Experiment. Auch in der Fähigkeit zur intentionalen Hemmung von Kognitionen konnten signifikante Gruppenunterschiede nachgewiesen werden. Im Unterschied zur gesunden Kontrollgruppe und zur TTM-Gruppe wurden in der Gruppe der Zwangspatienten von den Wörtern, die willentlich vergessen werden sollten (FORGET-Wörter), signifikant mehr negativ-valente TTM-Wörter als neutrale Wörter erinnert. Es fiel den Personen mit einer Zwangsstörung offenbar speziell schwer, negativ-valente Wörter absichtlich zu vergessen. TTM-Probanden zeigten diese Schwierigkeiten nicht.

Zusätzliche Gruppenunterschiede wurden in der Bewertung des Emotionsgehalts der präsentierten Wörter gefunden. Im Gegensatz zu den beiden klinischen Versuchsgruppen bewertete die gesunde Kontrollgruppe die erinnerten Wörter signifikant positiver als die nicht-erinnerten Wörter. Personen mit TTM oder einer Zwangsstörung scheinen demnach nicht die bei gesunden Personen gefundene Fähigkeit bzw. Neigung zu besitzen, positiv-valente Information vorrangig vor negativ-valenter Information zu erinnern.

Neuropsychologische Testbatterie. Auch im Bereich exekutiver Funktionen wurden signifikante Gruppenunterschiede gefunden. TTM-Probanden fiel es im Object Alternation Task schwerer als den gesunden Kontrollpersonen, die erforderliche alternierende Reaktionsfolge aufzubauen, was für eine Beeinträchtigung in der Reaktionsflexibilität bei TTM spricht. Im Gegensatz dazu zeigten Zwangspatienten im Vergleich zu gesunden Kontrollpersonen eine beeinträchtigte Fähigkeit, im Wisconsin Card Sorting Test aus Feedback zu lernen.

Zwischen den drei Versuchsgruppen wurden weder signifikante Unterschiede in grundlegenden verbalen oder visuell-räumlichen Fähigkeiten noch in den verbalen und nonverbalen Gedächtnisleistungen gefunden. Auch in ihrer Fähigkeit, komplexes verbales und nonverbales Material zu organisieren, sowie in der Fähigkeit zum Planen und Problemlösen unterschieden sich die drei Gruppen nicht signifikant.

Diskussion

Insgesamt sprechen die in dieser Forschungsarbeit gefundenen Ergebnisse für TTM-charakteristische Beeinträchtigungen in kognitiven Funktionen. Im Gegensatz zu Zwangspatienten und gesunden Kontrollpersonen scheint bei TTM-Personen die Reaktionsflexibilität eingeschränkt und die Fähigkeit zur intentionalen Hemmung motorischer Impulse vom persönlichen Ausmaß der Impulsivität abhängig zu sein. Es ergeben sich dabei

Hinweise, dass TTM-Personen mit einer größeren Impulsivität und größeren Schwierigkeiten in der motorischen Impulskontrolle einen früheren Störungsbeginn aufweisen als 'nicht-impulsive' TTM-Personen. Im Gegensatz zu Zwangsstörungen scheint TTM jedoch nicht mit einer Beeinträchtigung in der intentionalen Hemmung von Kognitionen einher zu gehen. Sowohl bei TTM- als auch bei Zwangspatienten scheint im Kontrast zu gesunden Kontrollpersonen nicht die Neigung zu bestehen, positiv-valente Information vorrangig vor negativ-valenter Information zu erinnern, was eventuell ein generelles Charakteristikum emotionaler Störungen ist.

Insgesamt scheinen kognitive Dysfunktionen durchaus eine Rolle bei TTM zu spielen. Auf der Basis der vorliegenden Daten könnte folgendes, als vorläufig und hypothetisch zu betrachtendes Erklärungsmodell der TTM entwickelt werden, dass einer Überprüfung in zukünftigen Studien bedarf. Eine mangelnde Neigung, positive Informationen vorrangig vor negativen Informationen zu erinnern, könnte den wahrgenommenen Stresslevel erhöhen und dadurch die Anwendung von Stressreduktionsmaßnahmen (wie z.B. das Haareausreißen) auslösen. Ein gesteigertes Maß an Impulsivität und damit verbundene Schwierigkeiten, motorische Impulse zu unterdrücken, wie sie bei einigen TTM-Personen beobachtet wurden, könnte die Wahrscheinlichkeit des Haareausreißens, das einen schnellen und effizienten Spannungsabbau zu ermöglichen scheint, erhöhen. Darüber hinaus könnte eine verminderte Reaktionsflexibilität dafür (mit)verantwortlich sein, dass TTM-Personen häufig von Schwierigkeiten berichten, eine einmal initiierte Episode des Haareausreißens zu unterbrechen bzw. zu beenden.

Die vorliegende Untersuchung weist methodische Schwächen auf, die an dieser Stelle kurz erwähnt werden sollten. Zum einen wurden mehrere Hypothesen an relativ kleinen und nahezu identischen Stichproben getestet. Die hier gezogenen Schlussfolgerungen müssen damit als vorläufig gelten. Generalisierungen sind erst dann sinnvoll, wenn die Ergebnisse in weiteren

Studien mit anderen Versuchspersonen repliziert werden konnten. Allerdings wurde die Testabfolge balanciert variiert, um möglichen Reihenfolgeeffekten zu begegnen. Zum Zweiten war der Frauenanteil in der TTM-Gruppe signifikant höher als in den anderen beiden Versuchsgruppen. Analysen zur Überprüfung eines möglichen Geschlechtereffekts sprachen jedoch nicht dafür, dass die gefundenen Ergebnisse durch das Geschlechterverhältnis in einer Stichprobe bestimmt wurden. Zum Dritten wiesen zahlreiche Versuchspersonen der klinischen Gruppen komorbide Symptome auf. Allerdings wurden Probanden, die unter psychischen Störungen litten, die die grundsätzliche kognitive Funktionsfähigkeit einer Person vermutlich wesentlich beeinflussen (wie z.B. Psychosen oder neurologische Störungen), von der Untersuchung ausgeschlossen.

Zusammenfassend, stellt sich TTM auf der Grundlage dieser Daten als eigenständiges Störungsbild dar, das wesentliche Unterschiede zu Zwangsstörungen aufweist. Eine Zuordnung der TTM zur Gruppe der Zwangsstörungen oder Zwangsspektrumstörungen, wie sie in der Fachliteratur z.T. gefordert wird, erscheint vor diesem Hintergrund kaum gerechtfertigt. Stattdessen scheint die derzeitige Zuordnung zur diagnostischen Kategorie der Impulskontrollstörungen angesichts der hier vorgestellten Ergebnisse zumindest für einen Teil der TTM-Personen angemessen. Allerdings ergeben sich vermehrt Hinweise darauf, dass TTM ein heterogenes Störungsbild mit unterschiedlichen Subtypen darstellt, das sich universell in keine der vorhandenen Kategorien zufriedenstellend einordnen lässt. Dimensionale Klassifizierungsansätze, wie z.B. die Einordnung von TTM in ein Impulsivitäts-Zwanghaftigkeits-Spektrum, könnten eine sinnvolle Alternative darstellen. Zukünftige Arbeiten zur Absicherung und Erweiterung der vorliegenden Ergebnisse sind notwendig, um ein besseres Verständnis des Störungsbildes und die Entwicklung wirksamer Therapiekonzepte zu ermöglichen.

Abstract

Introduction

Trichotillomania (TTM) is characterized by repetitive hairpulling which causes significant distress or functional impairment. Despite estimated prevalence rates of 1-3% and severe physical and/or psychological consequences of hairpulling, TTM is still underrecognized and insufficiently investigated. Previous studies on TTM mainly focused on descriptions of its phenomenology and clinical course as well as on phenomenological and neurobiological similarities with other mental disorders. Outcome of current pharmacological and psychotherapeutical treatments is poor especially regarding long-term efficacy.

Currently classified as an impulse-control disorder, TTM has also been categorized as an obsessive-compulsive spectrum disorder based on phenomenological and neurobiological similarities with obsessive-compulsive disorder (OCD). OCD is characterized by intrusive, anxiety- or discomfort-provoking thoughts (obsessions), which the individual attempts to control or neutralize by excessive performance of motor and/or mental actions (compulsions). In OCD, which so far has gained more empirical attention than TTM, numerous studies indicate cognitive dysfunctions such as an impaired ability in inhibiting thoughts and deficits in executive functions.

Research on cognitive functioning has proven fruitful in identifying mechanisms underlying the etiology and maintenance of mental disorders. Although this knowledge has successfully been integrated in treatment concepts (e.g., in phobias and OCD), cognitive functioning has rarely been investigated in TTM. The current thesis, thus, aims to investigate whether TTM is characterized by cognitive dysfunctions, and if so, whether these deficits are disorder specific.

Based on its clinical picture, it is important to investigate the ability to voluntarily control impulses in TTM. Furthermore, on the basis of the presumed similarities between TTM and

OCD, it is conclusive to investigate cognitive functions in TTM that have previously been found to be impaired in OCD. Specifically, in the current investigation I examined the following cognitive functions in TTM individuals compared to OCD individuals and healthy control (HC) individuals: (1) the ability to intentionally inhibit motor actions, (2) the ability to intentionally inhibit cognitions, and (3) the integrity of executive functions (i.e. the ability to organize complex stimulus material, planning and problem solving ability, as well as the ability to establish, maintain, and shift mental set). Similar to OCD, the key clinical symptom in TTM (repetitive hairpulling) might be related to deficits in these areas of functioning.

Methods

Thirty-five TTM, 26 OCD, and 33 HC individuals were recruited at the Massachusetts General Hospital, Boston, USA. Exclusion criteria for participation were a history of significant head injury and the following current or past psychiatric diagnoses: psychosis, alcohol or substance dependence, Tourette's Disorder or any other neurological disorder, comorbid OCD and TTM. HC individuals did not meet criteria for any current or past neurological or psychiatric disorder. Based on these criteria, 21 recruited individuals were excluded from study participation. Some of the participants had previous testing exposure to some of the tasks. In this case their data were not included in the task analysis.

Participants were tested individually. First of all, each participant was informed about the study and written informed consent was obtained. Then a structured diagnostic interview (SCID) was conducted which took about 45 minutes. The actual test phase comprised the administration of a 'GoNogo' experiment, a 'directed forgetting' experiment, and a neuropsychological test battery, as well as the completion of several self-report scales (assessing severity of TTM, OCD, depression, and anxiety symptoms). The sequences of tests

were counterbalanced to control for possible order effects. It took between 2.5 to 3 hours to complete the test session.

GoNogo experiment. The computerized GoNogo experiment was conducted to investigate the ability to intentionally inhibit motor actions. In this task participants were instructed to respond (by button-pressing) as quickly as possible to the presentation of a pre-defined (GO) stimulus and to repress the response to the presentation of a pre-defined (NOGO) stimulus. False-positive errors (failures to inhibit responses to the NOGO stimulus) are considered an indicator of impaired impulse control for motor actions.

Directed forgetting experiment. To investigate the ability to intentionally inhibit cognitions, a directed forgetting experiment was conducted. After encoding a word list, participants were instructed to intentionally FORGET these words and to REMEMBER another word list. Both lists equally included negative TTM-related and neutral words. A superior free recall of REMEMBER versus FORGET words (i.e. the so-called directed forgetting effect) is considered an indicator for intact cognitive inhibition.

Neuropsychological test battery. A neuropsychological test battery was used to investigate basic verbal abilities, visuospatial abilities, verbal and nonverbal memory, and executive functions. The test battery comprised subtests of the 'Wechsler Adult Intelligence Scale-Revised' and the 'Wechlser Memory Scale', as well as the 'Rey-Osterrieth Complex Figure Test', 'California Learning Test', 'Tower of Hanoi', 'Object Alternation Task', and 'Wisconsin Card Sorting Test'.

Results

The three groups (TTM, OCD, and HC) did not differ significantly with regard to mean age or number of years of education. The clinical groups, however, showed higher levels of depression and anxiety than the HC group based on self-report data ('Beck Depression

Inventory' and 'State-Trait Anxiety Inventory'). Furthermore, the TTM group differed significantly from the HC and OCD group in regard to the male-female ratio reflecting the reported predominance of females in the TTM patient population in contrast to a more balanced gender distribution in OCD.

GoNogo experiment. Groups differed significantly in their ability to intentionally inhibit motor actions. In the OCD and HC group, reaction time and total number of errors were positively correlated, which indicates that they performed either fast and accurate (i.e. task competent) or slow and inaccurate (i.e. task incompetent) in the GoNogo experiment. In contrast, the TTM group showed a negative correlation between reaction time and total number of errors. In addition, reaction time and number of false positive errors were significantly negatively correlated in this group. Both findings indicate that TTM participants performed either fast and inaccurate (i.e. impulsive) or slow and accurate (i.e. cautious) in the GoNogo experiment. The correlation coefficient of reaction time by total number of errors in the TTM group differed significantly from the correlation coefficients in the HC and OCD groups.

The data indicate a heterogeneous performance in the TTM group with a subgroup of participants showing deficits in intentional motor inhibition. Post hoc analyses give evidence that the TTM subgroup with an extremely 'impulsive' GoNogo performance had a significant earlier TTM onset than the TTM subgroup with an extremely 'cautious' performance.

Directed forgetting experiment. Groups also differed significantly in their ability to intentionally inhibit cognitions. In contrast to the HC and TTM groups, the OCD group remembered significantly more negative than neutral FORGET words. This finding indicates that OCD participants had specific difficulties with intentionally forgetting negative information. TTM participants did not show these difficulties.

In addition, significant group differences were found in the emotionality rating of words. In contrast to the clinical groups, the HC group rated the words freely recalled significantly

more positive than the words not recalled. This finding indicates that TTM and OCD individuals might be less inclined to ignore negative information than HC individuals.

Neuropsychological test battery. Significant group differences were also found with respect to executive functioning. TTM participants were less able than HC participants to establish and maintain the set of alternation on the Object Alternation Task, which suggests an impaired response flexibility in TTM. In contrast, OCD participants showed impaired feedback learning on the Wisconsin Card Sorting Test compared to HC participants. Significant group differences were not found in basic verbal abilities, visuospatial abilities, memory, organization or planning and problem solving ability.

Discussion

The current data suggest that TTM is characterized by particular cognitive dysfunctions. Unlike in OCD and HC individuals, in TTM individuals response flexibility seems to be impaired and the ability to intentionally inhibit motor actions appears to depend on impulsivity as a personal characteristic. There is preliminary evidence that TTM individuals characterized by difficulties in impulse control of motor actions have a significant earlier TTM onset than their 'non-impulsive' counterparts. In contrast to OCD, TTM does not seem to be characterized by impairments in the intentional inhibition of thoughts. Both, TTM and OCD, however, might be less inclined than HC individuals to ignore information with a negative-valence, which might be a rather general characteristic of emotional disorders.

The current findings suggest that cognitive dysfunctions seem to play an important role in TTM. On the basis of the current findings, one might propose the following preliminary and hypothetical model of TTM etiology and maintenance, that needs to be replicated in future studies. An inability to ignore negative information is likely to increase the perceived level of distress and might consequently trigger hairpulling as a stress reduction strategy. Inflated

impulsivity and associated difficulties to inhibit motor actions, as they have been found in some TTM individuals, might further increase the probability of hairpulling. In addition, decreased response flexibility might (in part) account for difficulties stopping hairpulling once initiated, a problem reported by many TTM sufferers.

The current investigation has some methodological limitations which deserve mention. First, sample sizes were relatively small and most of the people recruited participated in all three studies. Thus, conclusions based on the current data have to be considered preliminary and replication is needed to allow generalizations. However, the sequences of tests were counterbalanced to control for possible order effects. Second, there were more women in the TTM group than in the OCD and HC group. Our analyses, however, provide no evidence that significant between-group differences were affected by differences in gender ratio. Third, several of our TTM and OCD participants suffered from comorbid symptoms. However, individuals with comorbid psychiatric disorders which are thought to potentially impact cognitive functioning (e.g., psychosis, neurological disorders) were excluded from participation.

In sum, TTM appears to be characterized by different cognitive deficits than OCD. Thus, categorization of TTM as a variant of OCD or as an obsessive-compulsive spectrum disorder, as it is been suggested by some researchers, is not supported by the current data. Instead, classification of TTM as an impulse-control disorder seems adequate in at least a subgroup of TTM sufferers characterized by impulsivity and impaired motor inhibitory functioning. However, there is increasing evidence for TTM comprising heterogeneous subtypes and TTM may, thus, not fit as a whole into one of the currently defined classification categories. Therefore, a dimensional classification, which would organize disorders like TTM and OCD on an impulsivity-compulsivity continuum, would be advantageous. Further research replicating

and extending the current findings on cognitive dysfunctioning in TTM is necessary to enhance the understanding of its clinical picture and to help develop more effective treatment strategies.

1 General Introduction

Although trichotillomania (TTM) has already been described for more than a century (Hallopeau, 1889), this disorder is still underrecognized and poorly understood. Further research focusing on the onset and maintenance of TTM is needed, to support the development of both effective prevention and treatment strategies.

1.1 Trichotillomania: Clinical Picture, Etiology, and Treatment

TTM is characterized by recurrent hairpulling not better accounted for by another medical condition (e.g., an itch provoking somatic illness) or mental disorder (e.g., mental retardation, psychosis) causing noticeable hair loss and significant distress or impairment in important areas of functioning (American Psychiatric Association, APA, 1994, pp. 350-351). Although listed as a diagnostic criterion for TTM in the current Diagnostic and Statistical Manual of Mental Diseases, 4th edition (DSM-IV; APA, 1994), tension before pulling or when attempting to resist (criterion B), and/or pleasure, gratification or relief while pulling (criterion C) has been found to be not present in about 20% of clinically significant hairpullers (Christenson, Mackenzie, & Mitchell, 1991; Schlosser, Black, Blum, & Goldstein, 1994). Thus, the nosological importance of these characteristics has been challenged (Keuthen, O'Sullivan, & Jefferys, 1998).

TTM is a common disorder with a reported lifetime prevalence of 0.6% (Christenson, Pyle, & Mitchell, 1991). When criterion B and C are not taken into account the prevalence rate in the same non-clinical sample of American college students rose to 3.5% in females and 1.5% in males (2.5% of both sexes). From patient samples it can also be concluded that recurrent hairpulling is more frequent in females than in males (Keuthen, O'Sullivan, & Sprich-Buckminster, 1998). In the general population, however, men might be more likely to pull their

hair than initially thought, although they may not seek treatment as often as their female counterparts. Moreover, pulling of beard and scalp hair (which occurs frequently in men) is easily disguised by shaving or explained by natural hair loss (Christenson, Mackenzie, et al., 1991).

The onset of TTM is typically in late childhood to early adolescence. The mean age of onset has been estimated to be 13 years of age (Christenson & Mansueto, 1999). Recurrent hairpulling has also been observed in infants and babies but the behavior has often been reported to disappear without intervention. Except for those cases with early onset, TTM is a chronic disorder if untreated that may fluctuate over time in severity (Keuthen, O'Sullivan, & Jefferys, 1998).

The phenomenology of TTM seems rather heterogeneous with notable interindividual and intraindividual variability. Hairpulling may occur occasionally or several times a day, with hairpulling episodes lasting a few seconds up to several hours. The amount of hair extracted during an episode may also vary considerably. In some cases the hairpulling follows a specific ritual, in other cases the individuals are not even aware that they are engaging in this behavior (Swedo & Rapoport, 1991). Hair may be pulled from different body sites with scalp, eyelashes, eyebrows, facial and pubic hair most frequently pulled. Most of the sufferers pull from more than one site. Many people suffering from TTM play with the pulled hair by curling it around their fingers, rubbing it along their lips or chewing it. Some people habitually bite off the hair's root and digest the hair or part of it (Christenson, Mackenzie, et al., 1991).

Hairpulling may be triggered by various emotions (e.g., nervousness, tension, boredom), situations (e.g., watching TV, reading), diurnal circumstances (e.g., at night when going to bed), social contexts (e.g., being alone, being out of others' sight), specific postures (e.g., leaning the head on the hand), sensations (tactile, visual), and specific textures or color of hair

(e.g., curly, thick, gray). Sometimes thoughts (e.g., "These gray hairs have to go.") precede a hairpulling episode (Mansueto, Stemberger, Thomas, & Golomb, 1997).

Sufferers from recurrent hairpulling may face significant physical consequences, such as bald spots, thinning hair, or scars, and in some cases even serious medical problems, such as dental corrosion from chewing hair, or the formation of hairballs in the stomach (trichobezoars) from swallowing hair (Bouwer & Stein, 1998; O'Sullivan, Keuthen, Jenike, & Gumley, 1996; Schlosser et al., 1994). Related psychological problems may be lowered self-esteem, social rejection or avoidance (Soriano et al., 1996; Stemberger, Thomas, Mansueto, & Carter, 2000; Woods, Fuqua, & Outman, 1999). In addition, hairpullers often suffer from comorbid psychiatric disorders, which might be the cause or result of TTM (or may independently co-occur). Frequent comorbidities include anxiety, affective, addictive and eating disorders as well as body dysmorphic disorder (Christenson, Mackenzie, et al., 1991; Soriano et al., 1996).

Although research on TTM has increased greatly over the past decade, knowledge about its etiology remains sparse. One theory is that TTM can be viewed from a neuroethological perspective as a disorder of abnormal grooming. Similar behaviors have been observed in animals in times of stress (so called derived activities, e.g., acral lick dermatitis in dogs, avian feather picking in birds; Bordnick, Thyer, & Ritchie, 1994). Since hairpulling is often accompanied or followed by a decrease in tension, others have hypothesized that it might serve an emotion-regulation function. TTM has also been regarded as a habit disorder and learning models have been proposed (Diefenbach, Reitman, & Williamson, 2000). In addition, data from neuroimaging and neuropsychological studies have indicated abnormalities in the structure and functioning of the frontal lobe, which implicate neurobiological factors in TTM (Stein, O'Sullivan, van Heerden, Seedat, & Niehaus, 1998). Most likely, a combination of these variables play a role in the onset and maintenance of hairpulling.

Medical and non-medical treatments are currently used to alleviate the symptoms of TTM. Serotonin reuptake inhibitors (SRIs, e.g., clomipramine, fluoxetine, sertraline) are frequently effective in reducing hairpulling. Dopamine-blocking neuroleptics (e.g., risperidone, olanzapine), which are the medications of choice for tics, seem to be especially useful as an augmenting agent with SRIs. In addition, lithium and the opiate-antagonist naltrexone have also been reported to be helpful in the treatment of TTM. Medications, however, are not effective with all hairpullers and often seem to lose their efficacy over time (Christenson & Crow, 1996; Diefenbach et al., 2000; Keuthen, O'Sullivan, & Sprich-Buckminster, 1998; Jaspers, 1996).

Hairpulling has also been shown to respond to behavioral treatments. Habit reversal training (Azrin & Nunn, 1973) is considered the first-line intervention for TTM. It is a multi-component treatment package which entails, among other techniques, self-monitoring of urges and behavior, incompatible response training, and teaching of coping skills. Awareness of habit occurrence and training in the use of alternative responses are viewed as critical treatment steps. In addition, relaxation techniques and stimulus control procedures have also been successfully integrated into TTM treatment (Diefenbach et al., 2000; Keuthen, O'Sullivan, & Sprich-Buckminster, 1998). Limited data on treatment outcome in TTM indicate short-term effectiveness of current behavior therapy interventions with high rates of relapse in the long-term (Lerner, Franklin, Meadows, Hembree, & Foa, 1998).

1.2 Impulse-Control Disorder or Obsessive-Compulsive Spectrum Disorder?

TTM is currently classified as an impulse-control disorder (APA, 1994, pp. 350-351). This classification is mainly based on patient reports that hairpulling is generally caused by an irresistible urge or impulse. In contrast to other impulse-control disorders, however, not everyone who suffers from clinically significant hairpulling endorses a cycle of increasing

tension before and decreasing tension after hairpulling (Christenson, Mackenzie, et al., 1991; Schlosser et al., 1994). This finding has led to the recommendation to exclude these two phenomenological features from the diagnostic criteria for TTM (Keuthen, O'Sullivan, Sprich-Buckminster, 1998). However, if the tension-relief-cycle, which is the central feature of impulse-control disorders (APA, 1994, p. 344), is no longer considered to be necessary for the diagnosis of TTM, the rationale for its current classification is weakened.

At the same time, the demand to characterize TTM as an obsessive-compulsive (OC) spectrum disorder increases (Bienvenu et al., 2000; Stein, 2000). This categorization is based on phenomenological and neurobiological similarities of TTM with obsessive-compulsive disorder (OCD). Both disorders are characterized by repetitive, intentionally performed behaviors, which sufferers feel difficult to resist despite knowledge of potential adverse consequences. Furthermore, compulsions in OCD as well as hairpulling in TTM seem to be related to negative affective states (Keuthen, O'Sullivan, & Sprich-Buckminster, 1998). In addition, there is evidence that the neurotransmitter serotonin plays a role in both, TTM and OCD, and that similar psychopharmacological treatments (e.g., with serotonin reuptake inhibitors, SRIs) are effective (Jenike, 1989; Stein et al., 1998). Moreover, elevated prevalence rates of OCD have been found in TTM families (Lenane et al., 1992).

Despite these findings, which might suggest an association between TTM and OCD, there are several differences between the two disorders. In contrast to TTM, in which cognitions do not seem to play a major role in eliciting hairpulling, the repetitively performed behaviors in OCD are in general related to intrusive thoughts (Stanley, Swann, Bowers, Davis, & Taylor, 1992; Stein, Simeon, Cohen, & Hollander, 1995; Tükel, Keser, Karali, Olgun, & Çalikusu, 2001). In addition, the repetitive behavior itself is thought to be mainly ego-syntonic in TTM but ego-dystonic in OCD. Accordingly, in TTM a greater severity of hairpulling has been found to be correlated with lower resistance, a relation contrary to that observed in OCD

(Keuthen, O'Sullivan, & Sprich-Buckminster, 1998; Stanley et al., 1992). With respect to demographic features, TTM seems to be characterized by an earlier age at onset and a higher female-to-male ratio than OCD. And although similar psychopharmacological treatments have been found to reduce symptoms in both disorders, TTM seems to respond to a broader range of medication classes than OCD but with a less robust effect (Keuthen, O'Sullivan, & Sprich-Buckminster, 1998).

These dissimilarities seem to contradict notions that TTM might be best categorized as an OC spectrum disorder (Swedo & Leonard, 1992). Further studies comparing TTM with OCD, other OC spectrum disorders, and impulse-control disorders are needed to draw final conclusions regarding the best categorization of TTM.

1.3 Rationale for the Current Investigation

Knowledge about mechanisms underlying the etiology and maintenance of hairpulling remains sparse. Research on TTM has mainly focused on studying the phenomenological and neurobiological aspects of this disorder and, to date, not much is known about cognitive functioning in TTM. In few investigations neuropsychological tests have been applied to TTM sufferers (Coetzer & Stein, 1999; Keuthen et al., 1996; Rettew et al., 1991; Stanley, Hannay, & Breckenridge, 1997) and only once an experimental method has been employed (Martin et al., 1993) to further our knowledge in cognitive functioning of TTM. In other mental disorders, research on cognitive functioning has proven fruitful in identifying mechanisms underlying their etiology and maintenance (e.g., attentional biases in emotional disorders; for a review, see Williams, Watts, MacLeod, & Mathews, 1997). If TTM is also characterized by certain cognitive dysfunctions, this knowledge might provide a better understanding of its etiology and maintenance and might help clinical researchers to develop better treatments.

Thus, comparative research on cognitive functioning in TTM appears beneficial in further investigating the specific deficits and needs of these sufferers. Hypotheses about deficits in cognitive functioning related to TTM may, on the one hand, be deduced from its phenomenology. On the other hand, following the concept of TTM being an OC spectrum disorder, it seems reasonable to investigate those aspects of cognitive functioning in TTM that have been found impaired in OCD.

Given that TTM is characterized by recurrent, uncontrollable hairpulling, one may hypothesize an underlying deficit in inhibiting motor activity. However, to gain a broader perspective, it is beneficial to also investigate the ability to inhibit cognitions, a function that is considered independent from motor inhibition ability and that has been found to be impaired in OCD (e.g., Wilhelm, McNally, Baer, & Florin, 1996). Furthermore, when basing hypotheses on earlier findings of neuropsychological dysfunctioning in OCD (e.g., Savage et al., 1999), one may also predict that aspects of executive functioning - a set of higher level control processes that control and modulate more basic cognitive and motor functions - might be impaired in TTM. Motor inhibition, cognitive inhibition as well as executive functioning are all thought to depend on frontal lobe functioning, which appears to be impaired in TTM (e.g., O'Sullivan et al., 1997; Rettew et al., 1991) and OCD (e.g., Baxter, 1992; Tallis, 1997).

In this investigation, inhibitory and executive functioning were investigated in TTM compared to healthy control (HC) and OCD participants. In Study 1, the ability to intentionally inhibit motor actions was investigated in a GoNogo experiment (Drewe, 1975). Based on the phenomenology of TTM, which is characterized by repetitive, uncontrollable hairpulling, I hypothesized that TTM participants would show abnormal motor inhibition compared to HC and OCD participants. In Study 2, the ability to intentionally inhibit cognitions was investigated in a directed forgetting experiment (Johnson, 1994). Since OCD but not TTM seems to be characterized by intrusive thoughts, I expected that OCD but not TTM participants

would show poorer cognitive inhibition abilities than HC participants. In Study 3, a broad spectrum of neuropsychological functions was investigated using tests formerly shown to distinguish OCD from HC participants (Cox, 1997). Given evidence of frontal lobe dysfunction in TTM and OCD, I expected that participants of both groups would show impairments in executive functioning compared to HC participants.

2 General Methods

2.1 Participants

A total of 94 people was recruited: 35 individuals suffering from TTM, 26 individuals suffering from OCD, and 33 HC individuals. People were generally recruited through poster advertisements at the Massachusetts General Hospital (MGH), Boston, USA, and public libraries in the Boston area (see Appendix A). In addition, the MGH patient population was informed about the study by their clinicians in the outpatient unit for OCD and TTM. Moreover, some people suffering from TTM were enrolled through letters sent out by the Trichotillomania Learning Center (TLC; a non-profit organization established in the USA in 1991 by individuals with TTM), an advertisement in the TLC newsletter, and by contacting self-help groups located in the Boston area.

Psychiatric diagnoses were determined using the Structured Clinical Interview for DSM-IV-Axis-I-Disorders (SCID; First, Spitzer, Gibbon, & Williams, 1995). Exclusion criteria for participation were a history of significant head injury (e.g., temporary loss of consciousness) and the following (current or past) psychiatric diagnoses: psychosis, alcohol or substance dependence, Tourette's Disorder or any other neurological disorder, comorbid OCD and TTM. HC individuals did not meet criteria for any neurological or psychiatric disorder (neither currently nor in the past). All participants had to be fluent English speakers, within the age range of 18 to 65, and stable on medication for at least two weeks prior to the test session. None of the participants currently suffered from alcohol or substance abuse, or below normal intelligence. Twenty-one (22.3%) of the individuals recruited were found to be ineligible because they did not satisfy the inclusion criteria. Written informed consent of the remaining 73 individuals was obtained.

2.2 Measures

All participants completed several self-report scales and were administered tests of verbal ability and attention span. A brief description of each instrument follows.

Massachusetts General Hospital (MGH) Hairpulling Scale. The MGH Hairpulling Scale (MGH-HS; Keuthen et al., 1995) assesses the existence and severity of symptoms of repetitive hairpulling (see Appendix B). It comprises seven items focusing on urges to pull hair (frequency, intensity, and ability to control), actual hairpulling (frequency, attempts to resist, and perceived control), and distress associated with hairpulling. Each item is rated for severity on a scale from 0-4. Total scores range from 0-28, with higher scores indicating a higher severity of hairpulling symptoms. The MGH-HS is a reliable and valid research instrument with reported coefficients for test-retest reliability of $r = .97$, for convergent validity of $.63 < r < .75$, and for divergent validity of $.10 < r < .30$ (O'Sullivan et al., 1995).

Yale-Brown Obsessive Compulsive Scale. The Yale-Brown Obsessive Compulsive Scale (YBOCS; Goodman et al., 1989a) is a measurement of obsessive-compulsive symptoms. Ten questions are rated on a scale from 0-4, with five items each to assess the existence and severity of obsessive and compulsive symptoms. Total scores range from 0-40, with higher scores indicating more severe OCD symptoms. The YBOCS' reliability and validity has been demonstrated by internal consistency coefficients of $.88 < \alpha < .91$ (Goodman et al., 1989a) and a construct validity coefficient of $r = .74$ (Goodman et al., 1989b).

Beck Depression Inventory. The Beck Depression Inventory (BDI; Beck & Steer, 1987) is an instrument for measuring the existence and severity of depressive symptoms. It includes 21 items checking depressive symptoms, which are rated for severity on a scale from 0-3. The range of total scores is 0-63, with higher scores indicating a higher number and severity of self-reported depressive symptoms. The BDI is a reliable and valid self-report instrument with

coefficients for internal consistency of .76 < α < .95 and for test-retest reliability of r = .74 (Rehm, 1988), as well as for convergent validity of r = .67 (Williams, Barlow, & Agras, 1972).

State Trait Anxiety Inventory. The State Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) is an instrument assessing an individual's current (state) and general (trait) level of anxiety by two independent subscales each consisting of 20 items. Items are rated on a 4-point Likert scale ranging from 1-4. About half of the items of each subscale are inversely coded. Total scores for each subscale range from 20-80, with higher scores reflecting greater state resp. trait anxiety. Internal consistency coefficients for the state-anxiety scale (STAI-S) of .86 < α < .95, and for the trait-anxiety scale (STAI-T) of .89 < α < .91 have been reported. The test-retest coefficients for STAI-T are relatively high with .65 < r < .86. STAI-S, which is supposed to reflect situational stress reactions, is reported to have a lower temporal stability of .16 < r < .62 (Spielberger et al., 1983). The validity of STAI-S and STAI-T has also been documented with both scales being able to differentiate between different groups of anxiety patients (Oei, Evans, & Crook, 1990).

Edinburgh Handedness Inventory. The Edinburgh Handedness Inventory (EHI; Oldfield, 1971) is a quantitative measurement of an individual's handedness. Participants are asked to indicate their preference in the use of hands for ten different motor activities (e.g., writing, throwing, brushing teeth). Preferences in using the right or left hand for each of the listed activities are indicated by checking the appropriate column "left" versus "right". Intensity for the preference of one hand is rated by putting a single cross in the appropriate column indicating a simple preference or a double cross indicating strong preference (i.e. "would never try to use the other hand unless absolutely forced"). In case of real indifference participants are asked to put a cross in both columns. Handedness scores were computed following the suggestions of Oldfield and were compared to provided norm data (N = 1128 adults).

Participants were considered to be right-handed if their score fell within the 2nd to 10th decile value for right-handedness of the norm sample.

Wechsler Adult Intelligence Scale-Revised. Wechsler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1981) subtests including Information, Vocabulary, and Similarities were used to estimate general verbal abilities. The subtests Information and Vocabulary were presented in an abbreviated format (previously documented in Cabrera, McNally, & Savage, 2001). Of the Vocabulary subtest, which asks the participant to answer general knowledge questions, every third question (9 items total) was given. In this case, total Vocabulary scores range from 0-9. Likewise, every third item (11 items total) of the Information subtest was given, which requires the explanation of the meaning of words. In this case, total Information scores range from 0-22. The Similarities subtest contains 14 items, which require participants to find commonalties between verbal items. Scores range between 0-28. Span of verbal attention was measured using the Digit Span subtest of the WAIS-R, which requires participants to verbally remember sequences of numbers. Following the WAIS-R instruction, up to 28 items (up to 14 items with forward recall plus up to 14 items with backward recall) were given. Total scores range from 0-28.

Wechsler Memory Scale - Third Edition. The Spatial Span subtest of the Wechsler Memory Scale - Third Edition (WMS-III; Wechsler, 1997), which asks participants to repeat several block tapping sequences previously presented by the investigator, was included to measure span of non-verbal attention. Following the WMS-III instruction, up to 28 items (up to 14 items with forward recall plus up to 14 items with backward recall) were given. Total scores range from 0-28.

2.3 Materials

The materials used for the investigation comprised a computerized GoNogo task, a computerized directed forgetting task, and a neuropsychological test battery. The computerized tasks were designed and programmed by the thesis' author (software: SuperLab Pro 1.74).

GoNogo task. The computerized GoNogo task (Drewe, 1975) was designed and administered to assess basic motor inhibition ability. In this task participants were instructed to respond (by button-pressing) as quickly as possible to the presentation of a pre-defined GO-stimulus and to repress the response to the presentation of a pre-defined NOGO-stimulus. The design of the experiment and the materials used are described in detail in the Methods section of Study 1.

Directed forgetting task. To assess cognitive inhibition ability participants took part in a directed forgetting experiment (Johnson, 1994) during which they were confronted with several neutral and negative, potentially anxiety- or concern-related words. The design of the experiment and the materials used are described in detail in the Methods section of Study 2.

Neuropsychological tasks. Participants completed the following neuropsychological tasks designed to assess visuospatial abilities, memory, and various aspects of executive functioning: WAIS-R subtest Block Design, Rey-Osterrieth Complex Figures Test (RCFT; Osterrieth, 1944), California Verbal Learning Test (CVLT; Delis, Kramer, Kaplan, & Ober, 1987), Tower of Hanoi (TOH; Simon, 1975), Object Alternation Task (OAT; Freedman, 1990), and Wisconsin Card Sorting Test (WCST; Heaton, Chelune, Talley, Kay, & Curtiss, 1993). Each task is described in detail in the Methods section of Study 3.

2.4 Procedures

Before participating in the study, the participants were informed about the study goals and written informed consent was obtained. To create a sufficient incentive for HC individuals

to participate in the study they were paid 40 US-Dollars. Individuals suffering from TTM or OCD, who had the additional potential benefit from the study of learning about their diagnostic status and symptoms, and who were offered to receive feedback about their test performance, were paid 20 US-Dollars for their participation.

If not already recently completed as part of other research studies or as part of their psychiatric evaluation participants first completed the SCID to determine or verify their diagnostic status. For HC individuals this diagnostic interview took approximately 15 minutes and was generally conducted over the phone. For participants suffering from TTM or OCD the interview took about 45-60 minutes and was offered to be completed separately from the test session.

The actual test phase comprised the administration of the GoNogo experiment, the directed forgetting experiment, and the neuropsychological test battery, and completion of the self-report scales. It took between 2.5 to 3 hours to complete the test session. The sequences of tests was counterbalanced to control for possible order effects. Tasks involving verbal and nonverbal materials were presented in counterbalanced order to avoid interference effects. No memory test was ever presented during the break between short-term (part I) and long-term memory recall (part II) of the RCFT and CVLT to avoid interference. No tasks using verbal material were administered within part I and II of the verbal memory task (CVLT) and no tasks including complex nonverbal material were administered within part I and II of the nonverbal memory task (RCFT). The two tasks requiring verbal memory, CVLT and Directed Forgetting, were always presented with the largest possible time interval in between to minimize interference effects. Following these guidelines four different test sequences were established (see Appendix C). For illustration, Table 2.1 gives an overview of the potential course of a test session.

Table 2.1

Overview of the Potential Course of a Test Session

Test Sequence	Cognitive Function(s) Investigated by the Test
1) Directed Forgetting	Cognitive inhibition
2) OAT	Executive functioning (establish and maintain mental set)
3) WAIS-R-Digit Span	Auditory short-term memory for digits
4) Tower of Hanoi	Executive functioning (planning and problem solving)
5) WMS-III-Spatial Span	Spatial short-term memory
6) RCFT (Part I)	Complex visuospatial abilities, nonverbal short-term memory, executive functioning (organization)
7) WAIS-R-Information	General knowledge
8) WAIS-R-Vocabulary	Verbal abilities
9) WAIS-R-Similarities	Abstraction and verbal abilities
10) Go-Nogo	Motor inhibition
11) RCFT (Part II)	Nonverbal long-term memory, recognition
12) CVLT (Part I)	Verbal short-term memory, executive functioning (organization)
13) WCST	Executive functioning (set-shifting abilities, feedback learning)
14) WAIS-R Block Design	Basic visuo-constructive abilities
15) CVLT (Part II)	Verbal long-term memory, recognition

3 Study 1: Motor Inhibition in Trichotillomania and Obsessive-Compulsive Disorder

Antje Bohne

Sabine Wilhelm

Cary R. Savage

Thilo Deckersbach

Massachusetts General Hospital/Harvard Medical School, Boston, USA

Brunna Tuschen-Caffier

University of Siegen, Germany

Nancy J. Keuthen

Massachusetts General Hospital/Harvard Medical School, Boston, USA

a version of this manuscript is submitted for publication

3.1 Abstract

We investigated motor inhibition in TTM and OCD, two disorders characterized by repetitive, intentionally performed behaviors. Performance in a GoNogo experiment of 25 TTM and 21 OCD participants was compared to the performance of 26 HC participants. In contrast to OCD and HC participants, TTM participants tended to perform either 'fast and inaccurate' (indicating poor motor inhibition) or 'slow and accurate'. TTM participants with poor motor inhibition performance reported a significantly earlier age at TTM onset than those TTM participants who performed well. There was no evidence for motor inhibition deficits in OCD. Based on our data, a subgroup of TTM sufferers seems to be characterized by motor inhibition deficits.

3.2 Introduction

OCD and TTM are both characterized by repetitive, intentionally performed behaviors that cause significant distress or functional impairment. In OCD, (behavioral and/or mental) compulsions are triggered by intrusive anxiety- or discomfort-provoking thoughts (obsessions). Compulsions are mainly performed to 'neutralize' obsessive thoughts and consequently lessen associated anxiety or discomfort (APA, 1994, p. 417-423). Accordingly, OCD is currently classified as an anxiety disorder. In contrast, the repetitive behavior in TTM is mainly caused by an uncontrollable urge or impulse to pull one's hair accompanied by pleasure, relief or gratification (APA, 1994, p. 350-351). Unlike OCD, TTM is, thus, currently classified as an impulse-control disorder.

Due to phenomenological and neurobiological similarities to OCD, however, several researchers have suggested that TTM might be better conceptualized as an OC spectrum disorder (Jenike, 1989; Stein, 2000; Swedo & Leonard, 1992). Neurobiological studies, for example, implicate prefrontal cortex dysfunction in both disorders (for OCD: e.g., Baxter et al., 1987; Purcell, Maruff, Kyrios, & Pantelis, 1998a; Rauch et al., 1994; Tallis, 1997; for TTM: Keuthen et al., 1996; O'Sullivan et al., 1997; Rettew et al., 1991; Swedo et al., 1991). Among other cognitive functions, the prefrontal cortex supports adaptation to environmental changes by inhibiting an inherent response tendency, which allows an individual to make appropriate choices under varying conditions (Konishi et al., 1999). In accordance, animals and patients with frontal lobe lesions have been found to be characterized by a selective disturbance in the ability to suppress responses to irrelevant stimuli (Diamond, 1990; Stuss & Benson, 1983).

Based on this evidence, it has been suggested that OCD, much more thoroughly investigated than TTM, is secondary to dominant frontal dysfunction with a loss of normal inhibitory processes. These failures in inhibition have been presumed to lead to intrusive thoughts (obsessions) and, consequently, to compulsions (Flor-Henry, 1983). A similar etiology

can be hypothesized for TTM, with inhibition deficits (possibly originating from frontal dysfunction) lowering the ability to resist impulses or urges to pull hair. Deficits in fundamental inhibition abilities, therefore, can theoretically underlie both disorders.

It has been hypothesized that there are two different processes of inhibition, which are not necessarily related: the inhibition of cognitive material and the inhibition of motor activity (Harnishfeger, 1995; Ozonoff, Strayer, McMahon, & Filloux, 1998). This hypothesis is supported by the anatomic organization of frontal-striatal brain systems, implicated in OCD and TTM. Specifically, there are at least five parallel, anatomically segregated, frontal-subcortical circuits supporting distinct functions: a motor, an oculomotor, two different cognitive, and an affective motivational circuit (Cummings, 1993; Rauch & Savage, 1997). Thus, impairments in cognitive inhibitory functioning can conceivably occur with intact motor inhibitory functioning, and vice versa. In OCD, which is primarily characterized by intrusive thoughts, particularly *cognitive* inhibition deficits can be expected. Following this rationale, several studies have provided evidence for an OCD related deficit in inhibition of cognitive material (e.g., Enright & Beech, 1993a, 1993b; see also Study 2).

Based on the idea that compulsions in OCD are secondary to intrusive thoughts, motor inhibition deficits would not necessarily be expected; however, they might be possible. To date, few studies have investigated motor inhibition abilities in OCD, and existing data give a mixed picture. Two studies found abnormal neural activity associated with the inhibition of motor responses in OCD (Greenberg et al., 2000; Johannes et al., 2001). In addition, two studies testing oculomotor response inhibition in OCD participants found evidence for deficits in this aspect of functioning (Rosenberg, Averbach, et al., 1997; Rosenberg, Dick, O'Hearn, & Sweeney, 1997). Manual motor inhibition studies collecting behavioral data (i.e. reaction times and number of errors), however, did not indicate deficits in OCD (Beers et al., 1999; Johannes et al., 2001; Martin et al., 1993).

Thus, previous studies in OCD give evidence for motor inhibition deficits on a neural level but not consistently on a behavioral level. Deficits have been found in oculomotor inhibition but not in manual motor inhibition. These results may be interpreted with caution, though, since the studies were either limited by small sample sizes (Greenberg et al., 2000; Johannes et al., 2001; Rosenberg, Averbach, et al., 1997; Rosenberg, Dick, et al., 1997), or based on a relatively small number of behavioral trials (Martin et al., 1993), or included participants of a restricted age range (Beers et al., 1999; Rosenberg, Averbach, et al., 1997).

In contrast to OCD, *motor* inhibition deficits may be primarily expected in TTM. This disorder is essentially characterized by repetitive hairpulling, which sufferers feel driven to perform because of the pleasure it provides or other reinforcing immediate consequences (Mansueto et al., 1997). Weak resistance has accordingly been found to be associated with higher symptom severity in TTM, which is contrary in OCD (Keuthen, O'Sullivan, & Sprich-Buckminster, 1998; Stanley, Prather, Wagner, Davis, & Swann, 1993). Although thoughts have been reported to trigger hairpulling on occasion in some individuals, cognitions seem to play a minor role in the manifestation of the disorder (Mansueto et al., 1997; Stanley et al., 1992; Stein et al., 1995; Tükel et al., 2001). Accordingly, to date, no cognitive inhibition impairments have been documented for TTM (see Study 2).

To our knowledge, only one study so far has tested motor inhibition in TTM (Martin et al., 1993). In this study, motor inhibitory functioning was investigated using a GoNogo task, a task in which humans and animals with frontal lobe lesions have been found to perform poorly (Drewe, 1975; Malloy, Webster, & Russell, 1985; Rosenkilde, 1979). In this task participants are asked to react to the presentation of a predefined stimulus (the 'GO' signal) by performing a simple motor response, generally pressing a button, and to inhibit responding when another predefined stimulus (the 'NOGO' signal) is presented. The GoNogo task is thought to be simple

enough to be administered to psychiatric patients with even severe psychopathology (Malloy, Rasmussen, Braden, & Haier, 1989).

Behavioral data collected on the GoNogo task are generally reaction times and number of errors. Two types of errors can be distinguished: false negatives (failing to respond to the GO stimulus) and false positives (failing to inhibit a response to the NOGO stimulus). Patients with frontal lobe lesions have been found to make more errors and relatively more false positives than HC participants, which have been reported to make more errors of the false negative type (Drewe, 1975). Studies conducting the GoNogo with HC participants found reaction times on NOGO trials (false positive errors) to be significantly shorter than reaction times on GO trials (hits), which indicates that false positive reactions are quick guesses or premature responses (Falkenstein, Hoormann, & Hohnsbein, 1999; Falkenstein, Koshlykova, Kiroj, Hoormann, & Hohnsbein, 1995). Based on this evidence, false positive reactions in the GoNogo task are generally interpreted as an indicator of deficient motor inhibition ability.

In the GoNogo study of Martin et al. (1993), performance of individuals suffering from TTM was compared to data from OCD and HC participants. No motor inhibition deficits were found in TTM (or in OCD). However, the results may be interpreted cautiously given that the study has several limitations. Only 11 participants suffering from TTM were tested. In addition, few behavioral trials were conducted (3 GoNogo conditions with 24-48 experimental trials each) which makes it unlikely that a strong reaction tendency (required to maximally stress inhibitory functions) had built up. Furthermore, analysis of the indicator of motor inhibition ability (number of false positive reactions) was limited by a ceiling effect indicating that the task was too easy for the participants (likely due to the experimental design lacking time pressure to provoke false positive responses). In addition, the statistical analysis was limited given that the three participant groups were only compared on means and standard deviations of reaction time and number of false positive responses.

The present study was conducted to further examine motor inhibition abilities in TTM and OCD. A GoNogo experiment was designed to investigate motor inhibitory functioning. We hypothesized that individuals suffering from TTM would distinguish themselves from HC participants by inflated impulsivity characterized by motor inhibition deficits in the GoNogo task. Specifically, TTM participants were expected (a) to make more errors of the false positive type (indicator of deficient motor inhibition) than of the false negative type. In addition, we expected (b) that TTM participants would be characterized by a 'fast and inaccurate' (i.e. impulsive) performance. We further hypothesized that individuals with OCD would show normal motor inhibition abilities. In other words, we expected OCD participants' to perform comparably to HC participants.

3.3 Methods

3.3.1 Participants

Seventy-two individuals were tested: 25 individuals suffering from TTM, 21 individuals suffering from OCD, and 26 HC individuals. Clinical diagnoses for TTM and OCD participants, as well as the diagnostic status of HC participants, were determined using the SCID (First et al., 1995). Participants with a history of significant head injury, neurological disorder, psychosis, mental retardation, or alcohol or substance dependence were excluded from study participation. Individuals with current alcohol or substance abuse were also excluded, as were individuals who suffered from both TTM and OCD. Medicated participants had to be stable on medication for at least two weeks prior to the test session.

TTM group. In the TTM group, 22 (88.0%) participants were female. Mean age was 38.0 years (*SD* = 12.6), and the average number of years of education was 17.8 (*SD* = 2.6). Participants in this group met DSM-IV criteria for TTM with the exception of 3 (12.0%) individuals who did not meet criterion B (rising tension before or when attempting to resist

hairpulling) and/or criterion C (pleasure, gratification or relief when pulling out hair). These criteria are often not endorsed by people suffering from clinically significant hairpulling (Christenson, Mackenzie, et al., 1991; Schlosser et al., 1994), which has led to a recommendation for their exclusion from the diagnostic criteria for TTM (Keuthen, O'Sullivan, & Sprich-Buckminster, 1998). The mean age of onset was 13.4 years (*SD* = 4.6) with an average symptom duration of 24.6 years (*SD* = 13.9).

Eight (32.0%) TTM participants suffered from current Axis-I comorbid diagnoses including social phobia (*n* = 4), specific phobia (*n* = 3), major depressive disorder (MDD; *n* = 2), eating disorder NOS (*n* = 1), body dysmorphic disorder (BDD; *n* = 1), generalized anxiety disorder (GAD; *n* = 1), panic disorder with agoraphobia (*n* = 1), and post traumatic stress disorder (*n* = 1; PTSD). Five (20.0%) TTM participants took psychoactive medication including sertraline (*n* = 3), citalopram (*n* = 1), fluoxetine (*n* = 1), and venlafaxine (*n* = 1).

OCD group. In the OCD group, 11 (52.4%) participants were female. Mean age was 33.0 years (*SD* = 7.8), and the average number of years of education was 17.2 (*SD* = 3.5). All participants in this group met DSM-IV criteria for OCD. The mean age of OCD onset was 16.8 years (*SD* = 7.7) with an average symptom duration of 16.1 years (*SD* = 10.4).

Eleven (52.4%) OCD participants suffered from current Axis-I comorbid diagnoses including social phobia (*n* = 5), BDD (*n* = 4), MDD (*n* = 3), specific phobia (*n* = 1), GAD (*n* = 1), and PTSD (*n* = 1). Thirteen (61.9%) OCD participants took psychoactive medication including fluvoxamine (*n* = 5), sertraline (*n* = 4), fluoxetine (*n* = 2), alprazolam (*n* = 1), buspirone (*n* = 1), citalopram (*n* = 1), clonazepam (*n* = 1), paroxetine (*n* = 1), and risperidone (*n* = 1).

HC group. In the HC group, 16 (61.5%) were female. Mean age was 35.0 years (*SD* = 10.6), and the average number of years of education was 18.3 (*SD* = 4.1). Participants in this

group did not meet criteria for any current or past psychiatric diagnosis and were not taking psychoactive medication.

Between-group comparisons. The participant groups did not differ significantly with regard to mean age, $F(2, 69) = 1.29$, $p = .28$, or mean number of years of education, $F(2, 69) = 0.55$, $p = .58$. The TTM group, however, differed significantly from the HC and OCD group in regard to the male-female ratio (using Cohen's test for differences between proportions; Cohen, 1988, pp. 179-213), $h_s > .62$, $n' = 25$, $p < .05$. The significant difference reflects the reported predominance of females in the TTM patient population in contrast to a more balanced gender distribution in OCD (Himle, Bordnick, & Thyer, 1995; Keuthen, O'Sullivan, & Sprich-Buckminster, 1998; Stein et al., 1995). Compared to OCD participants, TTM participants showed a trend towards a lower age at onset, $t(32) = -1.78$, $p = .09$, and reported a significantly longer illness duration, $t(44) = 2.29$, $p < .05$.

3.3.2 Measures

All participants completed several self-report scales and were administered tests of verbal ability and attention span.

Scales. The Massachusetts General Hospital Hairpulling Scale (MGH-HS; Keuthen et al., 1995) was included to measure the presence and severity of symptoms of repetitive hairpulling. Obsessive-compulsive symptom severity was assessed using the Yale-Brown Obsessive Compulsive Scale (YBOCS; Goodman et al., 1989a). The Beck Depression Inventory (BDI; Beck & Steer, 1987) measured the presence and severity of depressive symptoms. The State Trait Anxiety Inventory (STAI; Spielberger et al., 1983) was included to assess the current (state) level of anxiety (STAI-S) and the general (trait) level of anxiety (STAI-T). The Edinburgh Handedness Inventory (EHI; Oldfield, 1971) assessed an individual's handedness.

Verbal intelligence and attention span measures. Wechsler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1981) subtests including Information, Vocabulary, and Similarities were used to estimate general verbal abilities. The subtests Information and Vocabulary were presented in an abbreviated format (previously documented in Cabrera et al., 2001). Span of verbal attention was measured using the Digit Span subtest of the WAIS-R. The Spatial Span subtest of the Wechsler Memory Scale - Third Edition (WMS-III; Wechsler, 1997) was included to measure span of nonverbal attention.

3.3.3 Procedure

Participants were recruited from outpatient clinics at the Massachusetts General Hospital, Boston, USA, and through advertisements in newsletters and flyers in local public libraries. At the beginning of a test session, all participants were informed of the study goals and written informed consent was obtained. DSM-IV diagnoses were then assessed using the SCID. The subtests of the WAIS-R and WMS-III (approximately 20-30 minutes) and the GoNogo task described below (approximately 15 minutes) were subsequently administered. At the end of the test session, participants were asked to fill out the questionnaire package (approximately 30 minutes). Participants were tested individually.

GoNogo experiment. The computerized GoNogo task included a practice block and two test blocks. At the beginning of each block, a GO and a NOGO stimulus were defined. Participants were instructed to press the spacebar on the keyboard as quickly as possible whenever they saw the GO stimulus and to refrain from pressing the spacebar whenever they saw the NOGO stimulus (see Appendix D). Participants took as much time as needed to read and understand the instructions, and questions were answered by the investigator. Participants were asked to use the index finger of their dominant hand and to rest it on the spacebar throughout the experiment (to avoid unintentional delays in reaction time).

Stimuli were presented on a computer screen in a pseudo-randomized order. Within the practice block 16 stimuli were presented. In this block, a green square served as the GO and a red square as the NOGO stimulus. Within each of the two test blocks 160 stimuli were presented. In these blocks, the letters 'X' and 'O' were chosen as the experimental stimuli. The presentation of the GO stimulus was increased to 75%, to build up a strong response tendency which challenges the inhibitory functions and increases the likelihood of false positive responses (Low & Miller, 1999). Hence, 120 GO and 40 NOGO stimuli were presented in each test block. Each stimulus was presented for 500 ms with a mean inter stimulus interval (ISI) of 1500 ms. The ISI varied between 1050, 1350, 1650, and 1950 ms with equal probability and presented in a pseudo-randomized order to prevent anticipatory responses (Martin et al., 1993). A moderate time pressure was induced by a feedback tone presented if a participant failed to respond within the response window of 500 ms. Participants were instructed to avoid the feedback tone at the risk of committing errors. Speed of decision was stressed in the instruction in order to enhance the participant's tendency to respond to the NOGO stimulus (the indicator of motor inhibitory dysfunctioning; Konishi et al., 1999).

Two types of errors were recorded: false positives (failures to inhibit responses to the NOGO stimulus) and false negatives (failures to respond to the GO stimulus within the response window). Reaction times (RT) were recorded separately for GO (hits) and NOGO (false positive) responses.

3.3.4 Statistics

Analyses of variance and Bonferroni correction were computed to analyze between-group differences. Paired t-tests were used to investigate within-group differences. To compare subgroups with small sample sizes non-parametric tests were chosen: for between-group comparisons the Mann-Whitney U-test, and for within-group comparisons the Wilcoxon test.

Effect sizes (Cohen's *d*) were also calculated. Pearson correlations were calculated to study relations between metric variables. Between-group differences in correlation coefficients were analyzed for significance using Fisher-Z transformations and following the instructions of Bortz (1989, pp. 259-269). Differences between proportions were analyzed following the suggestions of Cohen (1988, pp. 179-213). An alpha level of .05 was used for all statistical tests. Reported values for probability (*p*) are two-tailed unless otherwise indicated.

3.4 Results

3.4.1 Symptom Severity, Verbal Intellectual Abilities, and Attention Span

Scale scores indicated that TTM participants on average suffered from hairpulling of moderate severity (MGH-HS: $M = 13.7$, $SD = 5.2$), were minimally depressed (BDI: $M = 8.7$, $SD = 7.2$) and had a moderate general level of anxiety (STAI-T: $M = 46.2$, $SD = 12.2$). Their level of anxiety in the test situation was mild to moderately high (STAI-S: $M = 35.5$, $SD = 8.6$). Similarly, OCD participants suffered from moderate OCD symptoms (YBOCS: $M = 17.9$, $SD = 5.2$), were minimally depressed (BDI: $M = 9.1$, $SD = 7.2$), reported a moderate general level of anxiety (STAI-T: $M = 46.3$, $SD = 11.9$) and experienced mild to moderate anxiety in the test situation (STAI-S: $M = 37.4$, $SD = 11.2$). The HC participants' depression, trait and state anxiety symptom scores were minimal (BDI: $M = 1.5$, $SD = 1.7$; STAI-T: $M = 29.3$, $SD = 6.6$; STAI-S: $M = 27.3$, $SD = 6.0$). Clinical groups scored significantly higher than the HC group in depression, $F(2, 69) = 13.28$, $p < .001$, trait anxiety, $F(2, 69) = 23.18$, $p < .001$, and state anxiety scores, $F(2, 64) = 9.10$, $p < .001$, with no significant differences between the TTM and OCD group, all $p = 1.0$.

According to the EHI, 22 (88.0%) of the TTM participants, 18 (85.7%) of the OCD participants, and 24 (92.3%) of the HC participants were right-handed with no significant differences between the groups in the proportion of right-handers, $h_s < .26$, $n' = 23$, $p > .10$. No

significant group differences were found in the WAIS-R subtests Information, Vocabulary, Similarities and Digit Span, or in the WMS-III subtest Spatial Span, all $p > .15$. Thus, all three groups were comparable on handedness, estimated general verbal intellectual abilities, as well as verbal and nonverbal attention span.

3.4.2 Motor Inhibition

Groups did not differ significantly in average RT, neither for GO responses, $F(2, 69) = 0.72$, $p = .49$, nor for NOGO responses, $F(2, 67) = 1.40$, $p = .26$. In all groups, the average RT for responses to the NOGO stimulus (false positive reactions) was significantly shorter than for responses to the GO stimulus, all $p < .005$, all $d > 0.75$, indicating that NOGO responses were quick guesses or premature responses, and may be seen as an indicator for deficient motor inhibition.

Group means and standard deviations of errors made in the GoNogo task are presented in Table 3.1. There were no significant differences between the three groups with respect to the total numbers of errors, $F(2, 69) = 0.15$, $p = .87$, the number of false positives, $F(2, 69) = 0.26$, $p = .78$, or the number of false negatives, $F(2, 69) = 0.82$, $p = .45$. To test our hypothesis that TTM participants, in contrast to HC (and OCD) participants, would make more errors of the false positive than of the false negative type, we computed paired t-tests. The number of false positive and false negative errors did not differ significantly within the HC participants, $t(25) = -.73$, $p = .47$, or OCD participants, $t(20) = -.30$, $p = .77$. TTM participants, however, showed a trend towards significance to make more errors of the false positive than of the false negative type, $t(24) = 1.59$, $p = .06$ (one-tailed), representing a small-to-medium effect, $d = 0.44$.

Over all groups, male and female participants did not differ significantly in the total number of errors, $t(70) = .83$, $p = .41$, or number of false positives, $t(70) = .24$, $p = .81$. In addition, neither total number of errors nor number of false positives were significantly related

to BDI, STAI-S, or STAI-T scores, -.09 < *r*s < .05. Moreover, in the clinical group, consisting of both TTM and OCD participants, symptom duration and age at onset were not significantly correlated with the total number of errors or the number of false positives, -.07 < *r*s < .05. Thus, accuracy of performance in general and number of impulsive errors in specific did not seem to depend on gender, severity of depressive or anxiety symptoms, symptom duration, or age at onset, per se.

In the HC group, RT and total number of errors were significantly positively related, $r(26) = .41$, $p < .05$, indicating that these participants performed on a continuum ranging from 'short RT with few errors' (i.e. fast and accurate performance) to 'long RT with many errors' (i.e. slow and inaccurate performance). In the OCD group, RT and total number of errors were also positively correlated with a trend towards significance, $r(21) = .40$, $p = .08$. In contrast, a negative correlation of RT and total number of errors was found in the TTM group, $r(25) = -.26$, $p = .21$. Correlation coefficients were transformed into Fisher-Z values and analyzed for significant between-group differences (Bortz, 1989, pp. 259-269). The 'RT by total number of errors' correlation coefficient of the TTM group differed significantly from the coefficient in the HC group, $z = -2.36$, $p < .05$, and from the coefficient in the OCD group, $z = -2.17$, $p < .05$ (see also Figure 3.1).

Focusing specifically on impulsive errors, the negative relationship of speed and accuracy in the TTM group became even greater. In TTM participants, the correlation coefficient of average RT and the number of false positive errors was significantly negative, $r(25) = -.41$, $p < .05$, indicating that these participants performed on a continuum ranging from 'short RT with many impulsive errors' (i.e. fast and inaccurate performance) to 'long RT with few impulsive errors' (i.e. slow and accurate performance). Correlation coefficients of average RT and number of false positives in the HC group, $r(26) = -.17$, $p = .40$, and OCD group, $r(21) = -.16$, $p = .50$, were also negative but low and nonsignificant.

In summary, the performance of HC and OCD participants appeared to range on a continuum from 'fast and accurate' (i.e. task competent) to 'slow and inaccurate' (i.e. task incompetent). In contrast, TTM participants seemed to perform either 'fast and inaccurate' (i.e. impulsive) or 'slow and accurate' (i.e. cautious).

Based on this finding, we created, post hoc, two extreme groups of TTM participants using median splits. The first subgroup (n = 9) included those individuals who belonged to the 50% with the lowest average RT as well as to the 50% with the highest number of false positives (i.e. impulsive TTM participants). The second subgroup (n = 9) included those individuals who belonged to the 50% with the highest average RT as well as to the 50% with lowest number of false positives (i.e. cautious TTM participants).

See Table 3.2 for means and standard deviations of GoNogo and illness related indices for the two extreme groups. Based on Mann-Whitney U-tests, the two TTM subgroups differed significantly in average RT, U = 0.0, n = 18, p < .001, d = 3.28, and number of false positive errors, U = 0.0, n = 18, p < .001, d = 1.86, but not in the number of false negative errors, U = 35, n = 18, p = .66. Within-group comparisons using the Wilcoxon test revealed that 'fast and inaccurate' (i.e. impulsive) TTM participants made significantly more errors of the false positive than of the false negative type, Z = -2.43, n = 9, p < .05, representing a large effect, d = 1.12. In contrast, 'slow and accurate' (i.e. cautious) TTM participants made significantly more errors of the false negative than of the false positive type, Z = -1.96, n = 9, p = .05, again representing a large effect, d = 1.05.

Between-group comparisons of illness related indices revealed a significant difference in age at onset between the two TTM extreme groups, U = 16.0, n = 18, p < .05 (see also Table 3.2). Individuals with a 'fast and inaccurate' performance (impulsive TTM participants) reported a significant earlier age at onset than those with a 'slow and accurate' performance (cautious TTM participants). The corresponding effect was large, d = 1.00. Between-group

differences in self-reported MGH-HS scores were not statistically significant, $U = 26.0$, $n = 18$, $p = .22$, although representing a medium effect, $d = 0.53$. Between group differences in symptom duration were not significant, $U = 38.5$, $n = 18$, $p = .86$.

3.5 Discussion

The data partly support our hypotheses of motor inhibition deficits in TTM. In contrast to HC and OCD participants, TTM participants in general showed a trend to make more impulsive errors (i.e. false positives) than omission errors (i.e. false negatives). The effect was, however, only small-to-medium. Furthermore, TTM individuals were found to perform on a continuum ranging from 'fast and inaccurate' (i.e. impulsive) to 'slow and accurate' (i.e. cautious), while the performance of individuals in the HC and OCD group ranged on a continuum from 'fast and accurate' (i.e. task competent) to 'slow and inaccurate' (i.e. task incompetent). Thus, the TTM group appeared to be distinguished from the HC (and the OCD) group by the type of relationship between speed and accuracy of performance in the GoNogo task.

There is also evidence that the TTM participants' motor inhibition performance was not homogeneous. Only some of the TTM sufferers were characterized by motor inhibition deficits, making significantly more impulsive errors than omission errors. Others, in contrast to our initial hypothesis, were behaving extremely cautiously, making significantly more omission than impulsive errors. In post hoc analyses, we found that TTM participants with an extremely 'impulsive' and those with a distinct 'non-impulsive' (cautious) performance differed significantly in age at onset. Our data indicate that an earlier age at onset of TTM goes along with greater impulsivity. Differences in self-reported severity of hairpulling and symptom duration between 'impulsive' and 'non-impulsive' TTM participants were not significant. However, we cannot rule out the possibility that the statistically non-significant finding with

respect to self-reported symptom severity simply reflects a lack of statistical power. A medium sized effect indicates that impulsive TTM participants feel less severely disturbed by their hairpulling symptoms than their non-impulsive counterparts.

Thus, our data suggest that TTM is a heterogeneous disorder with respect to impulsivity, which seems to be related to age at onset. This interpretation might give evidence for the common distinction of an early and a late onset type of TTM (Jaspers, 1996). One might hypothesize that impulsivity, as a personal characteristic, might lead to earlier onset hairpulling, while the development of repetitive hairpulling at a later age at onset might be for 'non-impulsive' reasons. Alternatively, an early onset of hairpulling might impede the development, elaboration or preservation of sufficient motor inhibitory functioning. It is also possible that impulsivity and age at onset may independently co-occur, with no direct causal relationship. One may speculate, for example, that early onset TTM might be mediated by the presence of a developmental disorder, like attention-deficit hyperactivity disorder (ADHD). This interpretation would be backed by preliminary findings of a 25% prevalence of ADHD in adolescents with TTM (King et al., 1995). Sample numbers in our two extreme TTM groups are too small to draw final conclusions, and additional studies are needed to further investigate motor inhibitory functioning in TTM. Based on our data, it seems critical for both research and clinical practice to be aware of a potential motor inhibition deficit in some TTM sufferers, as well as its possible mediators and consequences.

Our data provide no evidence for impaired motor inhibition abilities in individuals suffering from OCD, who seemed to perform in our GoNogo experiment like HC participants. Given that our sample with 21 or more participants per group provided 80% power to detect a large effect, the lack of finding statistically significant differences between the OCD and HC group does not simply seem to be a power issue. Thus, in contrast to TTM, OCD did not appear to be characterized by motor inhibition deficits. This finding may indicate that compulsions in

OCD are not due to *motor* inhibition deficits, but secondary to intrusive thoughts probably resulting from primary *cognitive* inhibition deficits (Enright & Beech, 1993a, 1993b; see also Study 2).

However, previous studies investigating neural data (Johannes et al., 2001; Greenberg et al., 2000) or 'oculomotor' motor inhibition performance (Rosenberg, Averbach, et al., 1997; Rosenberg, Dick, et al., 1997) found evidence for motor inhibition abnormalities in OCD. One possible reason for the discrepant findings might be that neural processes associated with motor inhibition are abnormal in OCD but not severe enough to affect the actual behavior (or at least not to a measurable extent). In other words, the findings might be due to a higher sensitivity of neural than behavioral measures. In this case, the clinical relevance of abnormal neural processes in OCD, which do not provoke a significant behavioral expression, would become debatable. Alternatively, the discrepant findings might indicate that OCD is characterized by impairments in the 'oculomotor' frontal-subcortical circuit but not in the anatomically segregated 'motor' circuit (Cummings, 1993; Rauch & Savage, 1997). Additional OCD studies using differing tasks and collecting neural and behavioral data are needed to draw final conclusions and implications for clinical practice.

Regardless, our GoNogo data suggest abnormal motor inhibition performance in the TTM but not in the OCD group. Although the clinical groups differed significantly in symptom duration and gender proportion, the discrepant findings may not be better accounted for by these two variables. Gender as well as symptom duration (and age at onset), per se, were not found to affect accuracy of task performance. Thus, it seems most conclusive that motor inhibition abnormalities may be seen as a specific characteristic of TTM that is not shared by OCD.

It seems noteworthy, that neither TTM nor OCD participants differed from HC participants in speed or accuracy of performance, per se. Mean reaction time was about equal

for all groups and comparable to those reported in previous GoNogo studies with HC participants (Falkenstein et al., 1995, 1999). Hence, the OCD participants' performance did not seem to be characterized by 'obsessional slowness', a frequently reported characteristic of OCD (Hymas, Lees, Bolton, Epps, & Head, 1991; Nelson, Early, & Haller, 1993; Purcell, Maruff, Kyrios, & Pantelis, 1998b), which has been hypothesized to account for impairments in (timed) neuropsychological tasks in this disorder (Christensen, Kim, Dysken, & Hoover, 1992). In this aspect, our data are consistent with previous reports that individuals suffering from OCD show normal simple reaction times (Martin et al., 1993; Tallis, 1997).

In accordance to findings from Rosenberg, Averbach, et al. (1997) and Rosenberg, Dick, et al. (1997), no significant correlation between accuracy of task performance (total number of errors or number of false positives) and depression, state or trait anxiety scores were found. Thus, even though clinical groups reported significantly more severe depression and anxiety symptoms than HC participants, these symptoms, per se, did not seem to be associated with diminished accuracy performance.

Taken together, simple comparisons of reaction times and total numbers of errors (or false positives) did not indicate motor inhibition deficits in OCD or TTM, which is in accordance with previous studies (Beers et al., 1999; Johannes et al., 2001; Martin et al., 1993). However, further analyses of the relationship of speed and accuracy in the GoNogo task, revealed significant differences in motor inhibitory performance between TTM and HC participants. Moreover, the more complex analyses provided evidence for a heterogeneous performance in the TTM group with some TTM participants showing a very impulsive performance in contrast to others who performed very cautiously.

All in all, our data do not support the conceptualization of TTM as an OC spectrum disorder based on similarities with OCD. There was at least no evidence of abnormalities shared by TTM and OCD sufferers with respect to motor inhibitory functioning. Our data

instead, support the classification of TTM as an impulse-control disorder in at least a subgroup of TTM sufferers showing motor inhibition deficits leading to impulsivity. However, there seems to be an opposite subgroup of TTM sufferers showing a cautious (risk avoiding) type of behavior which challenges the current classification of TTM. In this light, suggestions of a dimensional classification, which propose to organize disorders like TTM and OCD on an impulsivity-compulsivity continuum (Higgins, 1996; McElroy, Phillips, & Keck, 1994; Ozonoff et al., 1998), seem advantageous.

There are some limitations of this study. While our groups did not differ with respect to age, education, handedness, verbal abilities, and attention span, there were more women in the TTM group than in the OCD and HC group, reflecting the preponderance of females in the TTM population. The reported data, however, support the notion that the main experimental effects are not due to gender variations between the groups. Another limitation of the study might be the presence of comorbidities in both the TTM and OCD groups. However, individuals with comorbid psychiatric disorders which are thought to potentially impact cognitive or motor functioning (e.g., psychosis, neurological disorders) were excluded from participation. In addition, our analyses revealed no evidence that depression or anxiety symptoms accounted for the results, indicated by null correlations of symptom questionnaire scores with accuracy of GoNogo performance. Moreover, both disorders are frequently accompanied by comorbid symptoms and our results might, therefore, resemble the impairment profiles of typical 'non-pure' TTM and OCD sufferers (excepting comorbid TTM and OCD sufferers). Finally, comparison of TTM subgroups are limited by small sample sizes. Thus, possible differences between 'impulsive' and 'non-impulsive' TTM sufferers (e.g., with respect to symptom severity) warrant further investigation.

If replicated, our findings of TTM heterogeneity might have important implications for treatment. TTM subtypes characterized by specific impairments might require differential

treatment strategies. Impulsive TTM sufferers, for example, might benefit from behavior therapy strategies that have successful in disorders that are characterized by repetitive behaviors elicited by an urge or impulse (like habit reversal in Tourette's disorder; Wilhelm et al., in press). TTM sufferers, however, who are not characterized by inflated impulsivity might need other treatment elements for improvement depending on the impairment profile characteristic for this subtype. Future research, thus, may further investigate the potential heterogeneity of TTM, the role of abnormal motor inhibitory functioning in differing subtypes, and its implications for successful treatment.

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Table 3.1

GoNogo Errors as a Function of Group and Error Type

	TTM (*n* = 25)		OCD (*n* = 21)		HC (*n* = 26)	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*
False positive errors	8.96	9.15	7.63	6.84	7.73	5.19
False negative errors	6.12	3.82	8.33	9.97	9.27	11.35

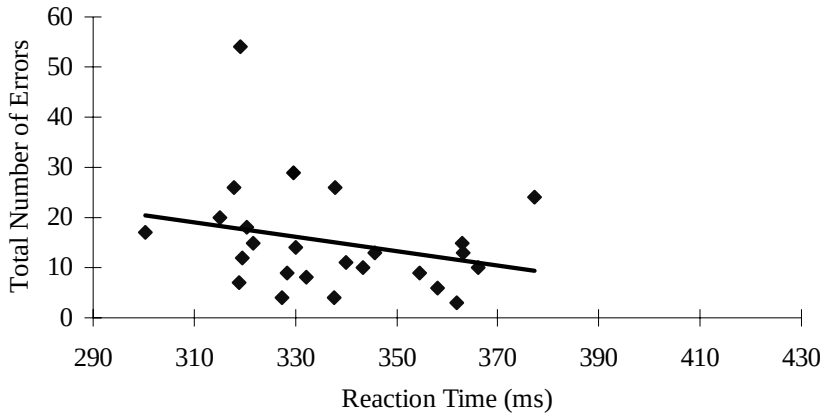
Table 3.2

GoNogo Errors and Demographic Variables as a Function of Trichotillomania Subtype

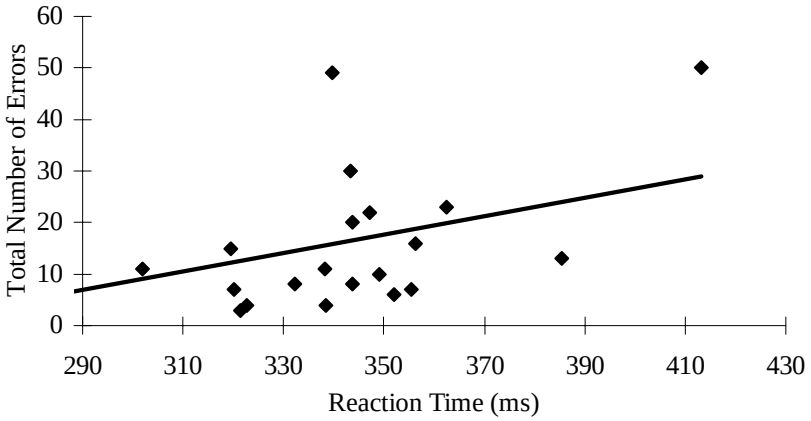
	Impulsive TTM (*n* = 9)		Cautious TTM (*n* = 9)	
Variable	*M*	*SD*	*M*	*SD*
False positive errors	15.78_a	11.76	3.11_a	1.90
False negative errors	7.00	3.97	5.89	3.41
Age at onset	11.33_a	2.59	15.78_a	6.29
MGH-HS score	11.72	4.31	14.56	6.43
Symptom duration (in years)	25.67	12.99	28.56	16.74

Note. MGH-HS = Massachusetts General Hospital Hairpulling Scale. Means in the same row that share subscripts differ significantly at $p < .05$.

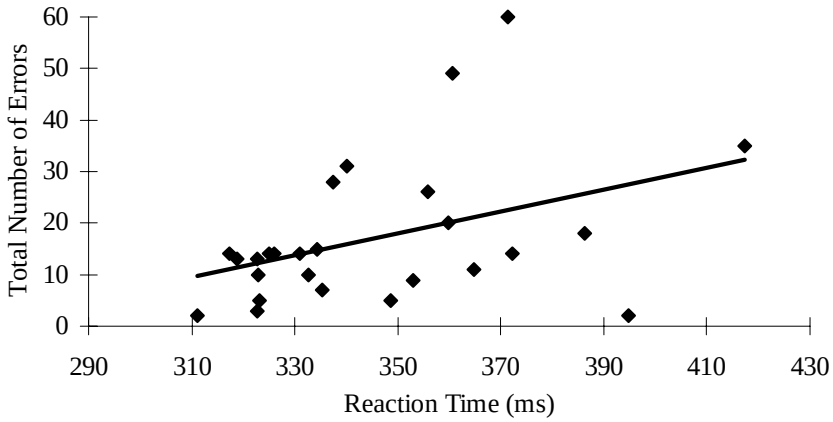
Figure 3.1. Scatter plots with trend line of speed by accuracy of performance in the GoNogo.



TTM Group



OCD Group



HC Group

4 Study 2: Cognitive Inhibition in Trichotillomania and Obsessive-Compulsive Disorder

Antje Bohne

Sabine Wilhelm

Massachusetts General Hospital/Harvard Medical School, Boston, USA

Brunna Tuschen-Caffier

University of Siegen, Germany

Nancy J. Keuthen

Massachusetts General Hospital/Harvard Medical School, Boston, USA

a version of this manuscript is submitted for publication

4.1 Abstract

Cognitive inhibition was investigated in 21 TTM, 21 OCD and 26 HC participants using a block cued directed forgetting task. After encoding a word list, participants were instructed to intentionally FORGET these words and to REMEMBER another word list. Both lists equally included negative TTM-related and neutral words. A superior free recall of REMEMBER versus FORGET words suggests intact cognitive inhibition. The performance of OCD participants indicated a specific deficit in inhibiting the retrieval of information with a negative valence. In contrast to TTM and OCD participants, HC participants were rather inattentive to negative information. In conclusion, although cognitive functioning abnormalities were found in both disorders, cognitive inhibition deficits appear specific to OCD.

4.2 Introduction

OCD and TTM are both characterized by repetitive, intentionally performed behaviors that cause significant distress or functional impairment. Although classified as an impulse-control disorder in DSM-IV (APA, 1994, p. 350-351), TTM has also been conceptualized as an OC spectrum disorder based on similarities with OCD (Jenike, 1989; Swedo & Leonard, 1992). Besides phenomenological similarities, similar responses to pharmacotherapy, and reports of increased rates of both TTM and OCD in the same families (Lenane et al., 1992; Stein et al., 1995), evidence exists for frontal lobe dysfunction in both disorders (for OCD, e.g., Baxter, 1992; Tallis, 1997; for TTM, e.g., O'Sullivan et al., 1997; Rettew et al., 1991).

Adequate frontal lobe functioning is necessary for the process of inhibition, which is thought to be crucial for efficient cognitive functioning (Wilson & Kipp, 1998). This assumption is based on theories that an individual's cognitive capacity is limited (e.g., Kahnemann, 1973) and that the effort spent on the processing of irrelevant information reduces the resources available for the processing of relevant information. Efficient cognitive functioning, therefore, requires the suppression of irrelevant information. Given evidence for frontal lobe dysfunction in TTM and OCD, one might question whether impairments in cognitive inhibition abilities exist, which might impede effective cognitive functioning in both disorders.

Based on the clinical picture, cognitive inhibition deficits seem especially likely in OCD. Several researchers have proposed that recurrent intrusive thoughts (obsessions) in OCD might be due to impaired cognitive inhibition abilities (Enright & Beech, 1993a; Steketee, Frost, Rhéaume, & Wilhelm, 1998). Because of the anxiety- and discomfort-provoking nature of obsessions, OCD sufferers try hard to control the intrusive thoughts by avoiding obsession-associated conditions or by performing repetitive behaviors or mental rituals (compulsions;

APA, 1994, p. 417-423). Thus, in OCD, compulsions might be interpreted as being secondary to obsessions, which might result from cognitive inhibition deficits.

In TTM, however, intrusive thoughts seem to play a minor role (Mansueto et al., 1997; Stanley et al., 1992; Stein et al.,1995; Tükel et al., 2001). In contrast to compulsions in OCD, repetitive hairpulling is thought to be mainly elicited by an irresistible urge or impulse accompanied by pleasure, relief or gratification when carrying out the desired activity (APA, 1994, p. 350-351). Correspondingly, TTM has been found to be related to abnormal motor inhibitory functioning (see Study 1). Cognitive inhibition deficits may, however, also be present in TTM.

The knowledge of whether cognitive inhibition impairments exist in each disorder illuminates its clinical picture and allows inferences about effective treatment strategies (e.g., cognitive therapy). To our knowledge, there has been no research to date on cognitive inhibition in TTM and limited investigation in OCD.

Inhibition studies in OCD have mainly focused on *unintentional* inhibition (e.g., using a negative priming paradigm; Enright & Beech, 1990, 1993a, 1993b; Enright, Beech, & Claridge, 1995; MacDonald, Antony, MacLeod, & Swinson, 1999; McNally, Wilhelm, Buhlmann, & Shin, 2001). The process of inhibition is called unintentional if irrelevant information is processed automatically when presented in combination with relevant information and is subsequently suppressed without reaching conscious awareness. Enright and colleagues found that individuals with OCD show impaired unintentional cognitive inhibition ability compared to anxiety control groups. Studies comparing OCD with HC individuals, however, did not reveal significant between-group differences (MacDonald et al., 1999; McNally et al., 2001). If unintentional inhibition deficits are present in OCD, previous studies indicate that these deficits are global rather than being conditional on emotional valence or threat relatedness of the material to be inhibited.

If an individual regards information as irrelevant and deliberately suppresses it, the inhibition is called intentional. Few studies have so far investigated this type of inhibition in OCD, although its clinical symptoms more readily suggest an intentional rather than an unintentional inhibition deficit. Given that even 'ordinary' people report intrusive thoughts similar to those in OCD but which differ in their frequency (Rachman & de Silva, 1978), it seems likely that OCD sufferers are not as good as other people in disregarding or suppressing these thoughts after they have reached conscious awareness (i.e. deficient *intentional* cognitive inhibition).

Different paradigms have been used to investigate intentional inhibition abilities in OCD. Two studies applied a thought suppression task (Janeck & Calamari, 1999; Tolin, Abramowitz, Przeworski, & Foa, 2002). Data from these studies give some evidence for an OCD specific impairment in intentional cognitive inhibition. An enhancement (rather than a reduction) in the occurrence of the to-be-suppressed thoughts was found in OCD, but not in HC or social phobia participants. Furthermore, findings from the two studies indicate that this deficit is global since suppression of both personally relevant negative material and neutral material appeared diminished in OCD. Conclusions regarding OCD specific deficits based on thought suppression data have to be drawn cautiously, however, since previous research suggests that explicit thought suppression instructions lead to paradoxical effects (i.e. increased rather than decreased frequency of the target thought) even in HC participants (Wegner, Schneider, Carter, & White, 1987). Neither Tolin and colleagues nor Janeck and Calamari were able to replicate this paradoxical effect in their HC participants, nor did they find significant differences between OCD and HC participants. Thus, it remains unclear whether the performance of OCD sufferers in thought suppression tasks can be interpreted as abnormal.

Another task that has been used to investigate intentional cognitive inhibition ability, and which is not known to produce paradoxical effects, is the directed forgetting (DF) paradigm

(Johnson, 1994). In this paradigm, several words are presented to be remembered with subsequent instructions to forget half of them. After presentation of the entire word list, memory is tested for all words irrespective of instruction. The so-called DF effect is defined by an enhanced memory for words instructed to be remembered (REMEMBER words) versus words instructed to be forgotten (FORGET words). Thus, the DF paradigm investigates the function of cognitive inhibition, which is to process and remember information probably useful in the future and to disregard or forget information that is not likely to be relevant. Impaired cognitive inhibition is suggested by a lack of DF effect.

At least two general DF methods are to be differentiated: item cued and block cued DF (Basden, Basden, & Gargano, 1993). In the item cued method, the presentation of each word is followed individually by either a remember or forget instruction. In this case, differential encoding (probably due to selective rehearsal) is thought to be the key factor for the DF effect (Wilson & Kipp, 1998). In contrast, in the block cued method a first list of words is presented followed by an unexpected forget instruction. A second list of words is subsequently presented with instructions to be remembered. The DF effect generated by the block cued method is thought to reflect successful retrieval inhibition or the intentional suppression of FORGET words (Johnson, 1994)

Two studies have tested DF in OCD so far, and both of them used the item cued method (Tolin, Hamlin, & Foa, 2002; Wilhelm et al., 1996). The data from Wilhelm et al.'s study indicated a specific intentional encoding inhibition deficit for words with a negative valence (in contrast to words with a positive or neutral valence) in OCD. However, no conclusions can be made as to whether emotional valence or OCD relevance was the key factor accounting for this deficit since the two factors were confounded in this study.

Tolin, Hamlin, et al. (2002) attempted to further investigate the factor 'personal relevance of stimulus material'. In their study, each OCD participant generated personally relevant and

non-relevant positive and negative OCD stimulus material, which was then presented to that individual, one yoked social phobia participant and one yoked HC participant in a DF experiment. OCD participants were found to recognize more 'relevant' FORGET words than the HC and anxious control groups. The authors interpreted their findings as indicating an OCD specific inability to intentionally forget personally relevant information. OCD relevance, rather than negative valence, was felt to be the key factor for this deficit.

This interpretation has to be handled with caution, however. While Tolin and colleagues should be complimented for their attempt to investigate the factor 'personal relevance of stimulus material' in cognitive inhibition, no conclusion can be drawn from their study (Tolin, Hamlin, et al., 2002) about the abilities of HC and anxiety controls to intentionally forget personally relevant words. 'OCD relevant words' generated by the OCD participants were 'personally relevant' to the OCD participants but 'personally non-relevant' to the non-OCD groups. Thus, one cannot conclude that the personal relevance effect is specific to OCD. Furthermore, it is unclear whether OCD participants recalled significantly more 'OCD relevant' than 'OCD non-relevant' FORGET words (lack of within-group comparison) which would be the indicator for a cognitive inhibition deficit specifically for OCD relevant words.

Thus, results from previous DF studies investigating OCD are equivocal. Both studies (Tolin, Hamlin, et al., 2002; Wilhelm et al., 1996) used an item cued design finding some evidence for an intentional encoding inhibition deficit (i.e. an inability to intentionally disregard specific information). It remains questionable whether this deficit in OCD is due to emotional valence, threat relevance or both. In addition, it is still unclear whether such a deficit is specific to OCD or more general to all anxiety or emotional disorders.

Overall, data from unintentional as well as intentional cognitive inhibition studies in OCD provide a mixed picture, but give some evidence for a cognitive inhibition deficit. Given that anxiety- or discomfort-provoking intrusive thoughts have been found to occur in all

humans, though more frequently in OCD sufferers than in other people (Rachman & de Silva, 1978), a specific deficit in intentional inhibition of negative threat relevant information seems to be especially likely in OCD. Besides the possible encoding inhibition deficit, retrieval inhibition might be impaired in this disorder. The clinical presentation of OCD suggests that they are unable to keep unpleasant information from being retrieved in situations in which this information is without relevance and/or clearly unwanted.

The current study aimed to investigate intentional cognitive retrieval inhibition in TTM and OCD. Performance of TTM participants in a DF experiment using negative TTM-related and neutral words was compared with HC and OCD groups. As an extension of previous research, inhibitory functioning in OCD was compared with both an HC and a clinical control group (TTM) using negative and neutral stimulus material, which was not primarily OCD relevant. To our knowledge, this is the first study investigating intentional retrieval inhibition abilities in OCD and TTM using a block cued DF design. The block cued DF method is thought to be advantageous compared to the item cued method because it allows investigation of intentional inhibition abilities not confounded by non-encoding or selective rehearsal (Wilson & Kipp, 1998).

In OCD, we hypothesized that cognitive inhibition impairments would exist as indicated by a relatively high recall of irrelevant information. Based on its phenomenology, we specifically hypothesized an inhibition deficit for words with a negative valence. Thus, in our DF experiment we expected OCD participants, in contrast to HC participants, to recall relatively more negative (TTM-related) FORGET words than neutral FORGET words. For TTM, we did not hypothesize cognitive inhibition deficits based on its clinical picture which, in contrast to OCD, is not characterized by intrusive thoughts.

4.3 Methods

4.3.1 Participants

Our sample (N = 68) consisted of 21 TTM, 21 OCD, and 26 HC individuals. Clinical diagnoses for TTM and OCD participants, as well as the diagnostic status of HC participants, were determined using the SCID (First et al., 1995). Participants with a history of significant head injury, neurological disorder, psychosis, mental retardation, or alcohol or substance dependence were excluded from study participation. Individuals with current alcohol or substance abuse were also excluded, as were individuals who suffered from both TTM and OCD. Medicated participants had to be stable on medication for at least two weeks prior to the test session. All participants spoke fluent English.

TTM group. Participants in the TTM group met DSM-IV criteria for TTM with the exception of 3 (14.3%) individuals who did not report rising tension before or when trying to resist the hairpulling (criterion B), and/or pleasure, gratification or relief when pulling out hair (criterion C). These criteria are often not endorsed by people suffering from clinically significant hairpulling (Christenson, Mackenzie, et al., 1991; Schlosser et al., 1994), which has led to a recommendation for their exclusion from the diagnostic criteria for TTM (Keuthen, O'Sullivan, & Sprich-Buckminster, 1998).

The mean age of the TTM participants was 38.0 years (*SD* = 12.1), and the average number of years of education was 17.7 (*SD* = 2.5). Nineteen (90.5%) TTM participants were female. The average age of TTM onset was 13.7 years (*SD* = 4.9) with a mean symptom duration of 24.3 years (*SD* = 14.1).

Seven (33.3%) TTM participants suffered from current Axis-I comorbid diagnoses including social phobia (*n* = 4), specific phobia (*n* = 3), MDD (*n* = 2), eating disorder NOS (*n* = 1), BDD (*n* = 1), GAD (*n* = 1), panic disorder with agoraphobia (*n* = 1), and PTSD (*n* = 1).

Four (19.0%) TTM participants took psychoactive medication including sertraline (n = 3), citalopram (n = 1), and venlafaxine (n = 1).

OCD group. All participants in the OCD group met DSM-IV criteria for OCD. The mean age was 32.8 years (SD = 8.1), and the average number of years of education was 17.2 (SD = 3.5). Eleven (52.4%) OCD participants were female. The mean age of OCD onset was 16.3 years (SD = 7.9) with an average symptom duration of 16.5 years (SD = 10.2).

Eleven (52.4%) OCD participants suffered from current Axis-I comorbid diagnoses including social phobia (n = 7), BDD (n = 4), MDD (n = 3), dysthymia (n = 1), GAD (n = 1), PTSD (n = 1), and specific phobia (n = 1). Thirteen (61.9%) OCD participants took psychoactive medication including fluvoxamine (n = 6), sertraline (n = 4), alprazolam (n = 1), buspirone (n = 1), citalopram (n = 1), fluoxetine (n = 1), paroxetine (n = 1), and risperidone (n = 1).

HC group. Participants of the HC group did not meet criteria for any current or past psychiatric diagnosis, and were not taking psychoactive medication. The mean age of this group was 35.0 years (SD = 10.6), and the average number of years of education was 18.3 years (SD = 4.1). Sixteen (61.5%) HC participants were female.

Between-group comparisons. The groups did not differ significantly with regard to mean age, $F(2, 65) = 1.31$, $p = .27$, or mean number of years of education, $F(2, 65) = 0.55$, $p = .58$. The TTM group, however, differed significantly from the HC and OCD group in regard to the male-female ratio (using Cohen's test for differences between proportions; Cohen, 1988, pp. 179-213), $h_s > .68$, $n' = 23$, $p < .05$. The significant difference reflects the reported predominance of females in the TTM patient population in contrast to a more balanced gender distribution in OCD (Himle et al., 1995; Keuthen, O'Sullivan, & Sprich-Buckminster, 1998; Stein et al., 1995). The clinical groups did not differ significantly in age of onset, $t(33) = -1.31$,

p = .20. TTM participants, however, reported a significantly longer illness duration than the OCD participants, $t(40) = 2.07$, $p < .05$.

4.3.2 Measures

All participants completed several self-report scales and were administered tests of verbal ability and attention span.

Scales. The Massachusetts General Hospital Hairpulling Scale (MGH-HS; Keuthen et al., 1995) was included to measure the presence and severity of symptoms of repetitive hairpulling. Obsessive-compulsive symptom severity was assessed using the Yale-Brown Obsessive Compulsive Scale (YBOCS; Goodman et al., 1989a). The Beck Depression Inventory (BDI; Beck & Steer, 1987) measured the presence and severity of depressive symptoms. The State Trait Anxiety Inventory (STAI; Spielberger et al., 1983) was included to assess the current (state) level of anxiety (STAI-S) and the general (trait) level of anxiety (STAI-T). The Edinburgh Handedness Inventory (EHI; Oldfield, 1971) assessed an individual's handedness.

Verbal intelligence and attention span measures. Wechsler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1981) subtests including Information, Vocabulary, and Similarities were used to estimate general verbal abilities. The subtests Information and Vocabulary were presented in an abbreviated format (previously documented in Cabrera et al., 2001). Span of verbal attention was measured using the Digit Span subtest of the WAIS-R.

4.3.3 Procedure

Participants were recruited from outpatient clinics at the Massachusetts General Hospital, Boston, USA, and through advertisements in newsletters and flyers in local public libraries. At the beginning of a test session, all participants were informed of the study goals and written informed consent was obtained. DSM-IV diagnoses were then assessed using the SCID. The

subtests of the WAIS-R (approximately 20 minutes) and the DF experiment described below (approximately 15-20 minutes) were subsequently administered. At the end of the test session, participants were asked to fill out the questionnaire package (approximately 30 minutes). Participants were tested individually.

Directed forgetting experiment. Four word lists were created (see Appendix E), each consisting of 14 words: 7 negative TTM-related words (e.g., 'balding'), and 7 NEUTRAL words (e.g., 'boiling'). The TTM words were selected based on suggestions generated from a survey of TTM sufferers and treating clinicians. NEUTRAL words were selected from the broad category 'kitchen'. The four generated lists did not differ significantly in average length of words with respect to the number of syllables and the number of letters, nor in the Kuçera-Francis (Francis & Kuçera, 1967) written frequency of words, all $F(3, 52) < 0.45$, all $p > .70$.

In the block cued DF procedure participants were instructed to memorize a list of words. Words were presented one at a time and in a pseudo-randomized order on a computer screen. Each word was presented for 2000 ms, the inter stimulus interval was 500 ms. After presenting the first list of words, the participants were instructed to forget these words, which were labeled 'practice' items, and to concentrate on memorizing a second list of words labeled 'actual test' list (see Appendix F). The selection and order of the two presented word lists was balanced across groups.

A numerical distractor task followed the presentation of the second word list to prevent selective rehearsal of REMEMBER words. Participants were instructed to cross out every digit '2' printed on a page containing 5000 digits. They were asked to work as quickly as possible without making mistakes. After a fixed time interval (3 minutes) the distractor task was interrupted. Participants then received a free recall and a recognition test (with a maximum of 5 minutes for each test) for all words irrespective of word list (i.e. REMEMBER as well as FORGET words). The recognition test consisted of 56 words: the 28 previously presented

words plus 28 new words (i.e. the two generated word lists not presented before). Finally, the participants were asked to rate each of the initially presented 28 words in terms of its personal emotional valence, from '-3 = very negative' to '+3 = very positive'.

4.3.4 Statistics

Analyses included 3 (group: TTM, OCD, HC) x 2 (instruction: REMEMBER, FORGET) x 2 (word type: TTM, NEUTRAL) ANOVAs with repeated measurement on the last two factors. We also conducted a 3 (group: TTM, OCD, HC) x 2 (free recall status: RECALL, NO-RECALL) ANOVA with repeated measurement on the last factor. The factor 'group' was between-subjects, the factors 'instruction', 'word type' and 'free recall status' were within-subjects. For further between-group analyses, univariate ANOVAs and Bonferroni correction were conducted. Paired t-tests were used to further explore within-group differences. Differences between proportions were analyzed following the suggestions of Cohen (1988, pp. 179-213). An alpha level of .05 was used for all statistical tests. Reported values for probability (p) are two-tailed. For significant differences and differences with a trend towards significance ($p < .10$) effect sizes (Cohen's d) were computed.

4.4 Results

4.4.1 Symptom Severity, Verbal Intellectual Abilities, and Attention Span

Self-report scale scores indicated that TTM participants suffered from hairpulling of moderate severity (MGH-HS: $M = 14.1$, $SD = 4.8$), were minimally depressed (BDI: $M = 9.3$, $SD = 7.5$) and had a moderate general level of anxiety (STAI-T: $M = 47.6$, $SD = 11.4$). Their level of anxiety in the test situation was mild to moderately high (STAI-S: $M = 35.9$, $SD = 8.2$). Similarly, OCD participants suffered from moderate OCD symptoms (YBOCS: $M = 17.4$, $SD = 5.6$), were minimally depressed (BDI: $M = 8.7$, $SD = 7.3$), reported a moderate general level of

anxiety (STAI-T: M = 46.7, SD = 11.4) and experienced mild to moderate anxiety in the test situation (STAI-S: M = 36.7, SD = 10.8). The HC participants' depression, trait and state anxiety scores were all minimal (BDI: M = 1.5, SD = 1.7; STAI-T: M = 29.3, SD = 6.6; STAI-S: M = 27.3, SD = 6.0). Clinical groups scored significantly higher than the HC group in depression, $F(2, 65) = 13.11$, $p < .001$, trait anxiety, $F(2, 65) = 26.37$, $p < .001$, and state anxiety scores, $F(2, 61) = 8.95$, $p < .001$, with no significant differences between the TTM and OCD group, all $p = 1.0$.

According to the EHI, 18 (85.7%) of the TTM participants, 18 (85.7%) of the OCD participants, and 24 (92.3%) of the HC participants were right-handed with no significant differences between the groups in the proportion of right-handers, $h_s < .26$, $n' = 23$, $p > .10$. No significant group differences were found in the WAIS-R subtests Information, Vocabulary, Similarities and Digit Span, all $p > .30$. Thus, all three groups were comparable on handedness, estimated general verbal intellectual abilities, and verbal attention span.

4.4.2 Free Recall

In free recall, a mean of 9.9 words (SD = 3.7) were correctly recalled and a mean of 1.3 words (SD = 1.3) were falsely remembered (i.e. intrusions). Table 4.1 gives an overview of the means and standard deviations of words correctly recalled depending on group (TTM, OCD, HC), instruction (REMEMBER, FORGET) and word type (TTM, NEUTRAL).

For the free recall data, a 3 (group: TTM, OCD, HC) X 2 (instruction: REMEMBER, FORGET) X 2 (word type: TTM, NEUTRAL) ANOVA with repeated measurement on the last two factors revealed a significant main effect of group, $F(2, 65) = 4.00$, $p < .05$, a significant main effect of instruction, $F(1, 65) = 5.30$, $p < .05$, and a significant interaction of word type X group, $F(2, 65) = 3.22$, $p < .05$. In addition, the interaction of instruction X word type X group showed a trend toward significance, $F(2, 65) = 2.82$, $p = .07$. There was no significant main

effect of word type, nor were the interaction of instruction X group or the interaction of instruction X word type significant, all $p > .30$.

The significant main effect of group suggests that groups differed in their general free recall ability. To further explore this effect, an univariate ANOVA and Bonferroni correction were computed comparing the corrected number of recalled words (hits minus intrusions) between the groups. Significant differences in recall ability were revealed, $F(2, 65) = 4.88$, $p < .05$, with participants suffering from OCD recalling significantly less words than both HC participants, $p < .05$, $d = 0.78$, and TTM participants, $p < .05$, $d = 0.82$.

The significant main effect of instruction indicates that significantly more REMEMBER than FORGET words were recalled (i.e. the DF effect). Further analyses using paired t-tests revealed that this difference was only significant over all participants, $t(67) = 2.50$, $p < .05$, $d = 0.40$, which suggests that participants were in general able to intentionally inhibit words. Even though every diagnostic group recalled more REMEMBER than FORGET words, these differences did not reach significance in any of the three groups, all $p > .05$.

The significant interaction of word type X group indicates between-group differences in free recall of words depending on whether the words were TTM or NEUTRAL. Separate ANOVAs and Bonferroni correction for TTM and NEUTRAL words revealed no significant group differences in the recall of negative TTM words, $F(2, 65) = 1.12$, $p = .33$. Groups, however, differed significantly with respect to the recall of NEUTRAL words, $F(2, 65) = 5.57$, $p < .01$, with OCD participants recalling significantly less NEUTRAL words than HC participants, $p <. 01$, $d = 1.10$, and than TTM participants, $p <. 05$, $d = 0.75$.

The trend towards an interaction of instruction X word type X group was further explored. This finding suggests differences between the diagnostic groups in the number of correctly recalled words as a function of instruction and word type. With respect to the recall of REMEMBER words, an ANOVA and Bonferroni correction of calculated difference scores

(the number of recalled TTM REMEMBER words minus the number of recalled NEUTRAL REMEMBER words) revealed no significant between-group differences, $F(2, 65) = .44$, $p = .64$.

With respect to the recall of FORGET words, however, analyses of calculated difference scores (the number of recalled TTM FORGET words minus the number of recalled NEUTRAL FORGET words) revealed significant between-group differences, $F(2, 65) = 5.36$, $p < .01$. OCD participants recalled relatively more negative TTM than NEUTRAL FORGET words compared to the HC group, $p < .01$, $d = 0.97$. There was a similar trend towards significance for the difference between the OCD and TTM group, $p = .09$, $d = 0.72$, while the HC and TTM group did not differ significantly in their difference scores, $p = 1.0$.

Further within-group analyses revealed that OCD participants showed a significant DF effect (i.e. enhanced recall of REMEMBER versus FORGET words) for NEUTRAL, $t(20) = 2.79$, $p < .05$, $d = 0.93$, but not for negative TTM words, $t(20) = 0.00$, $p = 1.0$, indicating a specific deficit in the intentional inhibition of negative TTM words in this group.

4.4.3 Recognition

In the recognition task, a mean of 19.4 words ($SD = 4.5$) were correctly remembered and a mean of 2.7 words ($SD = 2.4$) were incorrectly remembered (i.e. false positives). Table 4.2 gives an overview of the means and standard deviations of words correctly recognized depending on group, instruction and word type.

For the recognition data, a 3 (group: TTM, OCD, HC) X 2 (instruction: REMEMBER, FORGET) X 2 (word type: TTM, NEUTRAL) ANOVA with repeated measurement on the last two factors revealed a significant main effect of word type, $F(1, 65) = 20.96$, $p < .001$, and a significant interaction of instruction X word type X group, $F(2, 65) = 3.98$, $p < .05$. There was no significant main effect of group or instruction, nor were the interaction of instruction X

group, the interaction of instruction X word type or the interaction of word type X group significant, all $p > .10$.

The significant main effect of word type indicates that the recognition of words depended on word type. Further analyses using paired t-tests indicated that overall more TTM than NEUTRAL words were recognized, $t(67) = -13.73$, $p < .001$, $d = 2.29$. Post hoc within-group analyses for each group revealed that this difference was significant in the TTM group, $t(20) = 3.20$, $p < .01$, $d = 0.83$, and the OCD group, $t(20) = 3.44$, $p < .005$, $d = 0.58$, but not in the HC group, $t(25) = 1.28$, $p = .21$.

The significant interaction of instruction X word type X group indicates that the recognition ability significantly differed between the diagnostic groups depending on instruction and word type. With respect to the recognition of REMEMBER words, an ANOVA and Bonferroni correction of calculated difference scores (the number of recognized TTM REMEMBER words minus the number of recognized NEUTRAL REMEMBER words) revealed a trend towards significant between-group differences, $F(2, 65) = 3.00$, $p = .06$. TTM participants tended to recognize relatively more TTM than NEUTRAL REMEMBER words than the OCD group, $p = .08$, $d = 0.70$. In this respect, no significant differences were found between the TTM and HC group, $p = .17$, or the HC and OCD group, $p = 1.0$.

With respect to FORGET words, analyses of calculated difference scores (the number of recognized TTM FORGET words minus the number of recognized NEUTRAL FORGET words) revealed a trend towards significant between-group differences, $F(2, 65) = 2.92$, $p = .06$. OCD participants tended to recognize relatively more negative TTM than NEUTRAL FORGET words compared to the HC group, $p = .06$, $d = 0.78$. In this respect, no significant differences were found between the TTM and OCD group, $p = .62$, or the HC and TTM group, $p = .87$.

4.4.4 Emotionality Rating

The means and standard deviations of the emotionality ratings of words depending on group, instruction and word type are documented in Table 4.3. For the data of the emotionality rating task, a 3 (group: TTM, OCD, HC) X 2 (instruction: REMEMBER, FORGET) X 2 (word type: TTM, NEUTRAL) ANOVA with repeated measurement on the last two factors revealed a significant main effect of group, $F(2, 65) = 11.14$, $p < .001$, a significant main effect of word type, $F(1, 65) = 275.47$, $p < .001$, and a significant interaction of word type X group; $F(2, 65) = 15.38$, $p < .001$. There was no significant main effect of instruction nor any significant interaction of instruction with one or both of the other two factors, all $p > .40$.

The significant main effect of group indicates that the average emotionality rating of the initially presented words differed between the groups. An univariate ANOVA and Bonferroni correction of the mean emotionality ratings revealed significant group differences, $F(2, 65) = 11.14$, $p < .001$, with TTM participants rating the words overall significantly more negatively than HC participants, $p < .001$, $d = 1.47$, and OCD participants, $p < .05$, $d = 0.85$.

The significant main effect of word type indicates that the emotionality rating of words depended on word type. Post hoc computed paired t-tests revealed that overall TTM words were rated significantly more negative than NEUTRAL words, $t(67) = 13.73$, $p < .001$, $d = 2.29$, which was significant in all groups, all $p < .001$.

The significant interaction of word type X group indicates between-group differences in the average emotionality rating of words depending on whether the words were TTM or NEUTRAL. Separate ANOVAs and Bonferroni correction for TTM and NEUTRAL words revealed significant group differences for the emotionality rating of TTM words, $F(2, 65) = 19.92$, $p < .001$. TTM participants rated TTM words significantly more negative than HC participants, $p <. 001$, $d = 1.77$, and than OCD participants, $p <. 001$, $d = 1.53$. No significant

group differences were found in the emotionality rating of NEUTRAL words, $F(2, 65) = 1.75$, $p = .18$.

Emotionality rating data were also analyzed differentiating between words correctly remembered in free recall (RECALL) and words not freely recalled (NO-RECALL). A 3 (group: TTM, OCD, HC) X 2 (recall status: RECALL, NO-RECALL) ANOVA of the emotionality rating data with repeated measurement on the second factor replicated the significant effect of group, $F(2, 65) = 9.83$, $p < .001$. In addition, the analysis revealed a significant interaction of free recall status X group, $F(2, 65) = 3.85$, $p < .05$. There was no significant main effect of recall status, $F(1, 65) = 1.13$, $p = .29$.

The significant interaction of recall status X group indicates that the groups differed in their mean emotionality rating depending on whether words were recalled or not recalled. Further within-group analyses using paired t-tests revealed that HC participants rated NO-RECALL words ($M = -0.19$, $SD = 0.57$) significantly more negatively than RECALL words ($M = 0.03$, $SD = 0.57$), $t(25) = 2.03$, p = .05, $d = 0.39$, which contrasts with findings in TTM participants (NO-RECALL: $M = -0.59$, $SD = 0.54$; RECALL: $M = -0.85$, $SD = 0.56$), $t(20) = -1.60$, $p = .13$, and OCD participants (NO-RECALL: $M = -0.25$, $SD = 0.61$; RECALL: $M = -0.47$, $SD = 0.70$), $t(20) = -1.43$, $p = .17$ (see also Figure 4.1).

Calculated difference scores (mean emotionality rating of RECALL words minus mean emotionality rating of NO-RECALL words) differed significantly between the groups, $F(2,65) = 3.85$, $p < .05$. Bonferroni correction revealed that HC participants had a significantly greater mean difference score than TTM participants, $p = .05$, $d = 0.73$, and tended to have a greater difference score than OCD participants, $p = .08$, $d = 0.70$. This finding indicates that HC participants rated RECALL words relatively more positively than NO-RECALL words compared to TTM and OCD participants.

4.5 Discussion

Overall, the general DF effect was replicated with a significantly higher free recall of REMEMBER than FORGET words across our entire sample. This finding suggests that our participants were generally able to intentionally inhibit words. The fact that this effect was not significant in either of the groups alone might be due to relatively small sample sizes providing sufficient power to detect only large effects. In addition, low memory rates in free recall (35.4%) and recognition (69.3%) might have contributed to the lack of significant within-group REMEMBER versus FORGET word differences. The floor effect of memory is probably due to the length of word lists and short presentation times, and indicates that the task was rather difficult.

The overall equal recognition of REMEMBER and FORGET words indicates that, in general, words were encoded irrespective of instruction. FORGET words intentionally inhibited and not retrieved at free recall did become available when cued in the recognition task. This indicates that they had been sufficiently encoded. This finding supports the assumption that block cued DF tasks generate retrieval rather than encoding inhibition (Johnson, 1994). The equal recognition of REMEMBER and FORGET words also indicates that the distractor task was successful in preventing selective rehearsal of REMEMBER words.

In the emotionality rating task, all three groups rated TTM-related words significantly more negatively than neutral words. TTM participants, however, rated TTM-related words significantly more negatively than OCD and HC participants probably due to a higher personal relevance of these words for TTM participants.

Focusing on significant between-group differences, our data provide evidence for a selective cognitive inhibition deficit in OCD indicated by a DF effect depending on word type. While OCD participants recalled significantly more neutral REMEMBER than neutral FORGET words (i.e. the DF effect), negative (TTM-related) words were recalled irrespective

of instruction (i.e. lack of DF effect). In addition, a relatively greater free recall of negative versus neutral FORGET words was found in OCD compared to HC participants. Based on the fact that we applied a block cued directed forgetting paradigm, our data suggest that the inhibition deficit found in OCD is due to a deficit in intentionally inhibiting the retrieval (rather than the encoding) of negative words.

The trend towards a relatively greater recognition of negative versus neutral FORGET words in OCD compared to HC participants (representing a medium-to-large effect), however, suggests that emotional valence also tended to more strongly affect the depth of FORGET word encoding in OCD than in HC participants. Thus, our data provide evidence for an abnormally differential encoding of to-be-intentionally-inhibited (irrelevant) information based on its emotional valence in OCD. Irrelevant negative information tended to be more elaborately encoded by OCD participants than neutral irrelevant information. Given that the item cued DF design used by Wilhelm et al. (1996) is thought to investigate the ability of intentional non-encoding (Wilson & Kipp, 1998), our data seem consistent with their findings that OCD participants recall more negative than neutral FORGET words.

Moreover, our data suggest that the cognitive inhibition deficit in OCD is due to negative valence rather than concern-relatedness of information. In our experiment both word types, negative TTM-related words (e.g., 'uncontrollable', 'damaged') as well as neutral words (e.g., 'stove', 'knife'), included words that were potentially OCD-related. If impaired cognitive inhibition in OCD was due to concern-relatedness, an interaction of word type by instruction would not be expected in recall. OCD participants, however, preferentially recalled negative (TTM-related) versus neutral FORGET words, suggesting that negative valence was the key factor for the inhibition deficit. Following this interpretation, our data parallel the findings of Wilhelm et al. (1996) and are in contrast with the conclusions of Tolin, Hamlin, et al. (2002).

However, this interpretation requires further investigation through studies using definite OCD-related stimulus material not confounded by emotional valence.

With respect to memory performance, OCD participants remembered significantly less in free recall than HC and TTM participants, but not in recognition. This finding suggests that OCD participants are not as good as HC participants in retrieving information, while their encoding ability seems unimpaired. This finding in OCD might possibly be due to a lack (or diminished use) of effective strategies to facilitate retrieval. Block cued DF tasks are thought to encourage relational (i.e. organizational) processing (Basden & Basden, 1996), which might be less spontaneously activated in OCD. Evidence that decreased free recall rates of word lists in OCD might be due to an organizational rather than a memory deficit, per se, has previously been reported (Deckersbach, Otto, Savage, Baer, & Jenike, 2000). Furthermore, it is possible that a lack of confidence in memory accounts for the lower free recall rate in OCD (Deckersbach, Savage, Wilhelm, et al., 2000; MacDonald, Antony, MacLeod, & Richter, 1997; Williams et al., 1997, p. 56; McNally & Kohlbeck, 1993).

Alternatively, between-group differences in free recall but not in recognition might be due to the decreased sensitivity of recognition tasks to memory impairments (Williams et al., 1997, p. 56). The implied theoretical possibility of general memory deficits in OCD (i.e. impaired retrieval as well as encoding ability) is not supported by our data, though, given an equal performance of OCD and HC participants in general verbal abilities and attention span tasks.

In agreement with our hypothesis, our data do not provide evidence for impaired cognitive inhibition abilities in TTM. No significant differences between TTM and HC participants were observed in free recall or recognition. This finding suggests that TTM, in contrast to OCD, is not accompanied by a cognitive inhibition deficit, which seems to be congruent with differences in the clinical picture of the two disorders. Although both TTM and

OCD are characterized by repetitive behaviors, the reasons for the performance appear to differ between the disorders. In OCD, compulsions seem to be secondary to discomfort provoking obsessions, which might be due to cognitive inhibition deficits (Enright & Beech, 1993a; Steketee et al., 1998). In TTM, however, repetitive hairpulling is mainly thought to be due to an uncontrollable urge or impulse (APA, 1994, p. 350-351), congruent with findings of abnormal motor inhibitory functioning (see Study 1). Our data suggest that no additional cognitive inhibition impairments are present in TTM. However, given that our sample size provided only power to detect large effects, further studies replicating our findings with larger samples are recommended before final conclusions are made.

A significant difference between TTM and HC participants was, however, found in the emotionality rating task. While HC participants were rather inattentive to negative information (indicated by rating words not recalled significantly more negative than words recalled), TTM participants showed an opposite tendency to rate words recalled more negatively than words not recalled. The discrepancy between the TTM and HC group was significant, and there was also a trend towards a correspondingly significant difference between the OCD and HC group (representing a medium-to-large effect).

Our findings seem to be congruent with previous findings from visual dot-probe tasks (MacLeod, Mathews, & Tata, 1986; Tata, Leibowitz, Prunty, Cameron, & Pickering, 1996), in which anxious participants directed their attention disproportionately towards threat words while HC participants tended to be anxiety-avoidant (directing their attention away from threat words). This abnormality, thus, does not seem to be specific to OCD and TTM but might be a characteristic shared with other anxiety (or emotional) disorders. Our finding might indicate that mental health is accompanied by a tendency to disregard unpleasant information. One may speculate whether the lack of such a tendency might increase experiences of distress (or threat)

resulting in a greater vulnerability to the onset or maintenance of psychiatric symptoms (e.g., anxiety or pathological stress reducing strategies).

There are some limitations to our data which should be recognized. Several of our TTM and OCD participants suffered from comorbid symptoms and were significantly more depressed and anxious than the HC participants (indicated by BDI and STAI scores). The two clinical groups, however, did not differ from each other with regard to the number and severity of self-reported depression and anxiety symptoms. Thus, the specific impairments found in OCD do not seem to be better accounted for by depression or anxiety per se. Furthermore, TTM and OCD are both frequently accompanied by depressive and anxiety symptoms as well as additional comorbidities (Stein et al., 1995); thus, including TTM and OCD sufferers with comorbid problems might not ultimately be a limitation. Alternatively, it might reveal impairments in 'typical' TTM and OCD sufferers, rather than in an artificially 'pure' research population.

Another limitation of our data may lie in the significant between-group difference with respect to gender ratio (each reflecting the gender distribution in the respective population). Impairments found in OCD, however, do not seem to be attributable to this factor, since the gender ratio of this group was comparable to the ratio in the HC group. Additionally, the fact that our clinical participants were only mildly disturbed (indicated by moderate MGH-HS and YBOCS scores) might limit the generalizability of our results. Moreover, our DF task was quite difficult (indicated by a floor effect of memory). An easier version of the DF paradigm would have allowed a finer differentiation of memory performance and may have revealed further within- and between-group differences. The relatively small sample sizes provided only sufficient power for large effects to be significant. Thus, meaningful medium effects might have been undetected.

Based on our data, we can conclude that OCD is characterized by an intentional cognitive inhibition deficit. This finding is in agreement with previous research (Janeck & Calamari, 1999; Tolin, Abramowitz, et al., 2002; Tolin, Hamlin, et al., 2002; Wilhelm et al., 1996). Our data suggest that this impairment in OCD is not global but specific to the inhibition of negative information. Previous studies indicating a specific rather than a global deficit in OCD provide a mixed picture of whether negative valence or concern-relatedness of words is the key factor (Tolin, Hamlin, et al., 2002; Wilhelm et al., 1996). Since our study did not specifically include OCD-related words further research is necessary to draw final conclusions.

A partial intentional retrieval inhibition deficit in OCD seems congruent with its clinical picture. While intrusive thoughts have been found to occur in normal as well as in pathological states, they seem to be more frequent or persistent in OCD sufferers than in other people (Rachman & de Silva, 1978). Thus, OCD sufferers seem to be less able than other people to disregard or suppress these thoughts after they have reached conscious awareness, indicating an *intentional* cognitive inhibition deficit. The fact that obsessions in OCD contain anxiety- or discomfort-provoking, rather than pleasant, information is consistent with a *partial* inhibition deficit, with emotional valence or personal relevance as the key factor. The observation that OCD sufferers do not seem to be able to keep the negative information embedded in intrusive thoughts from being retrieved in situations, in which this information is without relevance or clearly unwanted, suggests a *retrieval* inhibition deficit.

Thus, our findings of an intentional retrieval inhibition deficit in OCD might help explain the phenomenology of OCD. Regardless of whether such an inhibition deficit in OCD is innate or evolved, it potentially causes primary intrusive negative thoughts and secondary compulsions. Following this interpretation, treatment of OCD needs to focus on teaching strategies to decrease elaborate encoding and processing of negative/concern-relevant information and to enhance the ability to disregard unpleasant information and intrusions.

Thus, our results indicate that therapy strategies focusing on modifying cognitive processes in OCD seem to be promising. Accordingly, cognitive therapy for OCD has been found to be successful (Van Oppen et al., 1995).

To our knowledge this has been the first study on information processing in TTM. Our data indicate that TTM, in contrast to OCD, is not characterized by a (major) cognitive inhibition deficit. However, TTM (and OCD) might be characterized by a deficient avoidance of unpleasant information, which has been found in other anxiety disorders as well. Generally, one may hypothesize that the lack of a tendency to disregard unpleasant information increases the amount of perceived distress, which subsequently increases the frequency of habitual tension-reducing behaviors. Like in many emotional disorders, stress is thought to commonly worsen symptoms (i.e. hairpulling) in TTM sufferers (Keuthen, Stein, & Christenson, 2001, p. 45). More studies are needed to draw final conclusions about abnormal cognitive processes in TTM, and their effect on its clinical picture, as a foundation for the development of cognitive therapy strategies for this disorder.

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Table 4.1

Correct Free Recall of Words as a Function of Group, Instruction and Word Type

	TTM (*n* = 21)			
	Negative TTM words		Neutral words	
Instruction	*M*	*SD*	*M*	*SD*
REMEMBER	3.00	1.45	2.81	1.91
FORGET	2.48	1.29	2.48	1.66
	OCD (*n* = 21)			
	Negative TTM words		Neutral words	
	M	*SD*	*M*	*SD*
REMEMBER	2.29	1.52	2.33	1.71
FORGET	2.29_a	1.35	1.19_a	0.75
	HC (*n* = 26)			
	Negative TTM words		Neutral words	
	M	*SD*	*M*	*SD*
REMEMBER	2.77	1.14	3.00	1.60
FORGET	2.27	1.40	2.69	1.35

Note. Means in the same row that share subscripts differ significantly at $p < .005$, statistical significance was computed using paired-samples t-tests. Means in the same row that do not share subscripts are not significantly different at $p < .05$.

Table 4.2

Correct Recognition of Words as a Function of Group, Instruction and Word Type

	TTM (n = 21)			
	Negative TTM words		Neutral words	
Instruction	*M*	*SD*	*M*	*SD*
REMEMBER	6.00_a	1.14	4.62_a	1.83
FORGET	5.14	1.68	4.38	1.77

	OCD (n = 21)			
	Negative TTM words		Neutral words	
	M	*SD*	*M*	*SD*
REMEMBER	4.57	1.78	4.48	1.63
FORGET	5.24_a	1.00	3.86_a	1.56

	HC (n = 26)			
	Negative TTM words		Neutral words	
	M	*SD*	*M*	*SD*
REMEMBER	5.19	1.41	4.85	1.69
FORGET	5.04	1.15	4.77	1.53

Note. Means in the same row that share subscripts differ significantly at $p < .005$, statistical significance was computed using paired-samples t-tests. Means in the same row that do not share subscripts are not significantly different at $p < .05$.

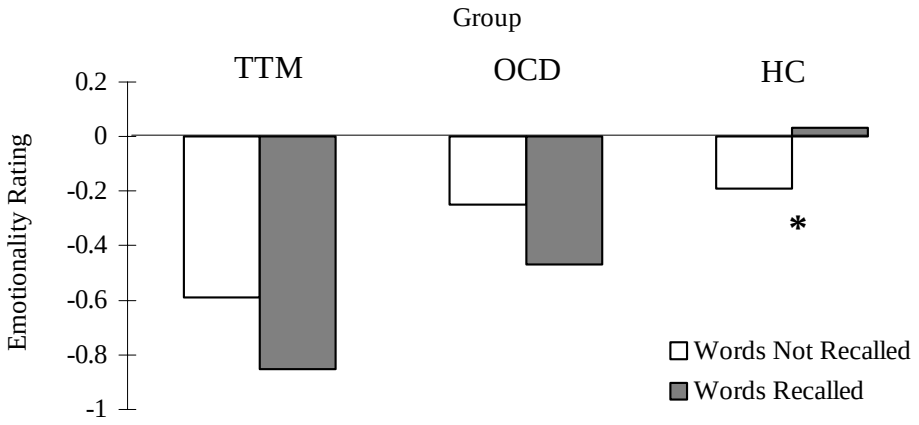
Table 4.3

Emotionality Rating of Words as a Function of Group, Instruction and Word Type

	TTM (*n* = 21)			
	Negative TTM words		Neutral words	
Instruction	*M*	*SD*	*M*	*SD*
REMEMBER	-1.80_a	0.82	0.49_a	0.59
FORGET	-1.67_a	0.67	0.35_a	0.44
	OCD (*n* = 21)			
	Negative TTM words		Neutral words	
	M	*SD*	*M*	*SD*
REMEMBER	-0.83_a	0.75	0.29_a	0.55
FORGET	-0.86_a	0.97	0.17_a	0.59
	HC (*n* = 26)			
	Negative TTM words		Neutral words	
	M	*SD*	*M*	*SD*
REMEMBER	-0.68_a	0.72	0.46_a	0.52
FORGET	-0.62_a	0.82	0.52_a	0.55

Note. Means in the same row that share subscripts differ significantly at $p < .005$, statistical significance was computed using paired-samples t-tests.

Figure 4.1. Emotionality rating of words as a function of group and free recall status.



Note. Emotionality ratings range between '-3 = very negative' to '+3 = very positive'.

*p = .05, statistical significance was computed using paired-samples t-tests.

5 Study 3: Executive Functioning in Trichotillomania and Obsessive-Compulsive Disorder

Antje Bohne

Cary R. Savage

Thilo Deckersbach

Nancy J. Keuthen

Michael A. Jenike

Massachusetts General Hospital/Harvard Medical School, Boston, USA

Brunna Tuschen-Caffier

University of Siegen, Germany

Sabine Wilhelm

Massachusetts General Hospital/Harvard Medical School, Boston, USA

a version of this manuscript is submitted for publication

5.1 Abstract

Few studies have compared neuropsychological functioning in TTM and OCD. In OCD, most studies suggest abnormal visuospatial abilities, memory, and executive functioning. We compared 23 TTM, 21 OCD and 26 HC individuals on neuropsychological tasks assessing these abilities. TTM participants showed increased perseveration on the Object Alternation Task suggesting difficulties with response flexibility. OCD participants showed impaired ability to learn from feedback on the Wisconsin Card Sorting Test. Other executive functions, as well as memory and visuospatial abilities were unimpaired in TTM and OCD. Our data suggest that TTM and OCD are characterized by different patterns of neuropsychological dysfunction.

5.2 Introduction

Individuals suffering from TTM pull out their own hair resulting in noticeable hair loss and clinically significant distress or functional impairment (APA, 1994, p. 350-351). While currently classified as an impulse-control disorder, TTM has also been conceptualized as an OC spectrum disorder based on similarities with OCD. More specifically, both TTM and OCD are characterized by repetitive, intentionally performed behaviors, exhibit responses to similar pharmacotherapy (e.g., serotonin reuptake inhibitors), and have increased rates of both TTM and OCD in the same families (Lenane et al., 1992; Stein et al., 1995). In addition, neurobiological studies suggest that frontal-striatal cortical structures may be involved in both disorders (for OCD: Baxter, 1992; Rauch et al., 1994; Robinson et al., 1995; for TTM: O'Sullivan et al., 1997). However, little is known regarding how abnormalities in this brain system are translated into the characteristic clinical symptoms.

Neuropsychological research has previously proven fruitful in linking brain dysfunction to clinical presentation in TTM. Data from one neuropsychological study of TTM indicate executive functioning impairments in this disorder, which were correlated with self-report of decreased resistance and control over hairpulling (Keuthen et al., 1996). Given that frontal-striatal brain networks support executive functioning (i.e. higher level control processes that control and modulate cognitive and motor functions), the finding of decreased hair pulling control in the presence of executive impairments seems consistent with earlier findings of abnormal frontal-striatal functioning in TTM.

Further investigation of neuropsychological functioning in TTM might advance our understanding of its clinical picture and support the development of more effective treatment strategies. Currently the etiology of TTM is still poorly understood and its treatment lacks long-lasting beneficial effects (Diefenbach et al., 2000; Jaspers, 1996). The findings of existing neuropsychological studies in TTM provide some preliminary evidence for impaired

performance on measures of nonverbal memory (Keuthen et al., 1996; Rettew et al., 1991), executive functioning (Keuthen et al., 1996), and divided attention (Stanley et al., 1997). Verbal abilities have consistently been found to be unimpaired in TTM (Coetzer & Stein, 1999; Keuthen et al., 1996; Martin et al., 1993; Stanley et al., 1997). Conclusions drawn from the previous studies, however, are limited by small sample sizes (Coetzer & Stein, 1999; Martin et al., 1993; Rettew et al., 1991) or the lack of comparisons between the TTM cohort and a clinical control group (Keuthen et al., 1996; Stanley et al., 1997).

Although OCD has been more thoroughly investigated than TTM, neuropsychological investigations have drawn divergent conclusions about the integrity of cognitive functions. While some researchers did not find any significant differences between the neuropsychological test performance of OCD and HC participants (Beers et al., 1999; Martin et al., 1993; Martin, Wiggs, Altemus, Rubenstein, & Murphy, 1995), the majority of studies reveal impairments in visuospatial abilities, memory performance and various executive functions, while general intellectual abilities and attention span appear preserved (e.g., Aronowitz et al., 1994; Christensen et al., 1992; Deckersbach, Otto, et al., 2000; Moritz et al., 2001; Woods, Vevea, Chambless, & Bayen, 2002).

Findings from recent studies suggest that primary executive dysfunction may account for other neuropsychological deficits in OCD. For example, investigations using complex memory tasks such as the Rey-Osterrieth Complex Figure Test (RCFT) and California Verbal Learning Test (CVLT) indicate inferior memory performance in OCD participants, which does not seem to be attributable to a primary storage deficit. Instead, it seems that a diminished use of organization strategies during encoding leads to retrieval deficits in this disorder (Deckersbach, Otto, et al., 2000; Savage et al., 1999; Savage et al., 2000). These findings of a deficit in the executive functions of memory are in agreement with other reports of poor organization abilities and a deficient use of strategy in OCD (Behar et al., 1984; Cabrera et al., 2001; Purcell

et al., 1998a). Thus, it appears that primary executive functioning deficits cause an inferior memory performance in OCD.

Planning and problem solving ability, another executive function, has also frequently been investigated in OCD. Accuracy of planning and problem solving, often investigated using Tower tasks such as the Tower of Hanoi (TOH), seems to be unimpaired in OCD (Beers et al., 1999; Purcell et al., 1998a, 1998b; Schmidtke, Schorb, Winkelmann, & Hohagen, 1998; Veale, Sahakian, Owen, & Marks, 1996). There is, however, evidence that motor and/or cognitive speed in problem solving is slowed in OCD (Purcell et al., 1998a, 1998b; Veale et al., 1996). This finding is consistent with reports of a generally inferior performance of OCD participants in timed neuropsychological tasks (Christensen et al., 1992) and might be an indicator for an OCD-specific neuropsychological 'slowness' (Purcell et al., 1998a).

Study findings are inconsistent regarding the ability of executive functions to establish, maintain and shift mental set in OCD. Several researchers found evidence of impaired ability to establish and maintain set in OCD when investigated with the Object Alternation Task (OAT; Abbruzzese, Bellodi, Ferri, & Scarone, 1995; Abbruzzese, Ferri & Scarone, 1997; Cavedini, Ferri, Scarone, & Bellodi, 1998; Gross-Isseroff et al., 1996). However, data on set shifting ability, often investigated using the Wisconsin Card Sorting Test (WCST), are divergent. Some researchers reported impaired performance of OCD participants (Hymas et al., 1991; Lucey et al., 1997), while data from other studies indicate preserved functioning (Beers et al., 1999; Deckersbach, Otto, et al., 2000; Gross-Isseroff et al., 1996).

Inconsistent findings across neuropsychological studies in OCD may reflect the heterogeneity of this disorder which has been hypothesized to consist of different subtypes (Cavedini, Cisima, Riboldi, D'Annucci, & Bellodi, 2001; Cavedini et al., 2002; Purcell et al., 1998a). Alternatively, discrepancies might be due to inconsistent inclusion/exclusion criteria across studies regarding psychoactive medication or the presence of comorbid conditions such

as depression or psychosis (Basso, Bornstein, Carona, & Morton, 2001; Moritz et al., 2001; Purcell et al., 1998b; Spitznagel & Suhr, 2002).

In sum, there is preliminary evidence of neuropsychological deficits in TTM similar to those found in OCD (i.e. nonverbal memory and executive functioning). However, findings in both disorders are inconsistent, and the study designs of previous TTM studies allow only limited conclusions. Direct comparison studies with sufficient sample sizes are needed to investigate whether TTM is characterized by neuropsychological functioning deficits, and whether its neuropsychological profile appears disorder-specific, or similar to related mental disorders such as OCD. Direct comparison of the neuropsychological profiles of TTM and OCD might provide further evidence as to whether or not TTM is best conceptualized as an OC spectrum disorder.

The purpose of the present study is to compare neuropsychological functioning in TTM and OCD. Using the previously reported patterns of neuropsychological findings in OCD as a springboard for further comparison, visuospatial abilities, memory, and various executive functions in TTM and OCD were investigated using tasks formerly shown to discriminate OCD from HC participants. Given recent evidence that OCD deficits might be due to primary executive dysfunction, aspects of executive functioning were emphasized in our study.

5.3 Methods

5.3.1 Participants

Seventy individuals were recruited including 23 individuals with TTM, 21 individuals with OCD, and 26 HC individuals. Clinical diagnoses for TTM and OCD participants, as well as the diagnostic status of HC participants, were determined using the SCID (First et al., 1995). Participants with a history of significant head injury, neurological disorder, psychosis, mental retardation, or alcohol or substance dependence were excluded from study participation.

Individuals with current alcohol or substance abuse were also excluded, as were individuals who suffered from both TTM and OCD. Medicated participants had to be stable on medication for at least two weeks prior to the test session. All participants spoke fluent English.

TTM group. In the TTM group, 20 (87.0%) participants were female. Mean age was 37.4 years (*SD* = 12.3) and the average number of years of education was 17.6 (*SD* = 2.5). Mean age at TTM onset was 13.8 years (*SD* = 4.5) and average symptom duration was 23.5 years (*SD* = 13.5). Participants in this group met DSM-IV criteria for TTM with the exception of two (8.7%) individuals who did not meet criterion B (rising tension before or when trying to resist hairpulling). This criterion is often not endorsed by people suffering from clinically significant hairpulling (Christenson, Mackenzie, et al., 1991; Schlosser et al., 1994), which has led to a recommendation for its exclusion from the diagnostic criteria for TTM (Keuthen, O'Sullivan, & Sprich-Buckminster, 1998).

Seven (30.4%) TTM participants suffered from current Axis-I comorbid diagnoses including social phobia (*n* = 4), specific phobia (*n* = 3), MDD (*n* = 2), BDD (*n* = 1), GAD (*n* = 1), and panic disorder with agoraphobia (*n* = 1). Four (17.4%) TTM participants took psychoactive medication including sertraline (*n* = 2), citalopram (*n* = 1), fluoxetine (*n* = 1), and venlafaxine (*n* = 1).

OCD group. In the OCD group, 12 (57.1%) participants were female. Mean age was 31.9 years (*SD* = 7.8) and the average number of years of education was 17.2 (*SD* = 3.5). Mean age at OCD onset was 16.5 years (*SD* = 7.9) and average symptom duration was 16.1 years (*SD* = 10.4). All participants in this group met DSM-IV criteria for OCD.

Ten (47.6%) OCD participants suffered from current Axis-I comorbid diagnoses including social phobia (*n* = 5), BDD (*n* = 4), MDD (*n* = 3), dysthymia (*n* = 1), GAD (*n* = 1), PTSD (*n* = 1), and specific phobia (*n* = 1). Thirteen (61.9%) OCD participants took psychoactive medication including: fluvoxamine (*n* = 6), sertraline (*n* = 4), fluoxetine (*n* = 2),

alprazolam (n = 1), buspirone (n = 1), clonazepam (n = 1), paroxetine (n = 1), and risperidone (n = 1).

HC group. In the HC group, 16 (61.5%) were female. Mean age was 35.0 years (SD = 10.6), and the average number of years of education was 18.3 (SD = 4.1). Participants in this group did not meet criteria for any current or past psychiatric diagnosis and were not taking psychoactive medication.

Between-group comparisons. The three participant groups did not differ significantly with regard to mean age, $F(2, 67) = 1.53$, $p = .22$, or mean number of years of education, $F(2, 67) = 0.57$, $p = .57$. The TTM group, however, differed significantly from the HC and OCD group in regard to the male-female ratio (using Cohen's test for differences between proportions; Cohen, 1988, pp. 179-213), $h_s > .59$, $n' = 24$, $p < .05$. The significant difference reflects the reported predominance of females in the TTM patient population in contrast to a more balanced gender distribution in OCD (Himle et al., 1995; Keuthen, O'Sullivan, & Sprich-Buckminster, 1998; Stein et al., 1995). The clinical groups did not differ significantly in their age at onset, $t(31) = -1.36$, $p = .18$, but TTM participants reported a significantly longer illness duration than the OCD participants, $t(42) = 2.02$, $p = .05$.

5.3.2 Measures

All participants completed several self-report scales and neuropsychological tasks investigating general verbal abilities, verbal and nonverbal attention span, visuospatial abilities, verbal and nonverbal memory, and executive functioning as described below.

Scales. The Massachusetts General Hospital Hairpulling Scale (MGH-HS; Keuthen et al., 1995) was included to measure the presence and severity of symptoms of repetitive hairpulling. Obsessive-compulsive symptom severity was assessed using the Yale-Brown Obsessive Compulsive Scale (YBOCS; Goodman et al., 1989a). The Beck Depression Inventory (BDI; Beck & Steer, 1987) measured the presence and severity of depressive symptoms. The State

Trait Anxiety Inventory (STAI; Spielberger et al., 1983) was included to assess the current (state) level of anxiety (STAI-S) and the general (trait) level of anxiety (STAI-T). The Edinburgh Handedness Inventory (EHI; Oldfield, 1971) assessed an individual's handedness.

Verbal intelligence and attention span measures. Wechsler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1981) subtests including Information, Vocabulary, and Similarities were used to estimate general verbal abilities. The subtests Information and Vocabulary were presented in an abbreviated format (previously documented in Cabrera et al., 2001). Span of verbal attention was measured using the Digit Span subtest of the WAIS-R. The Spatial Span subtest of the Wechsler Memory Scale - Third Edition (WMS-III; Wechsler, 1997) was included to measure span of non-verbal attention.

5.3.3 Neuropsychological Test Battery

Block Design. The Block Design subtest of the WAIS-R, which requires participants to replicate two-dimensional patterns using three-dimensional blocks, was included to measure basic visuospatial abilities.

RCFT. The Rey-Osterrieth Complex Figure Test (RCFT; Osterrieth, 1944) was used to examine complex visuospatial construction, nonverbal memory and organization ability. This test requires participants to copy and recall a complex geometric figure consisting of 18 defined details (Meyers & Meyers, 1995). Immediately after copying the figure, as well as after a 20-25 minutes delay, participants were asked (without prior notice) to redraw the design of memory followed by a delayed recognition test. The accuracy of copy and recall drawings and recognition abilities were scored using the Meyers and Meyers (1995) scoring system. Accuracy scores for copy, immediate, and delayed recall range from 0-36 points and scores for recognition range from 0-24. For copy and recall, participants were provided with colored pencils which were switched in order to allow subsequent scoring based on the order in which

the figure was constructed by each participant (organizational score). In an earlier study, pen switching was not found to interfere with performance by distracting participants (Somerville, Javorsky, Tremont, Westervelt, & Stern, 2000). Organization was scored according to Savage et al. (1999) and Deckersbach, Savage, Henin, et al. (2000) with scores ranging from 0-6.

CVLT. The California Verbal Learning Test (CVLT; Delis et al., 1987) was used to examine verbal memory and organization ability. This task evaluates memory for a list of 16 shopping items (from four semantic categories) presented auditorily in five study trials, with immediate recall after each trial. An interference list was presented following the fifth study-recall. Afterwards, short and long delayed (25-30 minutes) recall of the first list were assessed, followed by a recognition test. Number and sequence of words reproduced were recorded. Measures of the extent to which participants group semantically related items (e.g. fruits, clothing) together during learning (semantic clustering) provided a measure of how much participants used memory strategies during learning. A total semantic clustering ratio of observed to expected correct clustering scores of study-recall trials 1-5 (total semantic clustering ratio 1-5) was calculated following the instructions of Delis et al (1987).

TOH. The Tower of Hanoi (TOH; Simon, 1975) was used to examine problem solving and planning abilities. To arrive at the best (fewest moves) solution participants must mentally plan the steps needed to rearrange three disks of varying sizes from their initial position on one of three upright sticks to a predetermined goal position on another stick. The subjects have to observe the stipulation that when two or more disks are on the same stick, the smaller disks must always be on top of the larger ones. A trial was terminated when the goal position was reached or when 21 moves were made. Time and sequence of moves were documented, but there was no induction of time pressure and no information on the minimum number of moves criterion to minimize stress. Number of trials and number of moves needed for solution (2 trials at a minimum number of moves, which is 7 moves, with a maximum of 5 trials), as well as

time needed to initiate the first move (planning time) and total time needed for each trial were recorded. Average time needed per move (total time minus planning time, divided by the number of moves) was calculated.

OAT. The Object Alternation Task (OAT; Freedman, 1990) was used to measure the ability to establish and maintain the set of alternation. The participants were told that a coin was hidden in one of two cups presented on a computer screen and instructed to find the hidden coin by choosing one of the cups. After each trial they received feedback about their previous choice. The participant's task was to learn that the cup in which the coin was located was alternated after each correct response. Number of trials needed for solution (13 consecutive correct choices with a maximum of 50 trials), number of errors and number of perseverative errors (i.e. choosing the incorrect cup two or more consecutive times) were recorded.

WCST. The Wisconsin Card Sorting Test (WCST; Heaton et al., 1993) was used to examine the ability to form abstract concepts, shift set and learn from feedback. This test requires participants to sort cards relative to four reference cards. The sorting principle is not stated, so participants must abstract the sorting principle from feedback given for the previous trial. Once ten trials have been completed, the sorting principle is changed without notification and participants must derive a new sorting rule. Number of trials needed for solution (completion of 6 sorts with a maximum of 128 trials), number of errors, number of perseverative errors, and 'Learning to Learn' scores (as defined by Heaton et al., 1993) were compared.

5.3.4 Procedure

Participants were recruited from outpatient clinics at the Massachusetts General Hospital, Boston, USA, and through advertisements in newsletters and flyers in local public libraries. At the beginning of a test session, all participants were informed of the study goals and written

informed consent was obtained. DSM-IV diagnoses were then assessed using the SCID. The neuropsychological test battery was subsequently administered. Tasks involving verbal versus nonverbal material were presented in counterbalanced order. Within the time delay for recall in RCFT and CVLT, no other tasks investigating memory were presented to avoid interference effects. The administration of tests took about 1.5 to 2 hours. At the end of the test session, participants were asked to fill out the questionnaire package (approximately 30 minutes). Participants were tested individually. Some of the participants had previous testing exposure to some of the tasks. In this case their data were not included in the task analysis.

5.3.5 Statistics

One-way analyses of variance (ANOVAs) and Bonferroni correction were computed to analyze between-group differences. The non-parametric Mann-Whitney U-test was used to compare groups with small sample sizes. Effect sizes (Cohen's *d*) were calculated for each comparison, but only medium and large effects are reported. Pearson correlation coefficients were computed to study relationships between metric variables. Differences between proportions were analyzed following the suggestions of Cohen (1988, pp. 179-213). An alpha level of .05 was used for all statistical tests with reported values for probability (*p*) being two-tailed.

5.4 Results

5.4.1 Symptom Severity, Verbal Intellectual Abilities, and Attention Span

Scale scores indicated that TTM participants on average suffered from hairpulling of moderate severity (MGH-HS: $M = 14.1$, $SD = 5.2$), were minimally depressed (BDI: $M = 8.7$, $SD = 7.4$) and had a moderate general level of anxiety (STAI-T: $M = 46.5$, $SD = 12.6$). Their level of anxiety in the test situation was mild to moderately high (STAI-S: $M = 35.4$, $SD = 8.9$).

Similarly, OCD participants suffered from moderate OCD symptoms (YBOCS: M = 16.9, SD = 5.0), were minimally depressed (BDI: M = 8.6, SD = 7.2), reported a moderate general level of anxiety (STAI-T: M = 46.6, SD = 11.4) and experienced mild to moderate anxiety in the test situation (STAI-S: M = 35.8, SD = 8.2). The HC participants' depression, trait and state anxiety scores were minimal (BDI: M = 1.5, SD = 1.7; STAI-T: M = 29.3, SD = 6.6; STAI-S: M = 27.3, SD = 6.0). Clinical groups scored significantly higher than the HC group in depression, $F(2, 67) = 12.00$, $p < .001$, trait anxiety, $F(2, 67) = 22.65$, $p < .001$, and state anxiety, $F(2, 64) = 9.25$, $p < .001$, with no significant differences between the TTM and OCD group, all $p = 1.0$.

According to the EHI, 20 (87.0%) of the TTM participants, 18 (85.7%) of the OCD participants, and 24 (92.3%) of the HC individuals were right-handed with no significant differences between the groups in the proportion of right-handers, $h_s < .26$, $n' = 23$, $p > .10$. In addition, no significant group differences were found in the WAIS-R subtests Information, Vocabulary, Similarities, and Digit Span, or in the WMS-III subtest Spatial Span, all $p > .20$. Thus, all three groups were comparable on handedness, estimated general verbal intellectual abilities as well as verbal and nonverbal attention span.

5.4.2 Visuospatial Ability and Memory

Block Design. No significant between-group differences were found in the WAIS-R Block Design accuracy score, $F(2, 64) = 2.13$, $p = .13$, indicating unimpaired basic visuospatial abilities in TTM and OCD participants as compared to HC participants (see Table 5.1 for group means and standard deviations). Calculation of effect sizes revealed a medium-to-large effect, $d = 0.71$, with OCD participants exhibiting inferior performance to TTM participants.

RCFT. No significant between-group differences were found in complex visuospatial abilities based on the RCFT copy raw score, $F(2, 64) = .17$, $p = .84$. In addition, no significant between-group differences were found in nonverbal immediate and delayed free recall as well

as recognition abilities based on RCFT raw scores, all $F(2, 64) < 1.30$, all $p > .25$ (see Table 5.1 for group means and standard deviations).

CVLT. No significant between-group differences were found in verbal immediate, short- and long-delayed free recall as well as recognition abilities based on CVLT raw scores, all $F(2, 65) < 0.70$, all $p > .60$ (see Table 5.1 for group means and standard deviations).

5.4.3 Executive Functioning

RCFT. No significant between-group differences were found in nonverbal organization ability based on the RCFT organization raw score, $F(2, 64) = 0.08$, $p = .93$ (see Table 5.2 for group means and standard deviations). Across all participants, RCFT organization scores were significantly positively correlated with immediate, $r(67) = .36$, $p < .005$, and delayed recall scores, $r(67) = .38$, $p < .001$, indicating that in general a higher quality of organization during encoding was related to a superior nonverbal recall performance.

CVLT. No significant between-group differences were found in verbal organization ability based on the CVLT total semantic clustering ratio 1-5 score, $F(2, 65) = 2.03$, $p = .14$ (see Table 5.2 for group means and standard deviations). Over all participants, CVLT total semantic clustering ratio 1-5 scores were significantly positively correlated with recall scores (immediate recall trial 1-5 total score: $r(68) = .66$, $p < .001$; short-delayed free recall: $r(68) = .61$, $p < .001$; long-delayed free recall: $r(68) = .56$, $p < .001$) indicating that in general a greater use of semantic clustering during encoding was related to a superior verbal recall performance.

TOH. In the TOH, 16 (69.6%) TTM participants, 15 (79.0%) OCD participants, and 21 (84.0%) HC participants were able to reach criterion (2 trials at a minimum number of moves) within a maximum of 5 trials. The between-group difference in the proportion of successful participants was not significant, $h_s < .36$, $n' = 24$, $p > .10$. In addition, groups did not differ significantly in the number of trials or number of moves, nor in average planning time per trial

or average time per move, all $F(2, 64) < 1.50$, all $p > .20$ (see Table 5.2 for group means and standard deviations). Calculation of effect sizes revealed a medium effect, $d = 0.60$, of OCD participants spending more time on planning than HC participants. In summary, the groups showed equivalent accuracy and motor speed in planning and problem solving in the TOH with some evidence of slower cognitive speed in OCD relative to HC participants.

OAT. In the OAT, 11 (50.0%) TTM participants, 11 (55.0%) OCD participants, and 12 (50.0%) HC participants were able to reach criterion (13 consecutive correct choices) within a maximum of 50 trials. The between-group difference in the proportion of successful participants was nonsignificant, $h_s < .20$, $n' = 22$, $p > .10$. In addition, between-group differences in the number of trials and percentage of errors were not significant, all $F(2, 63) < 1.30$, all $p > .25$ (see Table 5.2 for group means and standard deviations). The between-group difference in the number of perseverative errors, however, reached significance, $F(2, 63) = 3.97$, $p < .05$, with TTM participants making relatively more perseverative errors than HC participants, $p < .05$, Bonferroni corrected. The difference remained significant when considering gender as a covariate, $p < .05$. Calculation of effect sizes revealed a large effect, $d = 0.82$, of TTM participants and a small-to-medium effect, $d = 0.48$, of OCD participants showing more perseveration than HC participants. Thus, OAT data indicate difficulties in TTM participants (and give minor evidence for difficulties in OCD participants) in establishing and maintaining the set of alternation.

WCST. In the WCST, 21 (95.5%) TTM participants, 18 (90.0%) OCD participants, and 23 (92.0%) HC participants were able to reach criterion (completion of 6 categories) within a maximum of 128 trials. The between-group difference in the proportion of successful participants was nonsignificant, $h_s < .25$, $n' = 22$, $p > .10$. In addition, groups did not differ significantly in the number of trials, percentage of errors or percentage of perseverative errors, all $F(2, 64) < 2.00$, all $p > .10$ (see Table 5.2 for group means and standard deviations). Groups,

however, differed significantly in their 'Learning to Learn' scores, $F(2, 64) = 3.68$, $p < .05$, with OCD participants showing significantly less improvement in their efficiency across consecutive categories than HC participants, $p <. 05$, Bonferroni corrected. Calculation of effect sizes revealed a medium-to-large effect, $d = 0.78$, of OCD participants showing inferior learning from feedback than HC participants. Furthermore, medium effects were found with OCD participants performing more poorly than TTM participants with respect to perseveration, $d = 0.57$, and learning from feedback, $d = 0.55$. Hence, based on the WCST data, the groups seemed unimpaired in concept formation and abilities to shift mental set with evidence for inferior learning from feedback in OCD.

5.4.4 Post Hoc Analyses in OCD

Within the OCD group, post hoc analyses revealed that medicated participants ($M = 5.0$, $SD = 1.3$) achieved significantly higher nonverbal organization scores in the RCFT than their non-medicated counterparts ($M = 2.8$, $SD = 2.1$), $U = 15.0$, $n = 18$, $p < .05$, $d = 1.29$. In addition, OCD participants currently suffering from comorbid disorders ($M = 2.8$, $SD = 1.0$) were found to need significantly less trials to solve the TOH than their comorbidity-free counterparts ($M = 3.9$, $SD = 1.1$), $U = 20.5$, $n = 19$, $p < .05$, $d = 1.05$. At the same time, OCD participants currently suffering from comorbid disorders ($M = 8.5$, $SD = 6.3$) took significantly more planning time in the TOH than their comorbidity-free counterparts ($M = 4.4$, $SD = 5.7$), $U = 20.0$, $n = 19$, $p < .05$, $d = 0.68$. Besides these findings, within the OCD group none of the investigated executive functioning indices seemed to be affected by medication status or presence of comorbidities, all $p > .05$, and none was found to be significantly related to BDI or YBOCS scores, all $p > .05$.

5.5 Discussion

We found a significant difference between TTM and HC participants in the percentage of perseverative errors on the OAT indicating an impaired ability to establish and maintain the set of alternation in TTM. Calculation of Cohen's *d* indicates a large effect. To our knowledge, performance of TTM individuals on the OAT has not been investigated before. Our data suggest that TTM participants have difficulties with response flexibility. One might hypothesize that clinically this is manifested in difficulties stopping hairpulling once initiated, a problem reported by many TTM sufferers (e.g., Baer, 2000, p. 157). If one assumes that TTM individuals are characterized by a deficit in the flexible alternation of ongoing behavior, effective treatment might focus on instructions to prevent the initiation of a hairpulling episode in the first place and on training strategies to successfully interrupt hairpulling once initiated.

We also found a significant difference between OCD and HC participants in the WCST 'learning to learn' index suggesting impaired learning from feedback in OCD. Calculation of Cohen's *d* indicates a large effect. Earlier studies did not report any analyses of the WCST 'learning to learn' index in OCD. A relationship between inefficient learning from feedback and OCD symptoms seems plausible because it implies that it takes several repetitions (rather than one single performance) of a subjectively important behavior (e.g., checking) to help someone determine that a particular goal has been reached (e.g., determine that a situation is reasonably safe). One may, thus, hypothesize that repetitive behaviors and reassurance seeking of OCD sufferers are the clinical expression of this cognitive limitation. Further investigation of the ability to learn from feedback in OCD sufferers might enhance understanding of the clinical picture of this disorder.

Besides these specific deficits in TTM and OCD, our data revealed no statistically significant between-group differences in the neuropsychological test measures. Our findings, thus, indicate that neither OCD nor TTM is characterized by broad neuropsychological

dysfunction. Indeed, TTM and OCD participants showed basic and complex visuospatial abilities comparable to HC participants. This finding is in agreement with data from several earlier studies (Behar et al., 1984; Stanley et al., 1997) but also in contrast to findings of other researchers (Christensen et al., 1992; Coetzer & Stein, 1999). In addition, we found no significant differences in memory performance between our TTM, OCD and HC participants, neither with respect to verbal nor nonverbal material. Our data, therefore, replicate some earlier findings (Behar et al., 1984; Stanley et al., 1997) but differ from others (Keuthen et al., 1996; Savage et al., 2000).

Furthermore, we found several aspects of executive functioning to be preserved in both OCD and TTM participants. Compared to HC participants, organization ability as an executive function of memory (i.e. utilization of encoding strategies) appeared to be normal in the two clinical groups. With respect to TTM, this finding is in agreement with data from earlier studies (Keuthen et al., 1996; Stanley et al., 1997). With respect to OCD, however, our findings are inconsistent with previous reports of an inferior use of encoding strategies in OCD (Behar et al., 1984; Purcell et al., 1998a; Savage et al., 2000). The failure to replicate earlier findings might partly be due to the inclusion of medicated OCD participants in our sample who showed significantly higher nonverbal organization scores than their non-medicated counterparts. In agreement with earlier studies (Savage et al., 2000), verbal and nonverbal free recall ability varied with the usage of an efficient encoding strategy indicated by a positive correlation between the two measures in RCFT and CVLT.

Our TOH data suggest that planning and problem solving ability is unimpaired in TTM and OCD. In TTM, this ability has not been investigated before. With respect to OCD, our data are in agreement with earlier studies on accuracy of planning and problem solving (Purcell et al., 1998a, 1998b; Schmidtke et al., 1998). We were not able to replicate earlier findings of statistically significant slowed motor and/or cognitive speed in OCD (Purcell et al., 1998a,

1998b; Veale et al., 1996), although, a medium effect of OCD participants needing more planning time than HC participants points in this direction. Given our relatively small sample sizes, our results should be considered preliminary.

Post hoc analyses within the OCD group suggested that increased planning time for the TOH might be related to the presence of comorbid disorders. This conflicts with interpretations of an OCD-based neuropsychological slowness (Christensen et al., 1992; Purcell et al., 1998a). It is also noteworthy, that longer planning times in OCD participants currently suffering from comorbid disorders was found to co-occur with a fewer number of trials needed to solve the TOH compared to their comorbidity-free counterparts. This finding suggests that increased planning time in the TOH indicates greater efforts to create an effective problem solving strategy rather than slowed cognitive speed.

With respect to the ability to establish and maintain mental set on the OAT, we did not find statistically significant differences between OCD and HC participants. One may hypothesize that this lack of finding is in part due to our relatively small samples sizes given that a medium effect is reported for OCD participants making more perseverative errors on the OAT than HC participants. The medium effect is in line with reports from earlier studies (Abbruzzese et al., 1995, 1997; Cavedini et al., 1998; Gross-Isseroff et al., 1996). Furthermore, we did not find significant impairments in set-shifting ability in our clinical groups based on the WCST 'perseverative errors' index, which replicates data from earlier studies on TTM and from several studies on OCD (Stanley et al., 1997; Gross-Isseroff et al., 1996).

Reports on neuropsychological test performance in OCD are discrepant and it is possible that inconsistent inclusion/exclusion criteria across studies with respect to medication status and presence of comorbid disorders (such as depression) might account for some discrepancies. However, none of these variables seem to provide sufficient explanation for major inconsistencies across OCD studies ranging from findings of preserved neuropsychological

functioning (Beers et al., 1999; Martin et al., 1993, 1995) to significant impairments in numerous areas of functioning (Aronowitz et al., 1994; Behar et al., 1984; Christensen et al., 1992; Purcell et al., 1998a). Heterogeneity of OCD might be a more comprehensive and convincing explanation. Based on a literature review, it seems likely that there is no broad cognitive deficit in OCD sufferers, but OCD subgroups with impairments in varying areas of cognitive functioning (Hollander, Liebowitz,, & DeCaria, 1989). The hypothesis of OCD subgroups with differing neuropsychological profiles warrants further investigation using large OCD sample sizes.

Taken together, our data suggest rather specific impairments in executive functioning in TTM and OCD. While performance of our TTM participants appeared to be characterized by perseveration in the OAT, OCD participants showed impaired learning from feedback in the WCST. No further statistically significant impairments were found in our clinical groups compared to our HC participants. Thus, based on our data, TTM and OCD participants do not seem to be characterized by comprehensive neuropsychological dysfunctions.

Furthermore, medium-to-large effects for differences between TTM and OCD performance provide evidence for rather distinct neuropsychological profiles for both disorders. Specifically in the WAIS-R block design test and WCST scores, between-group differences of medium effect sizes have been found. In these neuropsychological indices, TTM participants tended to perform slightly superior, while OCD participants tended to show a slightly inferior performance, as compared to our HC participants. This result may strengthen the impression that TTM is less characterized by inferior cognitive functioning than OCD (see Study 2). Further studies directly comparing neuropsychological test performance of TTM and OCD are needed to draw more definitive conclusions.

Our study has some methodological limitations which deserve mention. On the one hand, we have tested numerous hypotheses independently which creates the problem of alpha-

inflation. Thus, the two between-group differences found (even though representing large effects) should be interpreted cautiously. On the other hand, our relatively small sample sizes may have prevented meaningful effects from obtaining statistical significance in other cases. In particular, OCD within-group comparisons are limited by small sample sizes and should be considered preliminary.

Further limitations of our study might be that there were more women in the TTM group than in the OCD and HC group, reflecting the preponderance of females in the TTM population. Our analyses, however, provide no evidence that the significant difference between TTM and HC participants on the OAT was affected by differences in gender ratio.

In addition, our TTM and OCD participants differed significantly from the HC participants in their self-reported depression and anxiety symptom severity, and several suffered from comorbidities. However, individuals with comorbid psychiatric disorders which are thought to potentially impact cognitive functioning (e.g., psychosis, neurological disorders) were excluded from participation. Moreover, both disorders are frequently accompanied by comorbid symptoms and our results might, therefore, resemble the impairment profiles of typical 'non-pure' TTM and OCD sufferers (excepting comorbid TTM and OCD sufferers).

In sum, TTM and OCD do not seem to be characterized by broad neuropsychological deficits but by distinct impairments which appear to be consistent with the key clinical symptoms of each disorder. It seems beneficial for future research and practice to further investigate the potential neuropsychological impairments to enhance understanding of the clinical picture and to deduce effective treatment strategies for each disorder. The neuropsychological profiles of TTM and OCD seem to differ. Our findings, thus, do not provide further evidence for early notions that TTM might be a variant of OCD (Tynes, White, & Steketee, 1990). However, no definite conclusion may be drawn from the data with respect to the assumption that TTM might be part of an obsessive-compulsive spectrum. In TTM and

OCD there is some evidence for executive dysfunction but in both cases different aspects of executive functioning seem to be implicated. This finding might still be compatible with the concept of both disorders being part of an obsessive-compulsive spectrum, since groups on different ends of a spectrum might have similarities and differences. Future studies should further investigate the issue of the best conceptualization of TTM by comparing this disorder with OCD, impulse-control disorders and other disorders characterized by repetitive behaviors.

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Table 5.1

Group Means and Standard Deviations in Visuospatial and Memory Tasks

		TTM (*n* = 22)		OCD (*n* = 21)		HC (*n* = 26)	
Test	Condition	*M*	*SD*	*M*	*SD*	*M*	*SD*
Block Design		38.1	7.2	32.4	8.8	35.7	10.3
		TTM (*n* = 23)		OCD (*n* = 18)		HC (*n* = 26)	
		M	*SD*	*M*	*SD*	*M*	*SD*
RCFT	Copy	32.8	2.1	32.3	2.5	32.5	3.1
	Immediate	21.3	5.7	19.5	6.8	21.0	6.1
	Delay	20.7	6.2	18.1	6.9	20.9	5.9
	Recognition	20.3	1.7	20.3	2.1	20.3	1.7
		TTM (*n* = 23)		OCD (*n* = 19)		HC (*n* = 26)	
		M	*SD*	*M*	*SD*	*M*	*SD*
CVLT	Immediate 1-5	64.2	8.0	64.1	9.3	65.0	9.9
	Short-delay	13.7	2.2	13.3	2.6	13.7	2.6
	Long-delay	14.3	1.9	13.7	2.4	14.1	2.4
	Recognition	15.5	0.8	15.7	0.6	15.5	0.9

Note. RCFT = Rey-Osterrieth Complex Figure Test; CVLT = California Verbal Learning Test. Immediate = immediate recall, Delay = delayed recall; Immediate 1-5 = immediate recall trials 1-5 (total score); Short-delay = short-delayed free recall; Long-delay = long-delayed free recall.

Table 5.2

Group Means and Standard Deviations in Executive Functioning Tasks

		TTM (*n* = 23)		OCD (*n* = 18)		HC (*n* = 26)	
Test	Condition	*M*	*SD*	*M*	*SD*	*M*	*SD*
RCFT	Organization	3.9	1.8	4.0	2.0	3.8	1.9
		TTM (*n* = 23)		OCD (*n* = 19)		HC (*n* = 26)	
		M	*SD*	*M*	*SD*	*M*	*SD*
CVLT	Clustering 1-5	2.9	0.8	2.5	1.1	2.5	0.9
		TTM (*n* = 23)		OCD (*n* = 19)		HC (*n* = 25)	
		M	*SD*	*M*	*SD*	*M*	*SD*
TOH	Trials	3.4	1.3	3.3	1.2	2.9	1.1
	Moves	33.5	19.3	32.7	20.8	26.3	17.5
	Planning time (s)	6.4	10.8	6.6	6.2	3.7	3.5
	Time/move (s)	2.6	1.0	2.6	1.0	2.3	1.1
		TTM (*n* = 22)		OCD (*n* = 20)		HC (*n* = 24)	
		M	*SD*	*M*	*SD*	*M*	*SD*
OAT	Trials	38.4	13.0	39.5	11.5	39.7	12.1
	% Errors	35.6	11.5	34.8	9.2	31.1	10.1
	% Perseveration	16.7_a	7.7	14.0	6.3	11.1_a	6.0

Table 5.2 (Continued)

Test	Condition	TTM (n = 22)		OCD (n = 20)		HC (n = 25)	
		M	*SD*	*M*	*SD*	*M*	*SD*
WCST	Trials	82.3	15.9	88.6	17.3	84.5	17.4
	% Errors	17.0	6.7	21.1	10.7	18.4	9.6
	% Perseveration	9.2	3.2	12.4	8.1	9.6	5.1
	Learning	-0.2	3.4	-2.5_a	5.0	0.2_a	1.9

Note. RCFT = Rey-Osterrieth Complex Figure Test; CVLT = California Verbal Learning Test; TOH = Tower of Hanoi; OAT = Object Alternation Task; WCST = Wisconsin Card Sorting Test. Clustering 1-5 = semantic clustering ratio trials 1-5 (total score); Trials = number of trials; Moves = number of moves; Planning time (s) = average planning time per trial (in seconds); Time/move (s) = average time per move (in seconds); % Errors = percentage of errors; % Perseveration = percentage of perseverative errors; Learning = learning to learn score. Means in the same row that share subscripts differ significantly at $p < .05$, Bonferroni corrected.

6 General Discussion

The aim of this thesis was to explore cognitive functioning in TTM. Research on cognitive functioning has proven fruitful in identifying mechanisms underlying the etiology and maintenance of mental disorders, and although this knowledge has successfully been integrated in treatment concepts (e.g., in phobias; Lavy, van den Hout, & Arntz, 1993), cognitive functioning has rarely been investigated in TTM. In the current investigation, motor inhibition, cognitive inhibition and executive functioning in TTM was compared to the performance of HC individuals and an OCD control group, a disorder thought to share similarities with TTM. Experimental and neuropsychological study designs were applied.

The major findings of the current investigation may be summarized as follows. TTM was found to be characterized by abnormal motor inhibitory functioning. In general, TTM participants tended to perform more impulsively than HC and OCD participants. However, data indicate that performance of the TTM group was heterogeneous ranging from extremely impulsive to non-impulsive/cautious (Study 1). In contrast to OCD, cognitive inhibition abilities were not found to be impaired in TTM. The data also indicate that TTM as well as OCD individuals might be less inclined to ignore negative information than HC individuals (Study 2). Distinct executive functions appeared to be impaired in TTM and OCD, but seemed to be specific to each disorder. TTM was characterized by deficient response flexibility, while in OCD feedback learning was impaired (Study 3).

Conclusions may be drawn from the data with respect to three major aspects: (1) the etiology and maintenance of TTM, (2) the classification of TTM, and (3) the development of effective treatment strategies for TTM sufferers. Each aspect will be discussed integrating the current findings into previous knowledge of TTM.

6.1 Etiology and Maintenance of TTM

Knowledge regarding the etiology and maintenance of TTM is still sparse even though several models have been proposed to explain recurrent hairpulling (Diefenbach et al., 2000). Most of the models are based on phenomenological and/or neurobiological evidence. The findings of the current investigation of cognitive functioning indicate that TTM might be associated with decreased response flexibility, and that impulsivity might be inflated in some but not all sufferers. Furthermore, like other mental disorders, TTM does also seem to be characterized by difficulties disregarding unpleasant information. Due to the preliminary nature of the data, one may only speculate whether and how these abnormalities in cognitive functioning may cause, mediate, and/or aggravate the key clinical symptom of repetitive hairpulling in TTM. Integrating the current findings, one might propose the following hypothetical model of TTM etiology and maintenance:

An individual characterized by an *exaggerated attention towards negative information* is likely to perceive an increased amount of distress. The individual therefore has to manage more severe forms of stress and is more frequently forced to actively reduce an elevated stress level than a healthy individual. Various forms of stress management are conceivable with some of them potentially expressing in clinical symptoms (e.g., abnormal grooming, which is thought to be a form of 'derived activity'; Tinbergen, 1952; Moon-Fanelli, Dodman, & O'Sullivan, 1999).

Inflated impulsivity might increase the preference of stress management strategies that are directly available and immediately effective in reducing aversive affective states even at the cost of moderate self-harm. Under these circumstances, it is conceivable that hairpulling is used to manage elevated forms of stress since the hair is easily accessible, hairpulling has been found to effectively reduce negative affective states (Diefenbach, Mouton-Odum, & Stanley, 2002), and might, like other self-harming behaviors, additionally be positively reinforced by the release of endogenous opioids (Sandmann, Barron, Chicz-DeMet, & DeMet, 1991).

An *impaired response flexibility* might significantly increase the time spent with hair pulling and/or the number of hairs pulled before the individual is able to alternate the ongoing behavior. However, the more time is occupied by hairpulling and/or the higher the number of hairs pulled, the more severe physical and psychological consequences (e.g., bald spots, shame, social anxiety) of hairpulling one may expect. More severe consequences are likely to increase the amount of distress perceived by the hairpuller. At this point, a vicious cycle of 'elevated perceived distress - stress reducing hairpulling - delayed negative consequences - elevation of distress' might come into play.

The model proposed is clearly preliminary and hypothetical. It might be regarded as a first attempt to extend and integrate existing models of TTM etiology and maintenance (e.g., neuroethological perspective, behavioral theories, and neurobiological models; Diefenbach et al., 2000). No conclusions can be drawn from the current data on whether cognitive dysfunctions (if they are indeed present in TTM) are primary or secondary to, or whether they independently co-occur with clinically significant hairpulling. Thus, further studies on cognitive functioning in TTM are necessary to elucidate its role in the initial onset of this disorder.

We also need to consider that TTM is not always triggered by distress and its function does not always seem to be the reduction of negative affective states. In contrast, the motive of hairpulling sometimes seems to be to experience pleasure, which might explain why sedentary situations are frequent triggers of hairpulling (APA, 1994, p.350). A comprehensive model of TTM etiology would have to incorporate this aspect. In addition, inflated impulsivity plays a specific role in the hypothetical model presented. However, the data of the current investigation suggest that some hairpullers seem to have normal levels of impulsivity. This finding might either indicate that impulsivity is generally not important to the etiology of TTM (i.e. independently co-occurs with hairpulling) or, alternatively, this feature is only important to the

etiology in some hairpullers. In the latter case, the presented model may apply to impulsive hairpullers, while another model would have to be generated to explain hairpulling in 'non-impulsive' sufferers.

Anyhow, the current data provide further evidence for TTM being a heterogeneous disorder. Subtypes in TTM have previously been described with respect to its age at onset (early-onset versus late-onset type) and hairpulling triggers (contemplative-sedentary situations versus negative affective states; Keuthen, O'Sullivan, & Jefferys, 1998). The current finding of TTM sufferers being heterogeneous with respect to their individual level of impulsivity seems to harmonize with the earlier descriptions of subtypes. Firstly, the two subgroups identified in the current investigation (impulsive versus non-impulsive) were found to differ significantly in their age at onset (see Study 1). And secondly, a cluster analysis of self-reported hairpulling triggers indicates that the two subgroups also differ in their individual trigger profiles with 'impulsive' hairpullers significantly more often endorsing negative affective states as hairpulling triggers than their 'non-impulsive' counterparts (Bohne et al., 2002). Future research may further investigate subtypes in TTM and implications of heterogeneity for research and practice.

6.2 Classification of TTM

There is considerable discussion about the appropriate classification of TTM (APA, 1994, p. 350). The rationale for the current classification of TTM as an impulse-control disorder is weakened by findings that the tension-relief cycle does not seem to be universal in sufferers from clinically significant hairpulling (Christenson, Mackenzie, et al., 1991; Schlosser et al., 1994). The phenomenological observation seems to be supported by the current experimental data, which indicate that TTM does not seem to be generally accompanied by inflated impulsivity. Alternatively, one may argue that the investigation of motor inhibition in

TTM provides further evidence that impulsivity seems to be a characteristic in at least some sufferers corroborating their classification in the group of impulse-control disorders.

Early notions that TTM might be a variant of OCD (Tynes et al., 1990) are not supported by the current data. Instead, previous knowledge on dissimilarities between the two disorders (e.g., with respect to age at onset, gender distribution, trigger profiles, and the existence of intrusive thoughts; Mackenzie, Ristvedt, Christenson, Lebow, & Mitchell, 1995; Stanley & Cohen, 1999), is extended by evidence that TTM and OCD do not seem to be characterized by similar cognitive functioning deficits. While motor but not cognitive inhibition was found to be abnormal in TTM, the opposite has been found in OCD (Studies 1 and 2). In addition, the neuropsychological performance of TTM and OCD participants appeared rather dissimilar (Study 3). Furthermore, the information processing deficit that was found in both TTM and OCD participants (i.e. a difficulty to disregard unpleasant information) might be rather common in emotional disorders (Study 2). In sum, the comparative investigation of cognitive functioning in TTM and OCD did not reveal additional similarities between the two disorders, which would be expected if TTM was indeed a variant of OCD.

An OC spectrum disorder requires fewer similarities with OCD than an OCD variant. But despite the vague definition of OC spectrum disorders as a group of disorders sharing features such as phenomenology, clinical course, comorbidity, family history, and/or treatment response with OCD (a concept that has been criticized as overinclusive; Rasmussen, 1994), the conceptualization of TTM as an OC spectrum disorder seems questionable. In several of the defined domains fewer similarities between TTM and OCD have been observed than initially thought (Stanley & Cohen, 1999). Moreover, the current data on cognitive functioning do not add any supporting evidence for a joint conceptualization of TTM and OCD.

In conclusion, none of the categorizations discussed seem to be appropriate for TTM, which might be (partly) due to the possible heterogeneous nature of this disorder. Similar to

what is hypothesized in OCD (Hollander et al., 1989), TTM might comprise different subtypes with differing phenomenological features and functional impairments. On the one hand, several sufferers from clinically significant hairpulling satisfy criteria for an impulse-control disorder while others do not (Christenson, Mackenzie, et al., 1991; Schlosser et al., 1994). On the other hand, hairpulling in some sufferers seems more similar to compulsions in OCD than in others (e.g., when hairpulling is triggered by thoughts like "My eyelashes are crooked and they need to be straight."; Mansueto et al., 1997).

The current data seem to add more evidence that TTM is a heterogeneous disorder with respect to both, impulsive and compulsive features. In an analysis of cognitive functioning in two subtypes of hairpullers (based on differing trigger profiles), the performance of one subgroup was characterized by impulsivity while the performance of the other subgroup appeared compulsive resembling earlier findings in OCD (Bohne et al., 2002). This heterogeneity seems to impede an unique classification of TTM. In light of this, suggestions of a dimensional (rather than a categorical) classification, organizing disorders like TTM and OCD on an impulsivity-compulsivity continuum, may be advantageous (Hollander et al., 1996).

6.3 Conclusions on Treatment

Treatment outcome studies in TTM have shown limited efficacy for both behavior and psychopharmacological treatments, especially with respect to long-lasting effects (Jaspers, 1996; Keuthen, Fraim, et al., 2001). Based on the current data it seems important to be aware of potential hairpulling subtypes with different underlying mechanisms and cognitive impairments, which might require differential treatment strategies. Impulsive TTM sufferers, for example, might benefit from behavior therapy strategies that have proven successful in disorders which are characterized by repetitive behaviors elicited by an urge or impulse, like

habit reversal in Tourette's disorder (Wilhelm et al., in press) or even Dialectical Behavior Therapy (Linehan, 1993), which is currently used for the treatment of Borderline Personality Disorder. TTM sufferers, however, who are not characterized by inflated impulsivity might need other treatment elements for improvement depending on the impairment profile characteristic for this subtype. Furthermore, previous research indicates that hairpulling may serve different functions between and within individuals depending on situational context and emotional state (Mansueto et al., 1997). Hairpulling related to specific beliefs (e.g., "The gray hairs have to go.") is likely to require the application of other treatment strategies (e.g., cognitive restructuring; Beck, 1995) than habitual hairpulling that happens out of awareness. And the most effective treatment concept for hairpulling serving a tension-reducing function might differ from the most effective therapy for hairpulling performed to experience pleasure (e.g., motivational strategies currently used in substance abuse treatment might be helpful for the latter; Miller & Rollnick, 1991).

Thus, following general treatment guidelines and applying the same treatment package to a large number of hairpullers likely reduces the efficacy of the treatment because this procedure does not address the specific needs of the individual sufferer (Ninan, Mansueto, Rothbaum, O'Sullivan, & Nemeroff, 1998). Thus, further investigation of the various functions and mechanisms of hairpulling is crucial for the development of effective treatment strategies. The identification and analysis of functions of and impairments in TTM may guide the development of a treatment consisting of various modules that accommodate the specific needs of individuals with the various hairpulling subtypes. Once the modular intervention is developed, clinicians could individualize their treatment plans by selecting specific modules to address the specific impairments of individuals.

6.4 Limitations

The current investigation has some methodological limitations which deserve mention. First of all, sample sizes were relatively small and most of the people recruited participated in all three studies. This means that several hypotheses have been tested on relatively small and almost identical samples. Thus, conclusions based on the current data have to be considered preliminary and replication is needed to allow generalizations. However, the sequences of tests were counterbalanced to control for possible order effects.

Another limitation of the study might be that there were more women in the TTM group than in the OCD and HC group, reflecting the preponderance of females in the TTM population. Our analyses, however, provide no evidence that significant differences between TTM and HC participants were affected by differences in gender ratio.

An additional limitation of the study may be that several of our TTM and OCD participants suffered from comorbid symptoms and were significantly more depressed and anxious than the HC participants (indicated by BDI and STAI scores). The two clinical groups, however, did not differ with regard to the number and severity of self-reported depression and anxiety symptoms. Thus, the specific impairments found in TTM or OCD do not seem to be better accounted for by depression or anxiety per se. Furthermore, individuals with comorbid psychiatric disorders which are thought to potentially impact cognitive functioning (e.g., psychosis, neurological disorders) were excluded from participation. Moreover, both disorders are frequently accompanied by comorbid symptoms and our results might, therefore, resemble the impairment profiles of typical 'non-pure' TTM and OCD sufferers.

6.5 Concluding Remarks

The findings of the current investigation seem to contribute to the understanding of TTM, a common disorder causing significant distress and/or functional impairment. Application of

experimental and neuropsychological designs to TTM, HC and OCD individuals revealed evidence of particular cognitive functioning deficits in TTM that seem to be consistent with its clinical picture. Furthermore, the data support earlier notions of the heterogeneous nature of TTM, which seems to comprise differing hairpulling subtypes. The significant heterogeneity of this disorder challenges its current classification and treatment. Further investigation of the functions and mechanisms of hairpulling is likely to advance treatment efficacy.

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8 Appendix

8.1 Appendix A: Recruitment Information Used

Would you be interested in participating in a Cognitive Functioning Study?

The OCD Clinic at Massachusetts General Hospital/Harvard Medical School is sponsoring a research study. The purpose of this study is to investigate thought processes in people who suffer from trichotillomania (compulsive hairpulling, TTM) or obsessive-compulsive disorder (recurrent obsessions and/or compulsions, OCD). The data from patients will be compared with data from healthy control participants.

As part of this study, you will be asked to complete a number of tasks (mostly paper and pencil tests) that will examine cognitive functions such as memory or planning abilities. You will also be asked to fill out several questionnaires assessing anxiety, mood, TTM, and OCD symptoms. It will take approximately 2.5 to 3 hours to complete all tasks.

[Healthy control participants: You will receive $40 for your participation.]

[Patients: You will receive a diagnostic evaluation at no cost, $20 dollars for your participation and if desired, you can receive feedback about your performance.]

If you are interested in participating please call Antje Bohne at 617-724-4354.

8.2 Appendix B: The Massachusetts General Hospital Hairpulling Scale (MGH-HS)

The Massachusetts General Hospital (MGH) Hairpulling Scale

Instructions: *For each question, pick the one statement in that group which best describes your behaviors and/or feelings over the past week. If you have been having ups and downs, try to estimate an average for the past week. Be sure to read all the statements in each group before making your choice.*

For the next three questions, rate only the urges to pull your hair

1. **Frequency of urges.** On an average day, how often did you feel the urge to pull your hair?

0 This week I felt no urges to pull my hair.
1 This week I felt an **occasional** urge to pull my hair.
2 This week I felt an urge to pull my hair **often**.
3 This week I felt an urge to pull my hair **very often**.
4 This week I felt **near constant** urges to pull my hair.

2. **Intensity of urges.** On an average day, how intense or "strong" were the urges to pull your hair?

0 This week I did not feel any urges to pull my hair.
1 This week I felt **mild** urges to pull my hair.
2 This week I felt **moderate** urges to pull my hair.
3 This week I felt **severe** urges to pull my hair.
4 This week I felt **extreme** urges to pull my hair.

3. **Ability to control the urges.** On an average day, how much control do you have over the urges to pull your hair?

0 This week I could always control the urges, or I did not feel urges to pull my hair.
1 This week I was able to distract myself from the urges to pull my hair **most of the**
2 **time.**
3 This week I was able to distract myself from the urges to pull my hair **some of the**
4 **time.**
This week I was able to distract myself from the urges to pull my hair **rarely**.
This week I was **never** able to distract myself from the urges to pull my hair

For the next three questions, rate only the actual hairpulling.

4. **Frequency of hairpulling.** On an average day, how often did you actually pull your hair?

0 This week I did not pull my hair.
1 This week I pulled my hair **occasionally**.
2 This week I pulled my hair **often**.
3 This week I pulled my hair **very often**.
4 This week I pulled my hair so often it felt like I was **always** doing it.

5. **Attempts to resist hairpulling.** On an average day, how often did you make an attempt to stop yourself from actually pulling your hair?

0 This week I felt no urges to pull my hair.
1 This week I tried to resist the urge to pull my hair **almost all the time**.
2 This week I tried to resist the urge to pull my hair **some of the time**.
3 This week I tried to resist the urge to pull my hair **rarely**.
4 This week I **never** tried to resist the urge to pull my hair.

6. **Control over hairpulling.** On an average day, how often were you successful at actually stopping yourself from pulling your hair?

0 This week I did not pull my hair.
1 This week I was able to resist pulling my hair **almost all of the time**.
2 This week I was able to resist pulling my hair **most of the time**.
3 This week I was able to resist pulling my hair **some of the time**.
4 This week I was **rarely** able to resist pulling my hair.

7. **Associated distress.** Hairpulling can make some people feel moody, "on edge", or sad. During the past week. How uncomfortable did your hairpulling make you feel?

0 This week I did not feel uncomfortable about my hairpulling.
1 This week I felt **vaguely uncomfortable** about my hairpulling.
2 This week I felt **noticeably uncomfortable** about my hairpulling.
3 This week I felt **significantly uncomfortable** about my hairpulling.
4 This week I felt **intensely uncomfortable** about my hairpulling.

8.3 Appendix C: Test Sequences Used

Sequence 1:	*Sequence 2:*	*Sequence 3:*	*Sequence 4:*
Directed Forgetting	CVLT, Part I	Directed Forgetting	CVLT, Part I
OAT	Block Design	OAT	WCST
Digit Span	WCST	Spatial Span	Block Design
TOH	CVLT, Part II	TOH	CVLT, Part II
Spatial Span	RCFT, Part I	Digit Span	RCFT, Part I
RCFT, Part I	GoNogo	RCFT, Part I	Information
Information	Information	GoNogo	Vocabulary
Vocabulary	Vocabulary	Information	Similarities
Similarities	Similarities	Vocabulary	GoNogo
GoNogo	RCFT, Part II	Similarities	RCFT, Part II
RCFT, Part II	OAT	RCFT, Part II	OAT
CVLT, Part I	Spatial Span	CVLT, Part I	Digit Span
WCST	TOH	Block Design	TOH
Block Design	Digit Span	WCST	Spatial Span
CVLT, Part II	Directed Forgetting	CVLT, Part II	Directed Forgetting
Questionnaires	Questionnaires	Questionnaires	Questionnaires

8.4 Appendix D: Instruction Used in the GoNogo Experiment

Practice Block

In the following task we will show you two different stimuli on the screen. Please press the spacebar as quickly as possible whenever you see the

[green square; 'Go' stimulus].

Whenever you see the

[red square; 'Nogo' stimulus]

do not press the spacebar. That's all.

First, let's practice. Please press the spacebar as quickly as possible whenever you see the [green square; 'Go' stimulus] and do not press the spacebar whenever you see the [red square; 'Nogo' stimulus] without making mistakes. In case you do not respond quickly enough to the [green square; 'Go' stimulus] you will hear a feedback tone. Try to avoid the feedback tone at the risk of committing errors. Any questions? Press the spacebar to begin.

Test Blocks

Now we will show you again two different stimuli on the screen. This time please press the spacebar as quickly as possible whenever you see the

['O' respective 'X'; Go stimulus]

and do not press the spacebar whenever you see the

['X' respective 'O'; Nogo stimulus]

without making mistakes. In case you do not respond quickly enough to ['O' respective 'X'; Go stimulus] you will hear a feedback tone. Try to avoid the feedback tone at the risk of committing errors. Any questions? Press the spacebar to begin.

8.5 Appendix E: Word Lists Used in the Directed Forgetting Experiment

Word List 1	*Word List 2*	*Word List 3*	*Word List 4*
Boredom	Binge	Curtain	Bake
Broil	Boiling	Dishwasher	Balding
Bulb	Bottle	Eyebrow	Fry
Damaged	Coarse	Irresistible	Hair
Embarrassment	Cup	Itch	Knife
Glass	Grill	Nervous	Mug
Impulse	Mixer	Pitcher	Pan
Ladle	Scalp	Pluck	Pull
Lamp	Stress	Roast	Refrigerator
Oven	Thinning	Root	Shame
Pick	Towel	Scale	Shelf
Pot	Tray	Simmer	Stroke
Stir	Unattractive	Stove	Tension
Wig	Urge	Touch	Uncontrollable

8.6 Appendix F: Instruction Used in the Directed Forgetting Experiment

Initial Instruction

This is a memory task. I will now show you a list of words on the screen - one at a time. Your task is to memorize each word. I will be testing your memory for these words later. You will have 2 seconds to memorize each word. Do you have any questions?

Forget Instruction

The list you have just seen was only for practice. You can forget these words now. The list you will see next is the one I want you to remember. So forget the practice list and concentrate on memorizing the words I will show you know.

Distractor Task

Now I would like you to cross out every digit '2' printed on this page. Work as quickly as you can without making mistakes. You will have up to 3 minutes. Any questions?

Free Recall

Now I would like you to write down as many words as you can remember from those I showed you earlier, *regardless* of whether the words were from the practice list or from the actual test list. Write down any word that you remember seeing. You can write them down in any order and don’t worry about spelling. You will have up to 5 minutes. Any questions?

Recognition

Now I would like you to circle any word that you remember seeing from the words I showed you earlier, and again *regardless* of whether it was from the practice list or from the actual test list. Again, you will have up to 5 minutes. Any questions?

Emotionality Rating

Now I would like you to rate each of the words in terms of its emotionality - for you personally and not for other people in general. Please try to use the entire rating scale from '-3 = very negative' to '+3 = very positive". You can take as much time as you need. Any questions?

9 Curriculum Vitae

Name: Antje Bohne

Date of Birth: 18.01.1972

Place of Birth: Gütersloh, Germany

Academic Education and Appointments:

1995	First Diploma in Psychology, University of Marburg, Germany
1998	Research Assistant of Prof. Dr. Irmela Florin, University of Marburg, Germany
1998	Diploma in Psychology, University of Marburg, Germany
1999-2002	Visiting Fellow, Harvard Medical School/ Massachusetts General Hospital
1999-2000	Ph.D. Scholarship, Deutscher Akademischer Austauschdienst, Bonn, Germany
2000-2001	Ph.D. Scholarship, University of Marburg, Germany
2001-2002	Research Assistant of Prof. Dr. Sabine Wilhelm and Prof. Dr. Gail Steketee, Harvard Medical School/Massachusetts General Hospital and Boston University, Boston, USA
2002-	Advanced Professional Training in Behavior Therapy, Institut für psychologische Psychotherapieausbildung, University of Münster, Germany
2002-2003	First-Year Resident in Psychology, St. Marien-Hospital Hamm, Clinic for Psychiatry and Psychotherapy/ University of Witten/Herdecke
2002-	Therapist at the Outpatient Program for Psychotherapy, Department of Psychology, University of Münster, Germany
2002-	Tutor, Department of Psychology, University of Münster, Germany

Research Experience:

1999-2000 'Parallel Implicit and Explicit Information Processing in Obsessive-Compulsive Disorder', Primary Investigator: Prof. Dr. Scott Rauch, Harvard Medical School/Massachusetts General Hospital, Boston, USA

1999-2000 'Memory and Confidence in Obsessive-Compulsive Disorder', Primary Investigator: Dr. Thilo Deckersbach, Harvard Medical School/Massachusetts General Hospital, Boston, USA

1999-2000 'Verbal Organization During Learning in Obsessive-Compulsive Disorder and Body Dysmorphic Disorder', Primary Investigator: Prof. Dr. Cary Savage, Harvard Medical School/Massachusetts General Hospital, Boston, USA

1999-2000 'Do All Obsessive-Compulsive Disorder Symptoms Improve with Treatment?', Primary Investigators: Prof. Dr. Sabine Wilhelm and Prof. Dr. Lee Baer, Harvard Medical School/Massachusetts General Hospital, Boston, USA

1999-2001 'Development of Three Alternate Figures for the Rey-Osterrieth Complex Figure Test', Primary Investigator: Prof. Dr. Cary Savage, Harvard Medical School/Massachusetts General Hospital, Boston, USA

2000-2002 'Habit Reversal for Tourette's Disorder', Primary Investigator: Prof. Dr. Sabine Wilhelm, Harvard Medical School/Massachusetts General Hospital, Boston, USA

2000-2002 'Functional Impairment, Interpersonal Relatedness, and Quality of Life in Trichotillomania', Primary Investigator: Prof. Dr. Nancy Keuthen, Harvard Medical School/Massachusetts General Hospital, Boston, USA

2001-2002 'Cognitive Therapy in Obsessive-Compulsive Disorder', Primary Investigators: Prof. Dr. Sabine Wilhelm and Prof. Dr. Gail Steketee, Harvard Medical School/Massachusetts General Hospital and Boston University, Boston, USA

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