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Replacing intrusive thoughts: Investigating thought control in relation to OCD symptoms

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ABSTRACT

Background and objectives: Control of obsessive thoughts in Obsessive Compulsive Disorder (OCD) involves both avoidance and removal of undesirable intrusive thoughts. Thought suppression tasks tap both of these processes but experimental results have been inconsistent. Experimental tasks allowing more focused study of the processes involved in controlling intrusive thoughts may be needed. In two experiments, control over neutral, standardized intrusive and personal intrusive thoughts was investigated as participants attempted to replace them with neutral thoughts.
Methods: Non-selected university students (Experiment 1: $N = 61$) and university students scoring high and low on self-report measure of OC symptoms (Experiment 2: $N = 40$) performed a computerized thought replacement task.
Results: In experiment 1 replacing personal intrusive thoughts took longer than replacing neutral thoughts. Self-reports showed that intrusive thoughts were rated more difficult to replace and were associated with greater thought reoccurrence during replacement, larger emotional reaction and more discomfort. These results were largely replicated in experiment 2. Furthermore, the high OC symptom group experienced greater overall difficulty controlling thoughts on the replacement task, experienced more reoccurrences of personal intrusive thoughts, larger emotional reactions and discomfort associated with them, and felt a greater urge to remove them.
Limitations: All participants were non-clinical university students, and older adults with OCD should be tested.
Conclusions: The findings are in line with cognitive behavioural theories of OCD. They support the usefulness of thought replacement as a research paradigm to study thought control in OCD and possibly other psychological conditions characterized by repetitive thoughts.

1. Introduction

A central assumption in contemporary cognitive behavioural theories of obsessive-compulsive disorder (OCD) is that intrusive thoughts can develop into clinical obsessions if they are appraised as being personally meaningful or significant (Shafran, 2005). Dysfunctional appraisals of intrusions are more likely if people believe that they are responsible for preventing bad things from happening (i.e., inflated responsibility; Salkovskis, 1985, 1998), tend to fuse thoughts with actual actions (i.e., thought-action fusion beliefs) or hold high moral standards (Rachman, 1997, 1998). This will invoke distress, making the thoughts a focus of subsequent control attempts to reduce discomfort and prevent negative outcomes (Rachman, 1997, 1998). The efficiency of such thought control strategies can therefore play a role in the development of obsessions.

Thought suppression (Wegner, 1994; Wegner, Schneider, Carter, & White, 1987; Wenzlaff & Wegner, 2000) is frequently used by OCD patients to try to control obsessive thoughts (Freeston & Ladouceur, 1997; Ladouceur et al., 2000; Purdon, 1999; Purdon,

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Rowa, & Antony, 2007). However, clear empirical support for hypothesized paradoxical effects of suppression on frequency of intrusive thoughts is lacking (Abramowitz, Tolin, & Street, 2001; Magee, Harden, & Teachman, 2012). During thought suppression, participants typically need to keep target thoughts at bay by suppressing them, but also remove the ones that have occurred, without any specific instructions for how to do so. The frequency of thought intrusions may therefore reflect poor suppression abilities, poor removal abilities, problems with selecting appropriate strategies or all three. Experimental tasks allowing for more focused study of processes involved in controlling intrusive thoughts are needed to gain insight into the nature of thought control problems in OCD. Clark (2004) and Purdon, Gifford, McCabe, and Antony (2011) have pointed out that *thought removal* may provide an alternative way of investigating dysfunctional thought control in OCD. In a thought removal task, participants are asked to form a target thought, keep it in mind for a short while and to indicate when they have either dismissed it from their mind (thought dismissal) or replaced it with another thought (thought replacement). Longer dismissal or replacement times are indicative of difficulty with controlling the thought.

This relatively simple task has only been used in three studies to date, but has yielded interesting results. Sutherland, Newman, and Rachman (1982) compared thought dismissal times of personal intrusive and neutral thoughts under both happy and sad mood-induction conditions, in two non-clinical samples of 32 and 16 participants. Thought dismissal times were significantly longer for intrusive compared to neutral thoughts, particularly following sad compared to happy mood-induction. Edwards and Dickerson (1987) found for 43 non-clinical participants, that neutral thoughts were more difficult to form following intrusive compared to neutral thoughts, indicating that people may find disengaging attention from intrusive thought material more difficult. Finally, Purdon et al. (2011) investigated replacement of intrusive thoughts in a sample of 25 OCD patients and 25 Panic Disorder patients, using a modified computerized version of the Edwards and Dickerson (1987) task. The task consisted of two 8 min intervals where participants could think what they liked, but had to signal by key-press when a target thought came to mind, and when it had been replaced with a neutral thought. Purdon et al. (2011) measured the frequency of target-thought occurrences, target-thought replacement time, time between occurrences of the target thought and the total thought duration. They found that although OCD patients did not show significantly longer thought replacement times, their thought occurrences were more frequent and target thought duration was longer.

Thus, preliminary evidence supports the usefulness of experimental paradigms involving thought replacement but only three studies have been conducted to date with varied methodology. More studies are needed to both address methodological limitations of previous studies and to strengthen the relevance of the thought replacement paradigm for OCD. For example, subjects in the Sutherland et al. (1982) study were acquaintances, friends and colleagues that were tested face-to-face and a hand held stopwatch was used to measure thought dismissal times. Whereas Edwards and Dickerson (1987) measured thought formation and replacement times in a more accurate way in a university student sample, they did so in a face-to-face testing session. Although the findings from these two studies support the notion that personal intrusive thoughts are more difficult to remove than neutral ones, this needs to be replicated in independent samples using experimental setups reducing the risk of demand characteristics that may be elevated during face-to-face testing. It also remains to be seen whether observed differences in control of intrusive compared to neutral thoughts are related to measures of OCD pathology. Although Purdon's et al. (2011) study counters some of these limitations, replacement of intrusive and neutral thoughts was not compared. Cognitive theories of OCD (e.g., Rachman, 1998; Salkovskis, 1998) predict that the transition from normal intrusive thought to obsession can be explained by dysfunctional appraisals of the nature and meaning of the intrusive thought resulting in greater emotional reactions and thought control difficulties. A critical step in testing these predictions may be to compare removal of neutral and intrusive thoughts, both in non-clinical subjects and in subjects differing in levels of OCD psychopathology.

The present set of experiments was designed to do this by using both non-selected and an analogue sample of students having high or low OC symptom scores. We used the thought replacement paradigm to test predictions drawn from contemporary cognitive behavioural theories on control of intrusive thoughts. A thought replacement rather than a thought dismissal task was chosen, because signalling when a thought has been dismissed can lead to the reactivation of the thought (Clark, 2004). A critical test was to compare personal intrusive thoughts to neutral thoughts to see if control over personal intrusive thoughts would be more difficult as indexed by replacement times. We also included a standardized intrusive thought with an OCD relevant theme (hitting a young girl with your car and causing minor injury) to test whether expected differences between intrusive and neutral thoughts would depend on the fact that personal intrusive thoughts are idiosyncratic in nature and participants may differ in their prior experiences with the thoughts. Multiple indicators of replacement difficulty (i.e., replacement times, estimated replacement difficulty and reoccurrence of thoughts) were used to obtain varied assessment of thought control. These methodological changes were made to further strengthen the methodological basis of the thought replacement research paradigm as a tool to study thought control in OCD.

2. Experiment 1

Based on the evidence reviewed above we predicted that both personal intrusive and standardized intrusive thoughts would be more difficult to control than a neutral thought and that this would be evident in longer thought replacement times and greater subjective estimates of replacement difficulty. Based on studies of intrusive thoughts in the general population (Freeston, Ladouceur, Thibodeau, & Gagnon, 1991; Rachman & de Silva, 1978; Salkovskis & Harrison, 1984), it was also expected that personal and standardized intrusive thoughts would invoke stronger subjective emotional reactions and discomfort compared to neutral thoughts (see also Rowa & Purdon, 2003). Finally, because emotional thought material is more likely to intrude into awareness than neutral material, personal and standardized intrusive thoughts were expected to intrude or reoccur more often than neutral thoughts after being replaced.

There is some evidence of gender differences in thought control studies (e.g., Rutledge, 1998) and we therefore recruited only females for experiment 1 because analyses by gender would require larger samples.

2.1. Method

2.1.1. Participants

Participants were students that responded to an advertisement sent via email to all female students at the University of Iceland. In total, 61 females participated. Their mean age was 32.44 years (SD = 11.54; ranging from 20 to 61) year. Participants were paid 1000 ISK (approx. €7).

2.1.2. Materials[1]

2.1.2.1. Self-report measures. Symptoms of OCD were measured with the *Obsessive Compulsive Inventory-Revised* (OCI-R; Foa et al., 2002) that assesses distress and interference related to OCD symptoms during the past month. The OCI-R is a reliable and valid measure of OCD symptoms (Abramowitz & Deacon, 2006; Foa et al., 2002) and the Icelandic translation has good psychometric properties in non-clinical samples (Smári, Ólason, Eyþórsdóttir, & Frölunde, 2007). The mean total score in the present sample was 20.16 ($SD = 13.66$). The internal consistency was very high ($\alpha = .93$). OCD related beliefs and assumptions concerning responsibility/threat, perfectionism/uncertainty and thoughts/thought control were assessed with the *Obsessive Beliefs Questionnaire-44* (OBQ-44; Obsessive Compulsive Cognitions Working Group, 2005). Internal consistency of the OBQ-44 total score was excellent ($\alpha = .96$). The mean total score was 145.00 ($SD = 52.38$). The Icelandic translation of the OBQ-44 has adequate psychometric properties in non-clinical samples (Pétursdóttir, 2008). Immediate appraisals and interpretation of distressing target intrusive thoughts (which were used in the study) were assessed with the Interpretation of Intrusions Inventory (III; Obsessive Compulsive Cognitions Working Group, 2005). In the III, respondents read a definition of unwanted intrusions and are given illustrative examples. They then write down two of their recent intrusions (only one here) and then rate their frequency and associated distress and rate 31 statements concerning importance of the thought, thought control and responsibility. The internal consistency of the III total score was excellent ($\alpha = .95$), and the mean was 1090.00 ($SD = 625.40$). The psychometric properties of the Icelandic translation are currently under study (Ólafsson, Emmelkamp, Kristjánsson, & Ólason, 2012). Symptoms of anxiety and depression were measured with the Hospital Anxiety Depression Scale (HADS; Zigmond & Snaith, 1983), a self-report questionnaire with two seven-item subscales for anxiety and depression symptoms. The Icelandic translation has good psychometric properties (Smári, Ólason, Arnarson, & Sigurðsson, 2008). Internal consistency of the anxiety and depression scales in the present study was .82 and .73 and the mean scores were 8.46 ($SD = 4.07$) and 4.51 ($SD = 4.02$) respectively.

2.1.2.2. Measurement during the thought replacement task. Following each thought replacement block (see below), participants filled in a questionnaire (thought replacement task questionnaire) containing questions concerning thought reoccurrences during the task, replacement difficulty, thought characteristics, and estimates of emotional reactions and level of discomfort associated with the thoughts. Participants were asked to estimate how often on average the target thought had reoccurred when holding the replacement thought in mind, and how easy it was to replace the thought by making a mark on a 100 mm line on visual analogue scale (VAS) with anchors at both ends (Not at all easy vs. Very easy). They also indicated how vivid, real and picture like the first and the second thoughts were (*On average, how easy was it to visualize the first* [or second] *thought? The thought was …)*, on similar VAS scales (Not at all vivid/real/picture like vs. Very vivid/real/picture like). Emotional reactions to the thoughts (*On average, how strong were the emotional reactions to the first* [or second] *thought?*) and their discomfort (*On average, how uncomfortable was the first* [or second] *thought?*) were also rated on VAS scales (anchors: Not at all/Not at all uncomfortable vs. Very much/Very uncomfortable).

2.1.3. Apparatus

A PC with a 15-inch monitor was used to present the thought replacement task.

2.1.4. Procedure

The study was reported to the Data Protection Authority of Iceland and approved by the National Bioethics Committee. Participants were tested individually in 80–100 min sessions in a quiet room. Upon arrival, participants received information about the experiment and signed informed consent. After completing the questionnaires in a fixed order, participants were seated in front of a computer in a sound-proof booth, where they completed the thought replacement task. The task was programmed in E-Prime 2.0 and followed the description of the task used by Edwards and Dickerson (1987). There was a practice phase and a test phase containing three separate blocks. The blocks were defined by the type of target thought that participants had to replace during the block (neutral, personal intrusive, standardized intrusive, see Table 1). The target thought in the standard intrusive block was selected to be OCD relevant, involving an accident involving responsibility for harming others (i.e. You hit a six-year old girl with your car). The personal intrusive thought was the intrusion participants had listed on the III questionnaire. The neutral target thought involved a non-emotional every-day activity (i.e. You are bicycling). The replacement thought was a neutral thought and was the same thought in all three blocks (i.e. You are sitting on a bench, waiting for the bus to arrive.). During all parts of the task, participants had to form a thought (target thought), hold it in mind, then replace it by forming another thought (replacement thought) and hold that thought in mind. During the practice phase the experimenter read a description of the task to the participant. In the practice phase the target thought was the number *1* and the replacement thought the number *2*. A sound cue and a black computer screen were used to signal to the participant when to start forming the target thought. When the thought was clearly in mind, participants pressed a key on the computer keyboard. The interval from the sound cue to the key-press measured thought formation time. At key-press, the screen turned grey, indicating that participants should hold the thought in mind (thought retention period). After 15 s, the sound cue appeared again and the screen turned black indicating the participants should form the replacement thought. When the replacement thought was clear in

Table 1
Target thoughts and replacement thought in the three experimental blocks of the thought replacement task in experiment 1 and 2.[a]

Personal intrusive block (P)	
Target thought: The thought rated on the III questionnaire.	*Replacement thought*: You are sitting on a bench, waiting for the bus to arrive. You are not in any hurry.
Standardized intrusive block (S)	
Target thought: You hit a six-year old girl with your car. She gets a big bleeding cut on her forehead but no terminal damage.	*Replacement thought*: Same as above.
Neutral block (N)	
Target thought: You are bicycling when you see a middle aged man with a green scarf. You don' know the man at all.	*Replacement thought*: Same as above.

[a] Presentation of the blocks was counterbalanced between participants by using the following six sequences: 1. N-S-P; 2. N-P-S; 3. S-N-P; 4. S-P-N; 5. P-N-S; 6. P-S-N.

[1] Two neuropsychological tests and two self-report questionnaires, that are used in a number of studies conducted in our laboratory, were administered in this experiments but will not be analysed here. The tests are the AB-AC paired associates test, that was administered at the end of the testing session, and the Word Fluency Test that was administered at the beginning of the testing session. The questionnaires are the Attentional Control Scale (ACS) and the Barratt Impulsiveness Scale (BIS-11).

mind, they pressed the same key and the screen turned grey indicating they should try to hold the thought in mind (thought retention period). This second interval from the sound cue to the key-press measures thought replacement time. Fifteen seconds later, a message appeared indicating that this task round was finished. The practice phase consisted of two rounds but each of the three blocks in the test phase consisted of six consecutive rounds. Thus, during the test phase of the task, participants replaced the same type of target thought six times before moving on to the next block with a different type of target thought. Each block started with the experimenter describing the thoughts that participants should work with, first the replacement thought, then the target thought (repeated once). Then, the researcher left the room returning when the block was finished to administer the thought replacement questionnaire for that block. The blocks (neutral, standardized intrusive, personal intrusive) were presented in counterbalanced order between participants.

2.1.5. Statistical analysis

SPSS 19 was used for all statistical analyses. ANOVA's for repeated measures were used to test main effects and were followed up with one-tailed paired-samples *t* tests since the direction of observed differences was predicted beforehand in accordance with previous studies and available theories. Significance levels were set at $\alpha = .05$ in all analyses.

2.2. Results

2.2.1. Thought characteristics and thought formation times

Three repeated-measure ANOVA's with thought-type as a factor assessed ratings of how vivid, real and picture-like the thoughts were. No significant differences between the thoughts on any of the three measures were found ($ps > .05$). Formation times for the first thoughts were analysed with a repeated-measure ANOVA with type of first thought as within-subject factor. Reaction time measures were averaged within block followed by a logarithmic transformation to reduce positive skew. The main effect of thought-type was not significant, $F(2, 120) = .369$, $p = .692$. In sum, the neutral, standardised intrusive and personal intrusive thoughts in the thought replacement task were comparable in formation latencies and how vivid, real or picture-like they were.

2.2.2. Thought replacement times and replacement difficulty

According to our hypotheses, replacement times should be longer following standardized and personal intrusive thoughts than neutral ones, indicating greater replacement difficulty. A repeated-measures ANOVA tested this with thought-type to be replaced (neutral vs. standardized intrusive vs. personal intrusive) as within-subject factor. Reaction time measures were averaged within-block and a logarithmic transformation corrected positive skew (raw replacement times are reported in the Appendix). There was a marginally significant main effect of thought-type, $F(2, 120) = 2.57$, $p = .081$ partial $\eta^2 = .04$. Paired-samples *t* tests (one tailed) showed that, compared to neutral thoughts, replacement time was significantly longer following personal intrusive, $t(60) = -2.21$, $p < .05$, but not standardized intrusive thoughts, $t(60) = -.72$, $p = .238$ (Fig. 1a). A similar analysis of participant' evaluation of replacement difficulty showed a significant main effect of thought-type, $F(2, 120) = 9.74$, $p < .001$, partial $\eta^2 = .14$, and paired-samples *t* tests (one tailed) showed that personal intrusive, $t(60) = -4.14$, $p < .001$, and standardized intrusive thoughts, $t(60) = -3.80$, $p < .001$, were rated more difficult to replace than neutral thoughts (Fig. 1b).

2.2.3. Thought reoccurrence

According to our hypotheses, both personal and standardised intrusive thoughts should reoccur more frequently than neutral thoughts, after being replaced. A repeated-measures ANOVA with thought-type as within-subject factor and estimated number of thought reoccurrence as the dependent variable showed a significant main effect of thought-type, $F(2, 120) = 6.79$, $p < .01$, partial $\eta^2 = .10$. Paired-samples *t* tests (one tailed) showed that both personal intrusive, $t(60) = -3.35$, $p < .01$, and standardised intrusive thoughts, $t(60) = -2.69$, $p < .01$, reoccurred more frequently than neutral thoughts (Fig. 1c).

2.2.4. Reactions to thoughts

We analysed participants' ratings of thought-elicited emotional reactions and how uncomfortable they were. Two repeated-measure ANOVAs revealed significant main effects of thought-type on emotional reactions, $F(2, 120) = 23.82$, $p < .001$, partial $\eta^2 = .28$, and discomfort, $F(2, 120) = 97.27$, $p < .001$, partial $\eta^2 = .62$. Paired-samples *t* tests (one tailed) revealed that both standardised intrusive, $t(60) = -5.08$, $p < .001$, and personal intrusive thoughts, $t(60) = -7.02$, $p < .001$, were associated with stronger emotional reactions than neutral thoughts. Standardised intrusive, $t(60) = -11.94$, $p < .001$, and personal intrusive thoughts, $t(60) = -12.32$, $p < .001$, were also associated with greater discomfort than neutral thoughts (Fig. 1d).

2.2.5. Correlational analyses

The relationships between emotional reactions elicited by the thoughts and how uncomfortable they were, thought replacement times, replacement difficulty and thought reoccurrence, were investigated with Pearson product–moment correlation coefficients (Table 2). Greater emotional reactions and discomfort ratings were associated with greater replacement difficulty and more thought reoccurrence for standardized and personal intrusive thoughts. This relationship was weaker and less consistent for neutral thoughts. Also, for personal intrusive thoughts, replacement times became longer with greater emotional reactions and discomfort.

2.2.6. Relationship with anxiety, depression and OCD pathology

There were no significant relationships between symptoms of anxiety and depression (HADS) and thought formation and replacement times (r from .04 to .24, $ps > .05$), ratings of replacement difficulty, thought reoccurrences, emotional reactions or discomfort (rs from .05 to .25, $ps > .05$). Self-report measures of OCD pathology (OCI-R, OBQ-44 and III total scores) were generally not related to replacement times or ratings of replacement difficulty and thought reoccurrence. However, scores on the obsessing subscale of the OCI-R correlated with emotional reactions and discomfort ratings for personal intrusive thoughts (in both cases $r = .26$, $p < .05$). Also, the total score ($r = .29$, $p < .05$), and scores on the perfectionism/certainty ($r = .25$, $p < .05$) and importance of thoughts and thought control ($r = .35$, $p < .01$) subscales of the OBQ, were related to emotional reactions and discomfort ratings for personal intrusive thoughts.

2.3. Discussion

The results support the hypothesis that intrusive obsessive-like thoughts are more difficult to control than neutral thoughts. Compared to neutral thoughts, personal intrusive thoughts took longer to be replaced and both personal and standardized intrusive thoughts were experienced as more difficult to replace and to reoccur more often while being replaced. The main effect of thought type on replacement time was marginally significant

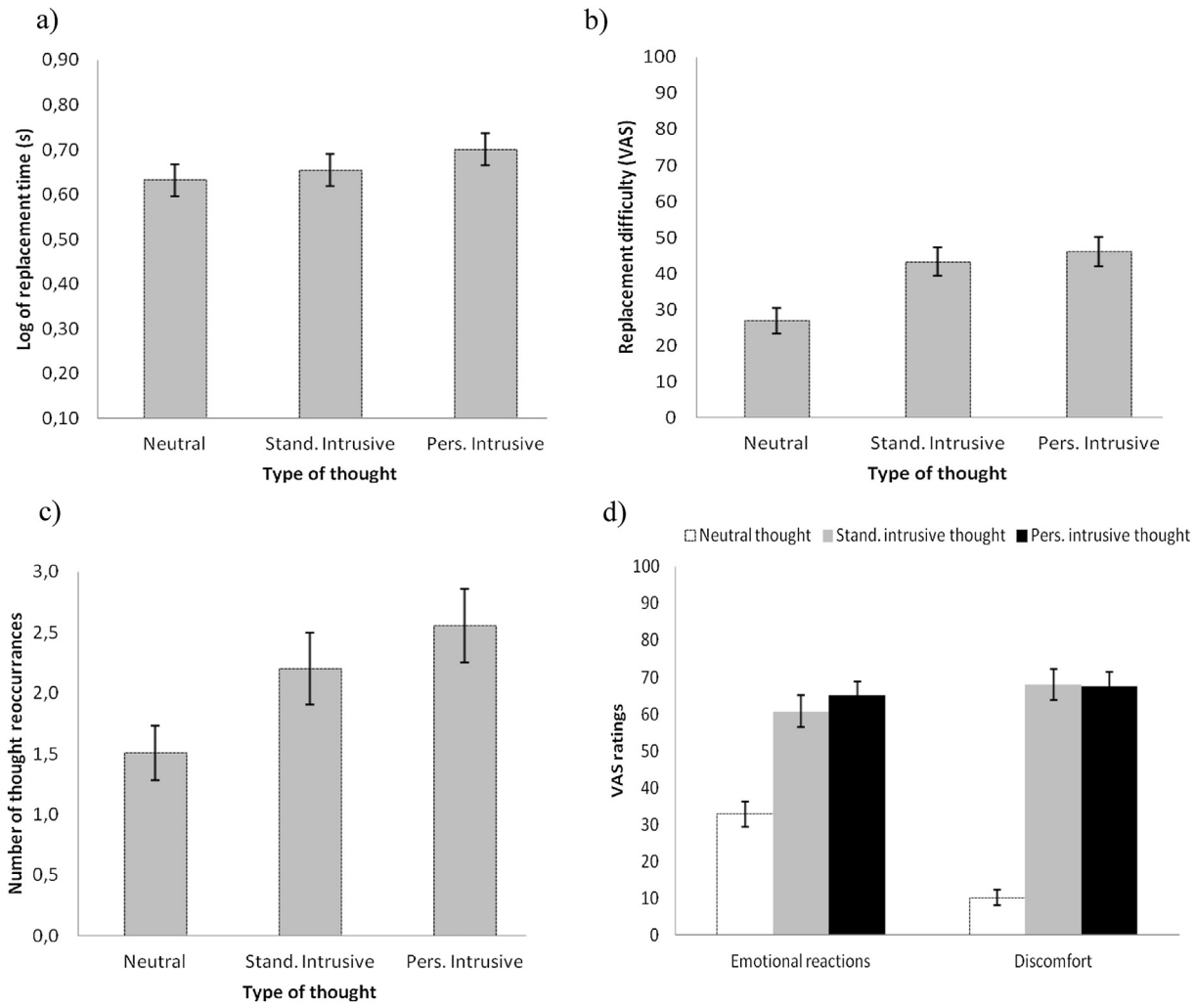

Fig. 1. Results from the thought replacement task in experiment 1, where participants formed a neutral, standardised intrusive and personal intrusive target thought and replaced it with a neutral thought: a) Log transformed mean replacement times; b) subjective estimates of replacement difficulty; c) estimated number of reoccurrences of target thoughts while being replaced; d) estimated emotional reactions and discomfort ratings for the target thoughts. Error bars represent one standard error.

($p = .081$) but results of specific comparisons were according to predictions. Both personal and standardized intrusive thoughts were rated as eliciting greater emotional reactions and discomfort. Formation times did not differ between thoughts nor were there any differences in their vividness, reality or picture-like qualities. This indicates that the observed differences between obsessive-like and neutral thoughts do not reflect slower overall reactions on blocks containing negative material in the case of thought replacement times of personal intrusive vs. neutral thoughts. Neither can emotional reactions, discomfort ratings or replacement difficulty be explained by differences in image characteristics (vividness, reality, picture like qualities) between thought types. Correlational analyses revealed a more consistent pattern between subjective indices of thought control (estimated difficulty and reoccurrences) and estimated emotional reactions and discomfort for personal intrusive compared to neutral thoughts. This suggests that emotional thoughts are more difficult to control. This is further supported by the finding that increased subjective emotional reactions and discomfort ratings were associated with longer replacement times for personal intrusive thoughts. However, no systematic associations were found between indices of thought control and levels of OC symptoms and beliefs as would be expected from the appraisal account of thoughts in cognitive behavioural theories of OCD (e.g., Rachman, 1998; Salkovskis, 1998).

Table 2
Correlations between emotional reactions and discomfort ratings with indices of thought control by thought type in experiment 1 ($N = 61$).

	Emotional reactions	Discomfort
Neutral thought		
Replacement time	.09	.04
Replacement difficulty	.12	.34**
Reoccurrence	.25	.20
Standardized intrusive thought		
Replacement time	.19	.13
Replacement difficulty	.56***	.42**
Reoccurrence	.51***	.41**
Personal intrusive thought		
Replacement time	.42**	.43**
Replacement difficulty	.35**	.37**
Reoccurrence	.38**	.36**

*$p < .05$; **$p < .01$; ***$p < .001$ (two-tailed).

3. Experiment 2

With experiment 2, we sought to replicate the results from experiment 1 and extend their clinical relevance. In experiment 1,

measures of OC pathology did not correlate with replacement times and ratings of replacement difficulty or reoccurrence of personal intrusive thoughts. Diary and interview studies show that OCD patients frequently use thought replacement to control their thought intrusions, but without much success (Ladouceur et al., 2000; Purdon et al., 2007). It may be that replacement difficulties are only observed at the more extreme end of OC pathology. Purdon et al. (2011) observed greater, yet non-significant, thought replacement times in their sample of OCD patients compared to patients with panic disorder, but thought reoccurrences were significantly greater in the OCD group. It remains to be shown that greater replacement difficulties (i.e., longer replacement times, greater estimated difficulty or thought reoccurrences) associated with intrusive compared to neutral thoughts, characterize those who have more OC symptoms or the full diagnosis of OCD. We investigated this in experiment 2 by testing university students with either high or low levels of OC symptoms.

We followed the same general procedure and task setup as in experiment 1 with the minor modifications described below. We expected to see longer replacement times for standardized and personal intrusive, than for neutral thoughts. Such differences were also expected for subjective estimates of replacement difficulty and thought reoccurrence, and for emotional reactions and discomfort. We measured the urge to remove, or stop having, the target thought, to assess the level of avoidance tendencies elicited by the thoughts. Since participants with high OC symptoms were also expected to hold stronger OCD related beliefs (responsibility, importance of thoughts and thought control, perfectionism), we predicted that the high OC group would experience greater thought control difficulties than the low OC group on indices of thought control concerning standardized and personal intrusive thoughts (i.e., longer replacement times, greater estimated replacement difficulty, greater reoccurrences) but not neutral thoughts. An interaction between thought-type and symptom group was therefore expected. The same predictions were made for negative emotional reactions, discomfort and the urge to remove the thoughts.

3.1. Method

3.1.1. Participants

Forty students at the University of Iceland (32 females) participated (age range: 20 to 64; $M = 31.2$, $SD = 10.22$). Initially, 556 students responded to an email sent to all students at the University of Iceland ($n \approx 7.500$) where they were invited to answer the OCI-R, over the Internet. Of those, 259 agreed to be contacted regarding participation in a related study. A quartile split was performed on their OCI-R scores and participants in the highest ($n = 61$, OCI-R total score ≥ 22) and lowest ($n = 68$, OCI-R total score ≤ 9) quartiles were contacted via email. Two reminders were sent and recruitment ended when 20 participants had been recruited from each group. They received 1000 ISK (approx. € 7) for participation.

3.1.2. Materials[2]

3.1.2.1. Self-report measures. In addition to the questionnaires used in experiment 1, we used the Dimensional Obsessive-Compulsive Scale (DOCS; Abramowitz et al., 2010) to measure severity of OCD symptoms. The Icelandic version of the DOCS has good psychometric properties in non-clinical samples (Ólafsson, Arngrímsson, et al., 2013). In the present study, the internal consistency of the total score was excellent ($\alpha = .93$).

3.1.2.2. Measurement during thought replacement task. A revised version of the thought replacement task questionnaire used in experiment 1 was administered after each block. The question concerning reoccurrence of target thought was made more precise (*How often on average did the first thought come to mind when you were to think the second thought* (i.e. during the period when you started calling the second thought to mind and then holding it in mind)). This was done to make it clear that the period included both the thought replacement phase and the thought retention phase. All ratings concerning the replacement thought (thought characteristics, emotional reactions, level of discomfort) were dropped to reduce the number of questions and make the questionnaire more focused on the target thoughts. The question about emotional reactions invoked by the target thought was made more precise by specifying that it referred to negative emotional reactions (*On average, how strong negative emotional reactions did the first thought invoke?*). Finally, one question was added to assess the urge to remove the target thought (*On average, how much did you want to remove or stop thinking the first thought?*).

3.1.3. Procedure

The same procedure was followed as in experiment 1, except that, instead of each block consisting of six rounds of target thought-formation and replacement, each block consisted of four rounds in this experiment. Questions in the thought replacement task questionnaire require participants to base their responses on average ratings of all rounds within each block and we hoped to make this evaluation easier and more accurate. The blocks were presented in counterbalanced order between participants.

3.1.4. Statistical analysis

Mixed ANOVA's were used to test main effects and interactions, and were followed up with one-tailed t tests since the direction of observed differences was predicted beforehand. Significance levels were set at $\alpha = .05$ in all analyses.

3.2. Results

3.2.1. Group assignment

Table 3 shows descriptive statistics by groups for age and self-report questionnaires in experiment 2. T-tests revealed significant differences between groups on all self-report measures ($ps < .01$) except HADS depression ($p = .534$). The Cohen' d effect-sizes

Table 3
Descriptive statistics by obsessive-compulsive symptom groups for demographics and self-report questionnaires used in experiment 2.

	OC symptom groups				
	Low ($n = 20$)		High ($n = 20$)		Cohen'
	M	*SD*	*M*	*SD*	*d*
Age	33.45	12.58	28.95	6.74	.47
OCI-R	8.95	4.78	30.00	21.05	1.63
DOCS	4.95	5.50	21.05	7.72	2.44
OBQ-44	95.15	23.97	157.30	37.98	2.01
III	589.50	409.34	1228.50	676.33	1.18
HADSanx	3.75	3.18	9.30	4.33	1.48
HADSdep	2.35	3.25	2.90	2.20	.20

Note: OCI-R = Obsessive Compulsive Inventory-Revised total score; DOCS = Dimensional Obsessive Compulsive Scale total score; OBQ-44; Obsessive Beliefs Questionnaire-44 total score; III = Interpretation of Intrusion Inventory total score; HADSanx = Hospital Anxiety and Depression Scale anxiety score; HADSdep = Hospital Anxiety and Depression Scale depression score.

[2] In this experiment, the Word Fluency Test that was administered at the beginning of the testing session and the Attentional Control Scale (ACS) were included in the self-report questionnaire booklet, but will not be analysed here.

measure (Cohen, 1988) was large in all cases ($d \geq 1.18$). The groups did not differ significantly in age ($p = .170$).

3.2.2. Thought characteristics and thought formation times

Given high correlations between ratings within each thought-type of vividness and how real and picture like the thoughts were (r' (low-high) for neutral = .67–.87; standardized intrusive = .70–.80; personal intrusive = .74–.83), ratings were collapsed within each thought-type. A mixed ANOVA revealed a significant main effect of thought-type, $F(2, 76) = 7.18$, $p < .01$, partial $\eta^2 = .16$, and an interaction between thought-type and group, $F(2, 76) = 5.52$, $p < .01$, partial $\eta^2 = .13$, but the main effect of group was not significant, $F(1, 38) = .196$, $p = .660$. Follow up repeated-measures ANOVAs showed that the main effect of thought-type was significant in the low symptom group, $F(2, 38) = 8.32$, $p < .01$, partial $\eta^2 = .31$. Bonferroni corrected pairwise comparisons showed that mean scores were significantly higher for neutral ($M = 78.33$, $SD = 21.97$) compared to standardized ($M = 66.01$, $SD = 27.02$) and personal intrusive ($M = 54.91$, $SD = 71.45$) thoughts ($ps < .05$) but standardized and personal intrusive thoughts were not significantly different ($p = .272$). The main effect of thought-type was not significant in the high symptom group, $F(2, 38) = 2.60$, $p = .09$ (Neutral thought: $M = 72.95$, $SD = 22.31$; Standardized intrusive thought: $M = 64.08$, $SD = 24.54$; Personal intrusive thought: $M = 71.45$, $SD = 21.31$).

For thought formation times, there was no main effect of either thought-type, $F(2, 76) = .573$, $p = .566$, or group, $F(1, 38) = 2.54$, $p = .119$, nor a thought-type by group interaction, $F(2, 76) = 2.03$, $p = .138$.

3.2.3. Thought replacement times and replacement difficulty

As before, reaction times were first averaged within block followed by a logarithmic transformation to correct positive skew (raw formation and replacement times are reported in the Appendix). A mixed ANOVA showed a marginally significant main effect of thought-type on replacement time, $F(2, 76) = 3.09$, $p = .051$, partial $\eta^2 = .08$, in line with experiment 1. Paired-samples t tests (one tailed) showed that replacement times were longer following standardized, $t(39) = -2.27$, $p < .05$, and personal intrusive thoughts, $t(39) = -1.98$, $p < .05$, compared to neutral thoughts (Fig. 2a). Neither the main effect of group, $F(1, 38) = 2.04$, $p = .162$, nor the thought-type by group interaction, $F(2, 76) = .46$, $p = .633$, were significant.

A mixed ANOVA with replacement difficulty as dependent variable showed a significant main effect of thought-type, $F(2, 76) = 5.48$, $p < .01$, partial $\eta^2 = .13$, and of group, $F(1, 38) = 12.10$, $p < .01$, partial $\eta^2 = .25$, but there was no thought-type by group interaction, $F(2, 76) = 1.44$, $p = .244$. For thought-type, paired-samples t tests (one tailed) showed that both standardized, $t(39) = -1.74$, $p < .05$, and personal intrusive thoughts, $t(39) = -2.85$, $p < .01$, were rated more difficult to replace than neutral thoughts (Fig. 2b). The main effect of group reflected greater overall replacement difficulty in the high ($M = 41.38$, $SE = 3.60$) compared to the low ($M = 23.69$, $SE = 3.60$) OC symptom group.

3.2.4. Thought reoccurrence

One participant in the high-symptom group reported extremely high estimates of frequency of standardized and personal intrusive thoughts (more than 3 SD from the mean on each) and was therefore removed from analyses of thought reoccurrences. The distribution of reoccurrences of all thought types was positively skewed and was logarithmically transformed. A mixed ANOVA with thought-type and group as factors, showed a significant main effect of thought-type on reoccurrence, $F(2, 74) = 6.25$, $p < .01$, partial $\eta^2 = .14$, replicating experiment 1. The main effect of group was not significant, $F(1, 37) = 2.64$, $p = .07$, but the thought-type by group interaction was significant, $F(2, 74) = 3.51$, $p < .05$, partial $\eta^2 = .09$. Comparing reoccurrence between groups within thought-type, using independent-samples t tests (one tailed), showed no differences for neutral, $t(37) = .37$, $p = .357$, or standardized intrusive thoughts, $t(37) = -1.60$, $p = .06$, but significant group differences for personal intrusive thoughts, $t(37) = -2.42$, $p < .05$ (Fig. 2c).

3.2.5. Reactions to thoughts

A mixed ANOVA with negative emotional reactions to the thoughts as dependent variable showed a significant main effect of thought-type, $F(2, 76) = 81.71$, $p < .001$, partial $\eta^2 = .68$, and group, $F(1, 38) = 14.56$, $p < .001$, partial $\eta^2 = .28$, which was qualified by a significant interaction, $F(2, 76) = 6.14$, $p < .01$, partial $\eta^2 = .14$. Group comparisons with independent-samples t tests (one tailed) showed no differences for neutral thoughts, $t(38) = -.63$, $p = .268$, but significant group differences for standardized, $t(38) = -2.85$, $p < .01$, and personal intrusive thoughts, $t(38) = -3.61$, $p < .01$ (Fig. 2d). The same pattern emerged for analyses of discomfort ratings and urge to remove the thoughts (data not shown).

3.2.6. Correlational analyses

For personal intrusive thoughts, indices of thought control showed strong positive correlations with estimated emotional reactions, discomfort and urge to remove, but not with removal time. This pattern was less clear for indices of control of neutral and standardized intrusive thoughts, although emotional reactions and the urge to remove were related to greater removal time of neutral thoughts and discomfort and urge to remove were related to greater reoccurrence of standardized intrusive thoughts (Table 4).

There was no significant relationship between self-report measures of OCD pathology (OCI-R, DOCS, OBQ-44 and III total scores) and indices of thought control for neutral and standardized intrusive thoughts (rs from .02 to .30, $ps > .05$). The estimated difficulty of replacing personal intrusive thoughts did, however, correlate significantly in the expected direction with the total scores of OCI-R ($r = .42$, $p < .01$), DOCS ($r = .53$, $p < .01$), and OBQ-44 ($r = .35$, $p < .05$) and estimated reoccurrence of personal intrusive thoughts had also significant correlations with total scores on OCI-R ($r = .47$), DOCS ($r = .52$) and OBQ-44 ($r = .43$, $ps < .01$ in all cases). Finally, the estimated urge to remove a personal intrusive thought correlated significantly with the total score of the OCI-R ($r = .55$), DOCS ($r = .54$), and OBQ-44 ($r = .52$, $ps < .01$ in all cases).

3.3. Discussion

The main findings of experiment 1 were replicated in experiment 2. Longer replacement times, greater subjective replacement difficulties and thought reoccurrences were observed for personal intrusive thoughts compared to neutral thoughts. The results for the standardized intrusive thought generally followed this pattern. Again, the main effect of thought-type was only marginally significant ($p = .051$) but hypothesis driven comparisons revealed the predicted differences between intrusive and neutral thoughts. The hypothesized interaction between OC symptom group and thought-type was observed for thought reoccurrence, negative emotional reaction, discomfort and urge to remove but not for replacement time or replacement difficulty. However, the main effect of group was significant for replacement difficulty. Thus, the high OC group experienced more overall difficulty replacing thoughts, in particular with reoccurrences of personal intrusive thoughts associated with greater emotional reaction, discomfort and urges to remove.

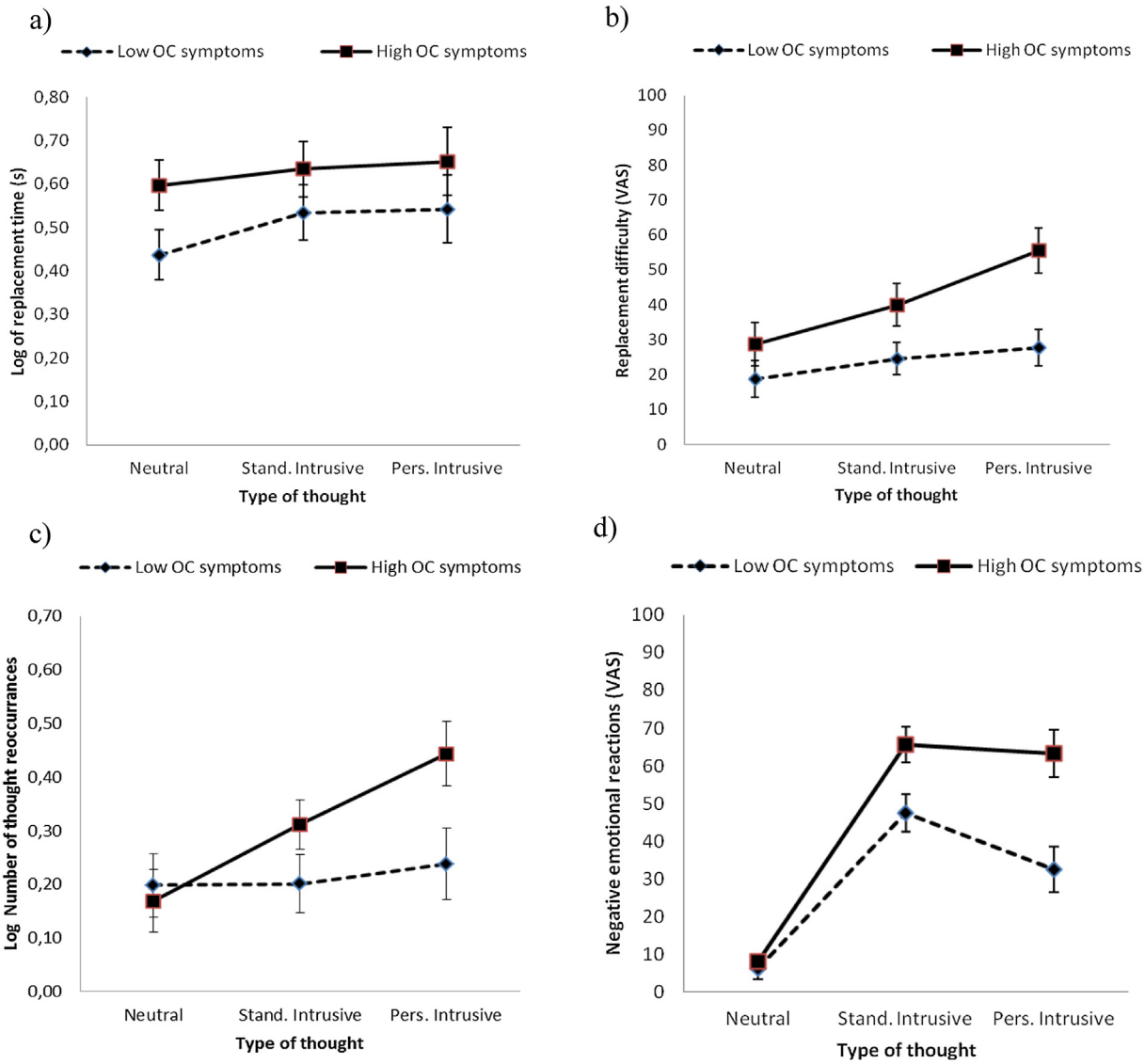

Fig. 2. Results from the thought replacement task in experiment 2 by OC symptom groups and type of thought (neutral, standardized intrusive, personal intrusive): a) Log transformed mean replacement times; b) subjective estimates of replacement difficulty; c) Log transformed subjective estimates of number of reoccurrences of target thought while being replaced; d) subjective ratings of negative emotional reactions to the target thoughts. Error bars represent one standard error.

Table 4
Correlations between emotional reactions, discomfort and urge to remove ratings with indices of thought control by type of thought in experiment 2.

	Emotional reactions	Discomfort	Urge to remove
Neutral thought			
Replacement time	.36*	.27	.37*
Replacement difficulty	−.09	.10	−.15
Reoccurrence	−.15	−.17	−.26
Standardized intrusive thought			
Replacement time	−.06	.00	.04
Replacement difficulty	.27	.29	.21
Reoccurrence	.27	.32*	.42**
Personal intrusive thought			
Replacement time	.15	.15	.09
Replacement difficulty	.64***	.74***	.60***
Reoccurrence	.60***	.68***	.67***

*$p < .05$; **$p < .01$; ***$p < .001$ (two-tailed). $N = 40$ in all analyses except four thought reoccurrence ($N = 39$).

4. General discussion

Our key finding is that personal intrusive thoughts were more difficult to control than neutral thoughts when being replaced. This is in line with existing cognitive theories of OCD (e.g., Rachman, 1998; Salkovskis, 1998) which predict that intrusive thoughts appraised as being personally significant, threatening or dangerous will elicit emotional reactions and discomfort and will therefore be difficult to control. Personal intrusive thoughts were indeed experienced as being emotionally invoking and uncomfortable. The role played by beliefs and appraisals in this relationship is however less clear. Beliefs and appraisal measures (i.e. OBQ, III) were not related to thought replacement times but scores on the OBQ correlated with greater replacement difficulty and reoccurrences of personal intrusive thoughts in experiment 2. It is possible that methodological and measurement factors, such as different modes of assessment (self-report vs. reaction times) and truncation of range in reaction times, influenced the assessment of the relationship

between OCD pathology and thought control. The findings also raise theoretical questions. Dysfunctional beliefs measured in the study may not have captured all relevant factors representing vulnerabilities for control problems when dealing with intrusive thoughts, since negative beliefs and appraisals may only characterize some but not all cases of OCD (e.g., Taylor et al., 2006). Not-just-right experiences or feelings of incompleteness may characterize some OCD patients (e.g., Coles, Frost, Heimberg, & Rheaume, 2003) and should be investigated in relation to thought replacement efficiency. It is possible that determining when a thought has been adequately removed from mind (i.e. replaced), may be affected by feelings of incompleteness.

Results from the second experiment indicate replacing intrusive thoughts is difficult for people with high OC symptoms. The high OC group experienced greater overall difficulty with thought replacement and greater reoccurrence of personal intrusive thoughts but the symptom groups did not differ significantly on replacement time. Greater overall difficulty could indicate general inflexibility in dealing with cognitive content but results comparing OCD patients to controls on tests of cognitive flexibility are not consistent (Kuelz, Hohagen, & Voderholzer, 2004). The fact that OCD patients only experience problems with certain thoughts but not thoughts in general, would speak against a general inflexibility hypothesis. Studies within the thought suppression paradigm show that OCD is sometimes associated with less suppression efficiency when dealing with neutral thought material (Tolin, Abramowitz, Przeworski, & Foa, 2002) and that intrusions during suppression can be the result of an interaction between active control attempts and low cognitive inhibition ability in non-clinical samples (Ólafsson, Emmelkamp, et al., 2013). It is possible that ability or flexibility of the cognitive system is a contributing factor to thought control problems in OCD, but only in interaction with both motivational factors leading to thought control being attempted in the first place and with the type of control strategies being used. This could be addressed in future studies.

It should be noted that avarage raw removal time for personal intrusive thoughts in the high OC group (i.e., 5.23 s, see Table in the Appendix) was considerably lower than the mean removal times reported by Purdon et al. (2011) in their OCD patient sample (around 17 s). Replacement times of personal intrusive thoughts in the present experiments are closer to the corresponding dismissal and replacement times reported by Sutherland et al. (1982) and Edwards and Dickerson (1987). More structured versions of the task used in these three studies (e.g., participants form and replace/dismiss thoughts in response to signals during the tasks) seem to yield shorter replacement/dismissal times than the less structured version (e.g., participants replace thoughts that intrude during a free thinking period) used by Purdon et al. (2011). Differences in participants' clinical status may also explain this. The current self-report ratings of replacement difficulty, indicate that participants did indeed experience personal intrusive thoughts as being more difficult to replace than neutral ones. Future studies using the same thought replacement task, will help clarify what range in replacement times can be expected in clinical samples when controlling personal intrusive thoughts. It should also be noted that replacement times were lower in experiment 2 than experiment 1 in the present study (e.g. the average replacement time of the high symptom group in experiment 2 was lower than that of an unselected sample in experiment 1). This could be due to random variation between studies, or methodological differences (i.e. each block in the thought removal task consisted of four rounds in experiment 2 but six rounds in experiment 1, although replacement times were averaged within blocks in both experiments).

Some limitations should be noted. Only females participated in experiment 1 and the majority of participants in experiment 2 were female, so conclusions regarding males need to be drawn with caution. All participants were non-clinical university students, and older adults with OCD should be tested. We used an analogue sample of university students scoring high or low on a valid self-report measure of OCD symptoms in experiment 2. Without diagnostic interviews we cannot confirm whether some of the participants met formal criteria for OCD or not. However, the mean score on the OCI-R in the high OC group was slightly higher than the mean score in an OCD sample in Abramowitz and Deacon (2006) and is well above the optimal cut-off score established by Foa et al. (2002). The DOCS mean score was lower than the mean score reported by Abramowitz et al. (2010) for OCD patients, indicating that although our high OC symptom group showed a large number of symptoms (comparable to patient groups), the symptoms were less severe.

Estimates of thought reoccurrance were obtained with self report. This method has been used in previous studies on thought suppression (e.g., Clark, Ball, & Pape, 1991; Lin & Wicker, 2007). The approach taken here may suggest a starting point for measuring reoccurrences during thought replacement and was chosen to avoid intrusive measures. It is encouraging that higher reoccurrences of obsessive-like compared to neutral thoughts was observed in both experiments. Research shows that people can be very accurate in estimating event-frequencies (Brown, 1990, cited in Rassin, Merckelbach, & Muris, 2000; Conrad, Brown, & Dashen, 2003). Lin and Wicker (2007) also found a correlation of $r = .81$ between counter-pressings and retrospective ratings as measures of thought frequency in a thought suppression task. This supports the use of self-reported estimates of target thought frequency although replication with objective measures will instill further confidence in the present findings.

It could be argued that greater reoccurrence of personal intrusive thoughts can be explained by a positive memory bias for threatening material observed in OCD (e.g., Radomsky & Rachman, 1999; Radomsky, Rachman, & Hammond, 2001). We are not aware of any studies reporting such a bias for thoughts. Memory bias is unlikely in the present results since participants worked with one target thought in each block of the thought replacement task and estimated its reoccurrence frequency, rather than working simultaneously with different stimulus materials (e.g., Radomsky & Rachman, 1999; Radomsky et al., 2001).

Taken together, our findings converge with two previous studies on thought removal in non-clinical samples (Edwards and Dickerson, 1987; Sutherland et al., 1982). The control-difficulty by thought–content interaction found here, was observed both on objective (reaction times in a computerized task) and subjective measures of control (replacement difficulty and reoccurrence) in two independent samples, indicating that this is a fairly robust pattern in non-clinical samples. This provides additional support for using thought replacement to study thought control in OCD and the preliminary evidence is encouraging for cognitive theories of OCD. The thought replacement paradigm may offer a number of possibilities to further advance the study of thought control in OCD and across different forms of psychopathology.

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Appendix

Means (standard deviation) of raw replacement times (seconds) for neutral, standardized intrusive and personal intrusive thoughts in experiments 1 and 2.

Target thought	Study 1	Study 2		
		Total	Low OC symp.	High OC symp.
Neutral	5.30 (4.00)	3.91 (2.32)	3.37 (2.34)	4.46 (2.22)
Standardized intrusive	5.96 (5.70)	4.79 (3.50)	4.74 (4.43)	4.83 (2.34)
Personal intrusive	6.86 (6.62)	5.23 (4.69)	5.07 (5.82)	5.39 (3.34)

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