Journal of Obsessive-Compulsive and Related Disorders 6 (2015) 39–48

Contents lists available at ScienceDirect

Journal of Obsessive-Compulsive and Related Disorders

journal homepage: www.elsevier.com/locate/jocrd

Exploring dimensionality in the contamination-relevant semantic network with simulated obsessions and association splitting

Terence H.W. Ching *, Winston D. Goh, Gabriel Tan

Department of Psychology, Faculty of Arts & Social Sciences, National University of Singapore, Block AS4, #02-07, 9 Arts Link, 117570 Singapore

ARTICLE INFO

Article history:
Received 22 March 2015
Received in revised form
30 May 2015
Accepted 3 June 2015
Available online 9 June 2015

Keywords:
OCD
Contamination
Semantic network
Dimensionality
Association splitting
Memory confidence

ABSTRACT

The semantic network approach to obsessive-compulsive disorder (OCD) represents a new cognitive approach to understanding the condition. With a dimensional perspective on OC symptoms, we attempted to: (1) uncover a contamination-relevant semantic network in an unselected undergraduate sample; and (2) validate the purported mechanism of association splitting, a network-based intervention for OC symptoms. Contamination-relevant, negatively valenced, and neutral Deese/Roediger-McDermott (DRM) word lists were presented, accompanied by relational or item-specific semantic processing simulations of obsessions or association splitting, respectively. Good veridical recognition performance across list types was observed with simulated obsessions and association splitting. Substantial false recognition rates across critical lure types followed simulated obsessions; such rates were lower with simulated association splitting. Network-based accounts of the contamination-relevant findings supported the aforementioned research aims. Additionally, enhanced contamination-relevant veridical recognition confidence with simulated association splitting suggests a memory confidence pathway through which the technique might reduce contamination-related symptoms. Lastly, contamination-relevant recognition performance was not related to contamination-related symptom severity across conditions, signaling non-dimensionality in contamination-relevant semantic network intensification. Our findings indicate the need for rigorous research on the semantic network approach to OCD to refine its tenets. Association splitting should also be more extensively researched as a viable technique for treating OCD.

1. Introduction

A semantic network is a constellation of linked concepts in memory which can be associatively activated (i.e., spreading activation; Anderson, 1983; Anderson & Bower, 1973; Anderson & Pirolli, 1984; Collins & Loftus, 1975) when any one or more of such concepts are first activated (McDermott & Watson, 2001; Roediger, Balota, and Watson, 2001; Roediger & McDermott, 2000). Semantic network models of obsessive-compulsive disorder (OCD) represent a new cognitive approach to understanding and treating the condition. For example, Moritz, Jelinek, Klinge, and Naber (2007) first conceptualized obsessions as exaggerated activations of linked concepts within an OC-relevant semantic network. They then demonstrated the efficacy of association splitting (Moritz & Jelinek, 2007) for ameliorating OC symptoms (see also Moritz & Jelinek, 2011; Moritz & Russu, 2013). Association splitting is a cognitive practice technique based on the fan effect in a semantic network (Anderson, 1974; Reisberg, 2001), which involves weakening each association to a concept in the network by increasing the number of competing associations to that same concept. In other words, association splitting reduces obsessions – and by functional linkage, compulsions – through practicing the redirection of spreading activation away from established associations in an OC-relevant semantic network to novel or atrophied links between OC-relevant and non-OC-relevant concepts.

Notably, an OC-relevant semantic network has yet to be uncovered beyond OCD patient groups (i.e., in an unselected sample), as would have been expected with dimensionality in OC symptom severity (Abramowitz et al., 2010; see also Blom et al., 2011; Fullana et al., 2009). The purported mechanism of association splitting has also not been empirically validated. These questions were examined here because of the significant potential research and clinical implications. Uncovering an OC-relevant semantic network in an unselected sample will validate the semantic network approach to OCD, thereby invigorating future related research in refinement of its tenets. There will also be motivation to investigate association splitting more rigorously as a viable

* Correspondence author.
E-mail addresses: thwching@gmail.com (T.H.W. Ching), psygohw@nus.edu.sg (W.D. Goh), psygt@nus.edu.sg (G. Tan).

http://dx.doi.org/10.1016/j.jocrd.2015.06.003
2211-3649/

technique for treating OCD, should there be sound evidence for its underlying mechanism. We chose to focus on contamination-related concerns in this study because it is a cross-culturally preponderant OC symptom dimension (Girischandra & Sumant, 2001; Kim et al., 2005; Li et al., 2009; Matsunaga et al., 2008; Wheaton et al., 2013).

The Deese/Roediger-McDermott (DRM) paradigm (Deese, 1959; Roediger & McDermott, 1995) is useful for our purposes, given the link between one of its most widely endorsed explanatory accounts (i.e., the activation-monitoring framework; McDermott & Watson, 2001; Roediger et al., 2001; Roediger & McDermott, 2000) and semantic network models. The DRM paradigm conventionally involves presenting words semantically related to non-presented items, eliciting robust veridical and false memory rates (for reviews, see Gallo, 2006, 2010). Veridical memory refers to memory for (e.g., recognition of) items presented during an earlier memorization phase, while false memory refers to memory for non-presented items semantically related to memorized ones. The non-presented items are typically termed as critical lures. The activation-monitoring framework attributes these findings to repetitive activations of memorized concepts and their associated critical lures in the semantic network, as well as failed monitoring of the source of activated information (Johnson, 1997; Underwood, 1965).

It is also within the DRM paradigm that semantic processing manipulations can be implemented to simulate obsessions and association splitting, as conceptualized by Moritz et al. (2007). Obsessions can be simulated via relational semantic processing of DRM lists (i.e., thinking of the meaning of each word that relates it to the others in the same list; Hunt and McDaniel, 1993; McCabe et al., 2004). This is because the deliberate, repetitive association of contamination-relevant concepts to each other in relational processing mimics the active repetition of contamination-relevant cognitions characteristic of contamination-related obsessions (see Fig. 1). In this example, the non-presented critical lure would be the word *disease*, organized around a to-be-memorized DRM list that comprises words such as *germ*, *virus*, and *infection*.

If a contamination-relevant semantic network does exist in all individuals, then substantial contamination-relevant veridical and false recognition rates should accompany relational processing (hypothesis 1). False recognition arises due to repeated activations of encoded contamination-relevant items spreading to related, non-presented critical lures.

Additionally, stronger links might be present in the contamination-relevant semantic network of individuals with greater contamination-related symptom severity, similar to expertise for

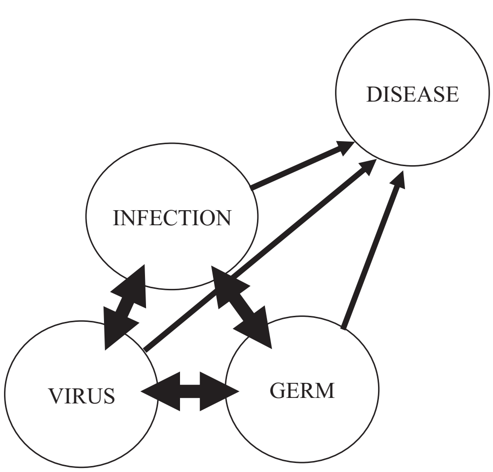

Fig. 1. Relational semantic processing as an experimental analog of obsessions (thick arrows) in a contamination-relevant semantic network, increasing the probability of falsely recognizing the critical lure (thin arrows; DISEASE).

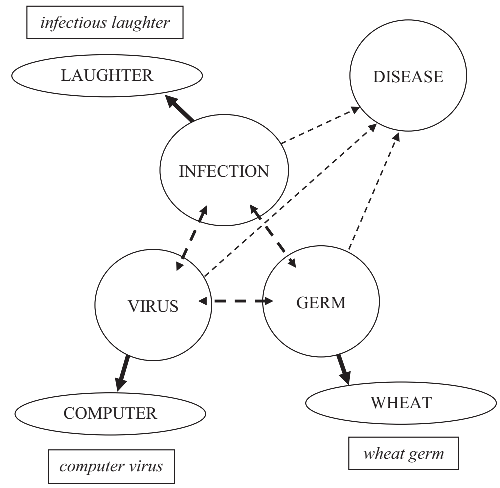

Fig. 2. Item-specific semantic processing as an experimental analog of association splitting (from thick dashed arrows to solid arrows and text in rectangles) in a contamination-relevant semantic network, decreasing the probability of falsely recognizing the critical lure (thin dashed arrows; DISEASE).

domain-specific information (Baird, 2003; Castel et al., 2007). Positive correlations between contamination-relevant recognition performance and contamination-related symptom severity were therefore expected following relational semantic processing (hypothesis 2).

While obsessions can be simulated with relational processing, association splitting can be simulated with item-specific semantic processing of DRM lists (i.e., thinking of a unique meaning or creative use of each word that differentiates it from the others in the same list; McCabe et al., 2004). The rationale is that item-specific processing, like association splitting, weakens contamination-relevant associations by redirecting spreading activation to non-contamination-relevant associations via the fan effect (see Fig. 2; Anderson, 2007; Anderson et al., 2004; Moritz & Jelinek, 2007).

Item-specific processing reduces false recognition rates in the DRM paradigm without detriment to veridical recognition rates (Butler et al., 2010; Hunt & McDaniel, 1993; Taconnat et al., 2006). This is because attention to distinctive semantic aspects – which non-presented critical lures lack – of encoded items helps participants differentiate between similar items. Therefore, if a contamination-relevant semantic network does exist in all individuals, and if association splitting does operate as purported, reduced contamination-relevant false recognition rates (relative to relational processing) amidst high contamination-relevant veridical recognition rates should be observed with item-specific processing (hypothesis 3).

Additionally, no significant correlation between contamination-related symptom severity and contamination-relevant recognition performance should be observed with item-specific processing (hypothesis 4). We hypothesize this because contamination-relevant associations may have been weakened to an extent that attenuates the influence of contamination-related symptom severity on contamination-relevant memory.

Finally, the effect of association splitting on contamination-relevant memory confidence has never been investigated. This is pertinent because memory confidence has consistently been demonstrated to be compromised in individuals with severe OC symptoms (Hermans et al., 2003; Tuna et al., 2005). It might also be interesting to explore the quality of contamination-relevant memory confidence in individuals differing in contamination-related symptom severity here. Therefore, recognition confidence was measured to explore the impact of both processing manipulations on memory confidence.

2. Method

2.1. Participants and design

One hundred and sixty introductory psychology undergraduates from the National University of Singapore participated for course credit. Eligibility criteria were normal or corrected-to-normal vision and English as a first language (i.e., language they were most proficient in). Participants were randomly assigned to the relational or item-specific semantic processing condition (23 and 20 males, respectively). List/critical lure type (contamination-relevant, negatively valenced, and neutral) was manipulated within-subjects. Therefore, this study had a 2(semantic processing strategy) × 3(list/critical lure type) mixed factorial design.

2.2. Stimuli

Twelve test (4 contamination-relevant, 4 negatively valenced, and 4 neutral) and two practice DRM lists, each with 10 words, were constructed. Twelve unrelated items, each paired with a critical lure in the recognition tests, were also employed. Target words representative of examples accompanying the "Concerns about Germs and Contamination" subscale of the DOCS (Abramowitz et al., 2010) were chosen as critical lures from which contamination-relevant lists were constructed. Negatively valenced and neutral lists and critical lures, commonly employed in the DRM tradition, were included to determine the specificity of the potential influence of contamination-related symptom severity on contamination-relevant recognition performance. These stimuli are listed in Appendices A and B.

Variability in certain lexical characteristics across list and critical lure types was eliminated or ensured, where appropriate, in order to limit its extraneous influence on memory performance (see Tables 1–3 for descriptives and contrasts).

Prior to this study, a separate sample of 20 undergraduates from the same population provided contamination relevance ratings for all word stimuli used. Contamination-relevant lists were rated significantly more contamination-relevant than negatively valenced, neutral, and practice lists, all $ps < .001$; no differences were found among the latter three, all $ps > .05$. Contamination-relevant critical lures were also rated significantly more contamination-relevant than negatively valenced and neutral critical lures, both $ps < .001$; no difference was found between the latter two, $p > .05$. Contamination-relevant critical lures were rated significantly more contamination-relevant than their accompanying unrelated test items; no such differences were found between negatively valenced and neutral critical lures and their accompanying unrelated test items.

All list types were equated on backward associative strength (BAS; strength of associations between list items and the corresponding critical lure; Nelson et al., 1998), association density (number of intra-list associations), word length (number of letters) and word frequency [specifically, logarithm of word frequency (Log_Freq_HAL); Balota et al., 2007], familiarity (values normed from an ongoing unrelated study using participants from the same population sampled here), and arousal (Bradley & Lang, 2010). As expected, contamination-relevant and negatively valenced lists were significantly lower in valence (Bradley & Lang, 2010) than neutral (both $ps < .001$) and practice lists ($p < .001$ and $p < .01$, respectively). No significant difference in valence was found between the former two ($p > .05$) and latter two ($p > .05$).

Contamination-relevant, negatively valenced, and neutral critical lures were equated on word length, word frequency, familiarity, and arousal. Contamination-relevant and negatively valenced critical lures were both significantly lower in valence than neutral critical lures, albeit marginally so in the former comparison ($p = .03$ and $p < .017$, respectively). No significant difference in valence existed between contamination-relevant and negatively valenced lures ($p > .05$).

Finally, all three types of critical lures did not differ significantly from their accompanying unrelated test items in word length, word frequency, familiarity, arousal, and valence.

2.3. Measures

2.3.1. Dimensional Obsessive-Compulsive Scale, "Concerns about Germs and Contamination" subscale (DOCS-Cont; Abramowitz et al., 2010)

The DOCS-Cont consists of 5 self-report items targeting contamination-related concerns. Five parameters of severity spanning the past month are assessed on a five-point scale, from 0 to 4 for *no symptoms at all* to *extreme symptoms*: (a) time occupied by symptoms; (b) avoidance; (c) distress experienced with symptoms; (d) functional impairment; and (e) difficulty ignoring and/or refraining from symptoms. The full scale was constructed based on evidence of the dimensional nature of OC symptoms (e.g., Olatunji et al., 2008), suiting the theoretical alignment of the present study. Cronbach's alpha for the finalized sample was .82.

2.3.2. Depression Anxiety Stress Scales, Depression and Anxiety subscales (DASS-21-D and DASS-21-A Lovibond and Lovibond, 1995)

OC symptoms are commonly comorbid with depressive and/or anxiety symptoms (Mathews & MacLeod, 2005). Therefore, any contributions of these symptoms to the hypothesized relationship between contamination-related symptom severity and contamination-relevant recognition performance following relational semantic processing must be assessed and controlled for. The DASS-21-D and DASS-21-A are dimensional, hence theoretically compatible, self-report measures of the severity of core symptoms of depression and anxiety spanning the past week. Each subscale

Table 1
Means, standard deviations, and contrasts for lexical characteristics across list types.

Lexical characteristic	List type: Contamination-relevant	Negatively valenced	Neutral	Practice	Contrast
Contamination relevance	4.36 (0.09)	1.94 (0.09)	1.70 (0.09)	1.76 (0.13)	$F(3, 136) = 186.64$, $p < .001$
Backward associative strength	.12 (.18)	.10 (.15)	.13 (.17)	.10 (.12)	$F < 1$
Association density	10.75 (4.99)	6.00 (4.76)	9.00 (6.06)	2.50 (3.54)	$F(3, 10) = 1.38$, $p > .05$
Word length	5.45 (1.74)	5.63 (1.48)	5.28 (1.13)	5.85 (2.01)	$F < 1$
Word frequency	8.73 (1.43)	8.96 (1.43)	9.08 (1.49)	9.30 (1.52)	$F < 1$
Familiarity	6.93 (0.10)	6.89 (0.13)	6.88 (0.19)	6.84 (0.26)	$F(3, 136) = 1.58$, $p > .05$
Arousal	4.86 (0.58)	4.93 (1.12)	5.03 (0.82)	4.74 (0.81)	$F < 1$
Valence	4.11 (1.64)	4.81 (1.89)	6.49 (0.81)	6.20 (0.94)	$F(3, 136) = 21.95$, $p < .001$

Note. Standard deviations, accompanying means, are in parentheses.

Table 2
Means, standard deviations, and contrasts for lexical characteristics across critical lure types.

	Critical lure type			
Lexical characteristic	Contamination-relevant	Negatively valenced	Neutral	Contrast
Contamination relevance	5.13 (0.46)	2.30 (0.60)	1.79 (0.53)	$F(2, 9)=45.71$, $p<.001$
Word length	5.25 (1.26)	4.00 (0.82)	4.00 (0.82)	$F(2, 9)=2.14$, $p>.05$
Word frequency	10.03 (0.39)	10.06 (0.54)	10.55 (0.61)	$F(2, 9)=1.26$, $p>.05$
Familiarity	7.00 (0.00)	6.99 (0.03)	6.96 (0.06)	$F(2, 9)=1.35$, $p>.05$
Arousal	4.62 (0.55)	4.52 (1.55)	4.48 (0.87)	$F<1$
Valence	3.56 (2.50)	2.95 (0.46)	6.99 (0.47)	$F(2, 9)=8.51$, $p<.01$

Note. Standard deviations, accompanying means, are in parentheses.

Table 3
Means, standard deviations, and contrasts for lexical characteristics of unrelated items paired with critical lures.

	Unrelated items			
Lexical characteristic	With CR	With NV	With N	Contrast
Contamination relevance	1.84 (0.10)	2.24 (0.49)	2.08 (0.52)	With CR: $t(6)=14.08$, $p<.001$ With NV: $t<1$ With N: $t<1$
Word length	5.25 (1.50)	4.25 (0.96)	4.25 (0.50)	With CR: $t<1$ With NV: $t<1$ With N: $t<1$
Word frequency	8.96 (2.93)	9.64 (1.90)	10.52 (1.64)	With CR: $t<1$ With NV: $t<1$ With N: $t<1$
Familiarity	6.91 (0.13)	6.88 (0.13)	7.00 (0.01)	With CR: $t(3)=1.45$, $p>.05$ With NV: $t(6)=1.54$, $p>.05$ With N: $t(6)=1.30$, $p>.05$
Arousal	5.21 (0.89)	5.19 (1.37)	5.11 (0.80)	With CR: $t(6)=1.13$, $p>.05$ With NV: $t<1$ With N: $t(6)=1.05$, $p>.05$
Valence	3.44 (0.53)	3.07 (0.86)	6.60 (0.12)	With CR: $t<1$ With NV: $t<1$ With N: $t(6)=1.63$, $p>.05$

Note. Standard deviations, accompanying means, are in parentheses. With CR=paired with contamination-relevant critical lures; With NV=paired with negatively valenced critical lures; With N=paired with neutral critical lures.

has seven items rated on a four-point scale, from 0 to 3 for *non-applicability* to *extremely high applicability of stated symptom to self*. For the finalized sample, Cronbach's alphas for the DASS-21-D and DASS-21-A were .88 and .71, respectively.

2.4. Procedure

This study incorporated procedural elements from McCabe et al. (2004) and Kawasaki and Yama (2006). Each participant engaged in a single session on a computer in a laboratory. All stimuli were prepared and presented via E-Prime 1.2 (Schneider et al., 2002).

Participants were first instructed to memorize serially presented word lists in 12 test trials by only thinking of either the meaning of each word that related it to other words in the same list (relational semantic processing), or a unique meaning or creative use of each word that differentiated it from other words in the same list (item-specific semantic processing). Participants then practiced their assigned processing strategy twice. Examples of strategy application were provided after each practice trial (see Appendix C). Participants subsequently practiced responding to arithmetic questions constituting the 30-s distractor task phases that immediately follow the memorization phases. A cumulative accuracy rate of at least 85% correct responses for these questions was mandated. Participants were also told that a recognition test for each preceding list will occur immediately after each distractor task phase, and that they were required to respond to each test item on a six-point scale integrating memory confidence responses with conventional *new* (not previously presented) and *old* (previously presented) responses (i.e., pressing 1, 2, and 3 for *highly*, *moderately*, and *lowly confident new*, respectively, and 4, 5, and 6 for *lowly*, *moderately*, and *highly confident old*, respectively).

In the memorization phases, contamination-relevant, negatively valenced, and neutral lists were randomly presented. Each list was presented according to decreasing BAS at a rate of 4 s per word. A distractor task phase immediately followed the last presented word of each list, with feedback and the cumulative accuracy rate being displayed for 1 s after every response. Each recognition test consisted of two memorized words (one from the first or second word, and the other from the fifth or sixth word) and two non-presented words (the corresponding critical lure and its accompanying unrelated item). Immediately after each test, a manipulation check question appeared. Participants responded by pressing either Y (yes) or N (no), according to whether they adhered to the assigned processing strategy as instructed for at least 9 out of the 10 words in the preceding list.

After the last test, the three subscales were administered and demographic information was collected. Participants were then debriefed.

3. Results

3.1. Sample characteristics

Only data from participants with cumulative arithmetic accuracy rates above .85 and strategy adherence proportions of not more than 2.5 SDs below the original sample mean were analyzed. Data from 18 participants (7 males, 11 females) were therefore excluded from analyses.

In the finalized sample, distractor task accuracy (*M*s=.97 and .98, *SD*s=.02 and .02, for the relational and item-specific processing conditions, respectively) and strategy adherence (*M*s=.88 and .90, *SD*s=.16 and .13, for the relational and item-specific processing conditions, respectively), were equated between processing conditions: $t(140)=1.63$, $p>.05$, for distractor task accuracy, and $t<1$, for strategy adherence. Distractor task accuracy (*M*s=.97, .98, and .98, *SD*s=.03, .03, and .03, for contamination-relevant, negatively valenced, and neutral lists, respectively) and strategy adherence (*M*s=.89, .88, and .89, *SD*s=.19, .20, and .18, for contamination-relevant, negatively valenced, and neutral lists, respectively) were also equated between list types, both *F*s <1.

The finalized sample included 73 [males: 15 Singaporean

Chinese (SC); 2 Singaporean Malay (SM); 2 Singaporean Indian (SI); females: 48 SC; 3 SM; 3 SI] and 69 (males: 13 SC; 2 SM; 2 SI; females: 46 SC; 3 SM; 3 SI) participants in the relational and item-specific processing conditions, respectively. No semantic processing strategy × sex × race interaction was found, χ^2 (2) = 0.01, $p > .05$. Age (Ms = 19.89 and 19.84, SDs = 1.23 and 1.54, for the relational and item-specific processing conditions, respectively) and years of education (Ms = 12.45 and 12.52, SDs = .67 and.95, for the relational and item-specific processing conditions, respectively) were equated between processing conditions, both ts < 1. Mean contamination-related, depressive, and anxiety symptom severity in the relational processing condition (Ms = 5.47, 5.44, and 4.37, SDs = 3.32, 4.55, and 3.17, respectively) were equated with those in the item-specific processing condition (Ms = 4.94, 5.07, and 5.16, SDs = 3.43, 4.39, and 3.60, respectively), $t < 1$, $t < 1$, and t (140) = 1.39, $p > .05$, respectively.

3.2. Analyses of covariance

Data for each dependent variable below were analyzed with a 2 (semantic processing strategy) × 3(list/critical lure type) mixed analysis of covariance (ANCOVA), with all three subscale scores entered as covariates (see Table 4 for descriptives). This was to test for differences in recognition and recognition confidence performance above and beyond the influences of contamination-related, depressive, and anxiety symptom severity. Even though there was a uniform lack of a significant semantic processing strategy × list/critical lure type interaction across all dependent variables (all Fs < 1.51), planned contrasts (with the same covariates and Bonferroni correction) between processing types for recognition and recognition confidence performance for each list/lure type were also conducted to assess hypotheses specified above. Results were highly similar when symptoms were not controlled for.

Table 4
Recognition and recognition confidence performance across all conditions.

Semantic processing strategy	Dependent variable	List type Contamination-relevant	Negatively valenced	Neutral
Relational	VR	.94 (.10)	.92 (.11)	.93 (.10)
Item-specific		.96 (.08)	.96 (.09)	.95 (.09)
Relational	VR_Conf	5.89 (0.19)	5.92 (0.18)	5.92 (0.16)
Item-specific		5.96 (0.08)	5.96 (0.09)	5.95 (0.10)
Relational	IncorrRej_Conf	1.68 (0.84)	1.37 (0.48)	1.33 (0.41)
Item-specific		2.29 (0.49)	1.64 (0.75)	1.93 (0.73)
			Critical lure type	
		Contamination-relevant	Negatively valenced	Neutral
Relational	FR	.39 (.31)	.28 (.25)	.22 (.24)
Item-specific		.21 (.24)	.16 (.21)	.07 (.16)
Relational	FR_Conf	5.34 (0.71)	5.45 (0.70)	5.16 (0.76)
Item-specific		5.22 (0.75)	5.36 (0.88)	5.42 (0.80)
Relational	CorrRej_Conf	1.49 (0.58)	1.46 (0.52)	1.31 (0.38)
Item-specific		1.49 (0.46)	1.37 (0.38)	1.29 (0.35)
			Paired critical lure type	
		Contamination-relevant	Negatively valenced	Neutral
Relational	FA	.01 (.05)	.01 (.06)	.01 (.05)
Item-specific		00 (.00)	.01 (.04)	.01 (.05)

Note. Standard deviations, accompanying means, are in parentheses. VR = veridical recognition rates; VR_Conf = confidence in veridical recognition responses (the higher the value, the greater the confidence); IncorrRej_Conf = confidence in incorrectly rejecting memorized items as new (the higher the value, the lower the confidence); FR = false recognition rates; FR_Conf = confidence in false recognition responses (the higher the value, the greater the confidence); CorrRej_Conf = confidence in correctly rejecting critical lures as new (the higher the value, the lower the confidence); FA = false alarms to unrelated items.

Contamination-relevant and neutral veridical recognition rates (VR) were not different between processing conditions, both $ps > .017$; significantly higher negatively valenced VR were observed with item-specific than relational processing, $p < .01$. There was no significant main effect of list type for VR, $F(2, 274) = 1.54$, $MSe = .01$, $p > .05$, $\eta_p^2 = .01$.

Significantly lower false recognition rates (FR) were found for all critical lure types with item-specific processing, compared with relational processing, all $ps < .01$. The contamination-relevant recognition results between processing conditions above therefore support hypotheses 1 and 3. There was a significant main effect of critical lure type for FR [$F(2, 274) = 4.79$, $MSe = .04$, $p < .01$, $\eta_p^2 = .03$], and pairwise comparisons with Bonferroni correction indicated that contamination-relevant FR ($M = .30$, $SD = .29$) were significantly higher than negatively valenced ($M = .22$, $SD = .23$; $p < .01$) and neutral FR ($M = .14$, $SD = .22$; $p < .001$), with negatively valenced FR being significantly higher than neutral FR, $p < .01$.

Significantly higher contamination-relevant veridical recognition confidence (VR_Conf) accompanied item-specific processing, compared with relational processing, $p < .01$; negatively valenced and neutral VR_Conf were not different between processing conditions, both $ps > .017$. No significant main effect of list type was observed for VR_Conf, $F < 1$.

Confidence in incorrectly rejecting memorized items as new (IncorrRej_Conf), false recognition confidence (FR_Conf), and confidence in correctly rejecting critical lures as new (CorrRej_Conf) were not different between processing conditions for all list/critical lure types, all $ps > .017$. No significant main effect of list/critical lure type was observed for IncorrRej_Conf and FR_Conf, both Fs < 1. For CorrRej_Conf, across critical lure types, Mauchly's test indicated that the assumption of sphericity had been violated, $\chi^2(2) = 19.72$, $p < .001$, and degrees of freedom were corrected using Huynh–Feldt estimations of sphericity ($\varepsilon = .92$). However, there was no main effect of critical lure type, $F(1.83, 239.65) = 2.85$, $MSe = 0.13$, $p > .05$, $\eta_p^2 = .02$.

Lastly, false alarms to unrelated test items accompanying each critical lure type were not different between processing conditions, all $ps > .017$. No significant main effect of critical lure type was observed for such false alarms, $F < 1$. Analyzable data for confidence in these responses were insufficient for discussion.

3.3. Correlational analyses

Prior to appropriate partial correlational analyses, it was pertinent to determine whether significant zero-order correlations existed between recognition and recognition confidence performance on one hand, and contamination-related, depressive, and anxiety symptom severity on the other, in the relational processing condition (i.e., hypothesis 2). These relationships should not exist in the item-specific processing condition (i.e., hypothesis 4). No significant relationships emerged in both processing conditions (rs = −.31 to .28, and −.41 to .33, in the relational and item-specific processing conditions, respectively, all $ps > .05$), save for the following three cases. State anxiety was significantly related to negatively valenced IncorrRej_Conf in the relational processing condition, $r = -.34$, $p < .05$. In the item-specific processing condition, contamination-related symptom severity was significantly related to both negatively valenced CorrRej_Conf ($r = -.24$, $p < .05$) and neutral IncorrRej_Conf ($r = -.46$, $p < .05$). Crucially, because of absent relationships between markers of contamination-relevant recognition performance and contamination-related symptom severity in both processing conditions, plans to proceed onto partial correlational analyzes were terminated.

4. Discussion

As hypothesized, high contamination-relevant veridical recognition rates were observed with both processing strategies. Predictably lower contamination-relevant false recognition rates were also observed with simulated association splitting, while simulated obsessions were accompanied by sizable contamination-relevant false recognition rates. The same results were obtained for the other list/lure types.[1] It can thus be inferred that relational semantic processing amplified repetitive activations of related concepts (including critical lures) in the contamination-relevant semantic network (McDermott & Watson, 2001; Roediger et al. 2001; Roediger & McDermott, 2000), similar to the exaggerated repetition of cognitions in actual obsessions (Moritz et al., 2007). On the other hand, item-specific semantic processing operated via the fan effect in the contamination-relevant semantic network, analogous to association splitting (Anderson, 2007; Anderson et al., 2004; Moritz & Jelinek, 2007). Specifically, spreading activation along contamination-relevant links was redistributed over novel or atrophied links to distinct, non-contamination-relevant concepts created or activated for each list item at the memorization phase. These findings therefore support a network-based conceptualization of contamination-relevant semantic memory beyond OCD patient groups in an unselected sample, as well as the purported mechanism of association splitting.

Improved contamination-relevant veridical recognition confidence was also observed with simulated association splitting, compared with simulated obsessions. In other words, simulated obsessions are accompanied by impaired veridical memory confidence for previously presented contamination-relevant information. The latter finding bears strong similarities to past research indicating strong uncertainty and poor memory confidence for OC- or non-OC-relevant stimuli in individuals diagnosed with OCD, especially checking symptoms (Klumpp et al., 2009; Muller & Roberts, 2005). Presumably, excessive activation of the contamination-relevant semantic network during the course of simulated obsessions similarly reduced the clarity of, and hence confidence in, veridical memory, as with repeated checking (Hout & Kindt, 2004; Radomsky & Alcolado, 2010; Radomsky et al., 2006). On the other hand, it is unclear if the memory confidence benefits of simulated association splitting can be sustained when re-experiencing obsessions. It is possible that by improving confidence in veridical memory for contamination-relevant information, association splitting can reduce the tendency for contamination-related obsessions to trigger compulsive decontamination behaviors in a cyclically reinforcing manner. Affirming this possibility in future clinical trials will thus shed light on an alternative memory confidence pathway through which association splitting addresses contamination-related concerns. Simulated association splitting was not beneficial, however, for reducing false recognition confidence. This indicates a qualitative difference in the efficacy of the technique for improving memory confidence between veridical and false recognition.

The secondary finding of between-list type differences in rates of false recognition of critical lures can be attributed to differences in valence and emotional aversiveness (Dewhurst & Parry, 2000; Howe et al., 2010; for psychophysiological evidence, see Maratos et al., 2000). It is also plausible that this finding was due to differences in the number of competing themes in the semantic networks tapped (Howe & Derbish, 2010). It is noteworthy that all aforementioned findings were not due to systematic errors in responding, given that false alarms to unrelated test items were invariant between processing and list/lure types.

Interestingly, the bulk of the findings here were obtained independently of variations in contamination-related, depressive, and anxiety symptom severity in both processing conditions. This signals a possible nonlinear trend in the strengthening of contamination-relevant network associations up along the contamination-related symptom severity continuum. Jelinek and colleagues presented evidence for a more tightly-knit OC-relevant semantic network in individuals with OCD, compared with normal controls (Jelinek et al., 2009, 2014). As the present sample was a probable non-clinical one, with regard to contamination-related concerns ($M=5.21$, $SD=3.37$), there could thus be a clinically significant threshold point along the contamination-related symptom severity continuum above which increases in symptom severity intensify contamination-relevant network associations in a correlated fashion. This hypothesis can be tested in comparative investigations that include OCD-diagnosed samples, extending from the present study.

4.1. Limitations

The present study has a few limitations. Because only contamination-related concerns were tapped into here, there remains a need to determine if the current findings are replicable within networks corresponding to other OC symptom subtypes assessed by the DOCS (e.g., responsibility for harm, unacceptable intrusions, and need for symmetry, completeness, and exactness; Abramowitz et al., 2010). The negatively valenced list with the lure “evil” might be relevant to aggressive obsessions, and so, unpredictably linked to contamination-related concerns. This potential link should be ascertained and controlled for in future research. Additionally, larger studies are needed to determine if OC-relevant semantic networks are also found in the general population. Lastly, the cross-sectional findings here precluded any conclusions about the longevity of the memory and memory confidence benefits of association splitting, which may differ between non-clinical individuals and individuals with OCD. Longitudinal research with OCD samples and appropriate controls will thus be vital to answering these questions.

4.2. Conclusions and suggestions for future research

Despite such limitations, the present study is the first to uncover a contamination-relevant semantic network that operates via spreading activation and is amenable to association splitting within an unselected sample. Additionally, evidence was presented for the purported mechanism of association splitting, suggesting that it should be investigated more rigorously as a viable technique for treating OCD. For example, a potential memory confidence pathway through which association splitting might reduce contamination-related symptoms was introduced here. Future clinical trials for association splitting could investigate memory confidence as an additional variable. Furthermore, the lack of a relationship between contamination-relevant recognition performance and contamination-related symptom severity has a significant implication for the semantic network approach to OCD. Specifically, dimensionality in the intensification of the contamination-relevant semantic network should not be assumed, at least below our hypothesized threshold point of clinically significant contamination-related concerns. More research is needed

[1] Although a general DRM effect was obtained for the other two list/lure types, the same effect was observed for the specifically manipulated contamination-relevant stimuli here. This indicates that our conclusions of the existence of a contamination-relevant semantic network in an unselected sample, as well as the validity of the purported mechanism of association splitting, are irrefutable (see further down the paragraph). For the latter, association splitting was never espoused as specific for targeting obsessions in OCD; it could work for, say, depressive cognitions, or even other non-pathological cognitions with the goal of, for example, targeted learning of domain-specific words.

to ascertain this.

As the mechanism of association splitting was validated here, it might be interesting to consider how the technique can be integrated into cognitive-behavior therapy for OCD. For example, future research can examine whether association splitting can prime one for exposure and response prevention, which has been shown to be effective for treating contamination-based OCD (Sookman et al., 2005). This is because the attenuation of contamination-relevant associations within the contamination-relevant network might aid in decatastrophizing feelings of discomfort about feared contaminants. Given that certain dysfunctional beliefs/appraisals (e.g., inflated responsibility and thought–action fusion) figure heavily in OCD (Rachman, 1993, 1997; Salkovskis, 1985, 1989, 1996), it is also worthy to study the impact of association splitting on such cognitions. The specificity of the possible influences of such cognitions on the strengthening of networks for different OC symptom subtypes can also be examined (see Sookman et al., 2005). All these suggested studies should be undertaken in order to determine how the semantic network approach to OCD can complement traditional cognitive-behavioral models of OCD.

Role of funding sources

This research was completely self-funded.

Contributors

The first and third authors conceptualized the research. The first author conducted the literature searches, developed the protocol, collected and analyzed the data, and wrote the first draft of the manuscript. The second author assisted in data analyses. All authors contributed to the final version of the manuscript.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgments

The authors are grateful to Eugene Chong and Mabel Lau for their assistance in the collection and organization of stimuli-related data.

Appendix A. DRM word lists

A.1. Contamination-relevant lists

Clean	Dirty	Disease	Sick
Tidy	Filthy	Infection	Ill
Bath	Pollution	Germ	Hospital
Soap	Nasty	Virus	Fever
Shower	Dump	Fungus	Vomit
Bathtub	Rotten	Disorder	Clinic
Towel	Garbage	Rash	Gross
White	Foul	Flu	Uneasy
Carpet	Disgusting	Skin	Cold
Soak	Toilet	Health	Patient
New	Hairy	Rat	Allergy

A.2. Negatively valenced lists

Fat	Tired	Dumb	Evil
Thin	Lazy	Smart	Wicked
Slim	Sleep	Idiot	Devil
Gain	Weary	Moron	Demon
Heavy	Boring	Foolish	Good
Pastry	Awake	Retarded	Kind
Huge	Busy	Absurd	Holiness
Short	Relax	Wisdom	Innocence
Fries	Hungry	Loser	Vampire
Ugly	Useless	Nonsense	Policeman
Butter	Thirsty	Fail	Mischief

A.3. Neutral lists

King	Tree	Sky	Color
Queen	Leaf	Cloud	Rainbow
Royalty	Shrub	Star	Race
Palace	Fig	Meteor	Bright
Prince	Bark	Comet	Decorate
Castle	Grove	Moon	Yellow
Empire	Wood	Sunset	Green
Leader	Trunk	Soar	Art
Loyal	Swing	Balloon	Cartoon
Master	Land	Tower	Orange
Power	Flower	Glide	Photo

A.4. Practice lists

River	Time
Creek	Moment
Flow	Hour
Bridge	Noon
Lake	Opportunity
Raft	Legend
Canoe	Vacation
Waterfall	Story
Rocks	Hobby
Valley	Passage
Alligator	Week

Note. Each capitalized word in the first row represents the critical lure of the contamination-relevant/negatively valenced/neutral/practice DRM list in the same column, the items of which are arranged here in decreasing BAS from top to bottom.

Appendix B. Unrelated items

B.1. Unrelated items uniquely paired with contamination-relevant critical lures

Critical lure	Unrelated item
Clean	Work
Dirty	Penalty
Disease	Warden
Sick	Cram

B.2. Unrelated items uniquely paired with negatively valenced critical lures

Critical lure	Unrelated item
Fat	Old
Tired	Drama
Dumb	Flaw
Evil	Slave

B.3. Unrelated items uniquely paired with neutral critical lures

Critical lure	Unrelated item
King	Zoom
Tree	Head
Sky	Able
Color	Favor

Note. Each unrelated item above was uniquely affixed to its assigned contamination-relevant, negatively valenced, or neutral critical lure in the corresponding recognition test.

Appendix C. Processing examples provided for one practice trial

River	Relational	Item-specific
Creek	A small stream	The TV show “Dawson's Creek”
Flow	Liquid flows	Flow of ideas
Bridge	A structure over water	“London Bridge is falling down…”
Lake	A large water body	Lakeside Train Station
Raft	Floats on water	Made out of wood
Canoe	Moves on water	Canoe polo
Waterfall	A falling body of water	A Pokémon skill
Rocks	On the riverbed	Gin on the rocks
Valley	Eroded by water	Silicon Valley
Alligator	Spends most of its time in swamps	“See you later, alligator.”

Note. The first column from the left contains list associates of the critical lure *river*, which were presented in one practice trial. The second column contains examples of how to apply the relational semantic processing strategy to these presented words provided at the end of the practice trial, while the third column contains examples for the item-specific semantic processing condition.

References

Abramowitz, J. S., Deacon, B. J., Olatunji, B. O., Wheaton, M. G., Berman, N. C., Losardo, D., Timpano, K. R., McGrath, P. B., Riemann, B. C., Adams, T., Björgvinsson, T., Storch, E. A., & Hale, L. R. (2010). Assessment of obsessive-compulsive symptom dimensions: development and evaluation of the Dimensional Obsessive-Compulsive Scale. *Psychological Assessment*, *22*, 180–198.

Anderson, J. R. (1974). Retrieval of prepositional information from long-term memory. *Cognitive Psychology*, *6*, 451–474.

Anderson, J. R. (1983). A spreading activation theory of memory. *Journal of Verbal Learning and Verbal Behavior*, *22*, 261–295.

Anderson, J. R. (2007). *How can the human mind occur in the physical universe?*. New York: Oxford University Press.

Anderson, J. R., Bothell, D., Byrne, M. D., Douglass, S., Lebiere, C., & Qin, Y. (2004). An integrated theory of the mind. *Psychological Review*, *111*, 1036–1060.

Anderson, J., & Bower, G. H. (1973). *Human associative memory*. Washington, DC: Winston.

Anderson, J. R., & Pirolli, P. L. (1984). Spread of activation. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *10*, 791–798.

Baird, R. R. (2003). Experts sometimes show more false recall than novices: a cost of knowing too much. *Learning and Individual Differences*, *13*, 349–355.

Balota, D. A., Yap, M. J., Cortese, M. J., Hutchison, K. A., Kessler, B., Loftis, B., Neely, J. H., Nelson, D. L., Simpson, G. B., & Treiman, R. (2007). The English lexicon project. *Behavior Research Methods*, *39*, 445–459.

Blom, R. M., Hagestein-de Bruijn, C., de Graaf, R., ten Have, M., & Denys, D. A. (2011). Obsessions in normality and psychopathology. *Depression and Anxiety*, *28*, 870–875.

Bradley, M. M., & Lang, P. J. (2010). *Affective norms for English words (ANEW): Stimuli, instruction manual and affective ratings. Technical Report C-2, Gainsville, FL*. The Center for Research in Psychophysiology, University of Florida.

Butler, K. M., McDaniel, M. A., McCabe, D. P., & Dornburg, C. C. (2010). The influence of distinctive processing manipulations on older adults' false memory. *Aging, Neuropsychology, and Cognition*, *17*, 129–159.

Castel, A. D., McCabe, D. P., Roediger, H. L., III, & Heitman, J. L. (2007). The dark side of expertise: domain-specific memory errors. *Psychological Science*, *18*, 3–5.

Collins, A. M., & Loftus, E. F. (1975). A spreading-activation theory of semantic processing. *Psychological Review*, *82*, 407–428.

Deese, J. (1959). On the prediction of occurrence of particular verbal intrusions in immediate recall. *Journal of Experimental Psychology*, *58*, 17–22.

Dewhurst, S. A., & Parry, L. A. (2000). Emotionality, distinctiveness, and recollective experience. *European Journal of Cognitive Psychology*, *12*, 541–551.

Fullana, M. A., Mataix-Cols, D., Caspi, A., Harrington, H., Grisham, J. R., Moffitt, T. E., & Poulton, R. (2009). Obsessions and compulsions in the community: prevalence, interference, help-seeking, developmental stability, and co-occurring psychiatric conditions. *The American Journal of Psychiatry*, *166*, 329–336.

Gallo, D. A. (2006). *Associative illusions of memory: False memory research in DRM and related tasks*. Philadelphia: Psychology Press.

Gallo, D. A. (2010). False memories and fantastic beliefs: 15 years of the DRM illusion. *Memory & Cognition*, *38*, 833–848.

Girischandra, B. G., & Sumant, K. (2001). Phenomenology of obsessive compulsive disorder: a factor analytic approach. *Indian Journal of Psychiatry*, *43*, 306–316.

Hermans, D., Martens, K., De Cort, K., Pieters, G., & Eelen, P. (2003). Reality monitoring and metacognitive beliefs related to cognitive confidence in obsessive-compulsive disorder. *Behavior Research and Therapy*, *41*, 383–401.

Hout, M. A., & Kindt, M. (2004). Obsessive-compulsive disorder and the paradoxical effects of perseverative behavior on experienced uncertainty. *Journal of*

Behavior Therapy and Experimental Psychiatry, *35*, 165–181.

Howe, M. L., Candel, I., Otgaar, H., Malone, C., & Wimmer, M. C. (2010). Valence and the development of immediate and long-term false memory illusions. *Memory*, *18*, 58–75.

Howe, M. L., & Derbish, M. H. (2010). On the susceptibility of adaptive memory to false memory illusions. *Cognition*, *115*, 252–267.

Hunt, R. R., & McDaniel, M. A. (1993). The enigma of organization and distinctiveness. *Journal of Memory & Language*, *32*, 421–445.

Jelinek, L., Hauschildt, M., Hottenrott, B., Kellner, M., & Moritz, S. (2014). Further evidence for biased semantic networks in obsessive-compulsive disorder (OCD): when knives are no longer associated with buttering bread but only with stabbing people. *Journal of Behavior Therapy and Experimental Psychiatry*, *45*, 427–434.

Jelinek, L., Hottenrott, B., & Moritz, S. (2009). When cancer is associated with illness but no longer with animal or zodiac sign: investigation of biased semantic networks in obsessive-compulsive disorder (OCD). *Journal of Anxiety Disorders*, *23*, 1031–1036.

Johnson, M. K. (1997). Source monitoring and memory distortion. *Philosophical Transactions of the Royal Society of London Series B: Biological Sciences*, *352*, 1733–1745.

Kawasaki, Y., & Yama, H. (2006). The difference between implicit and explicit associative processes at study in creating false memory in the DRM paradigm. *Memory*, *14*, 68–78.

Kim, S. J., Lee, H. S., & Kim, C. H. (2005). Obsessive-compulsive disorder, factor analyzed symptom dimensions and serotonin transporter polymorphism. *Neuropsychobiology*, *52*, 176–182.

Klumpp, H., Amir, N., & Garfinkel, S. N. (2009). False memory and obsessive-compulsive symptoms. *Depression and Anxiety*, *26*, 396–402.

Li, Y., Marques, L., Hinton, D. E., Wang, Y., & Xiao, Z. (2009). Symptom dimensions in Chinese patients with obsessive-compulsive disorder. *CNS Neuroscience and Therapeutics*, *15*, 276–282.

Lovibond, S. H., & Lovibond, P. F. (1995). *Manual for the depression anxiety stress scales* (2nd ed.). Sydney: Psychology Foundation.

Maratos, E. J., Allan, K., & Rugg, M. D. (2000). Recognition memory for emotionally negative and neutral words: an ERP study. *Neuropsychologia*, *38*, 1452–1465.

Mathews, A., & MacLeod, C. (2005). Cognitive vulnerability to emotional disorders. *Annual Review of Clinical Psychology*, *1*, 167–195.

Matsunaga, H., Maebayashi, K., Hayashida, K., Okino, K., Matsui, T., Iketani, T., & Stein, D. J. (2008). Symptom structure in Japanese patients with obsessive-compulsive disorder. *The American Journal of Psychiatry*, *165*, 251–253.

McCabe, D. P., Presmanes, A. G., Robertson, C. L., & Smith, A. D. (2004). Item-specific processing reduces false memories. *Psychonomic Bulletin & Review*, *11*, 1074–1079.

McDermott, K. B., & Watson, J. M. (2001). The rise and fall of false recall: the impact of presentation duration. *Journal of Memory and Language*, *45*, 160–176.

Moritz, S., & Jelinek, L. (2007). *Association splitting–Self-help guide for reducing obsessive thoughts*. Hamburg: VanHam Campus Press.

Moritz, S., & Jelinek, L. (2011). Further evidence for the efficacy of association splitting as a self-help technique for reducing obsessive thoughts. *Depression and Anxiety*, *28*, 574–581.

Moritz, S., Jelinek, L., Klinge, R., & Naber, D. (2007). Fight fire with fireflies! Association splitting: a novel cognitive technique to reduce obsessive thoughts. *Behavioral and Cognitive Psychotherapy*, *35*, 631–635.

Moritz, S., & Russu, R. (2013). Further evidence for the efficacy of association splitting in obsessive-compulsive disorder. An internet study in a Russian-speaking sample. *Journal of Obsessive-Compulsive and Related Disorders*, *2*, 91–98.

Muller, J., & Roberts, J. E. (2005). Memory and attention in obsessive-compulsive disorder: a review. *Journal of Anxiety Disorders*, *19*, 1–28.

Nelson, D.L., McEvoy, C.L., & Schreiber, T.A. (1998). The University of South Florida word association, rhyme, and word fragment norms. ⟨http://www.usf.edu/FreeAssociation/⟩.

Olatunji, B. O., Williams, B. J., Haslam, N., Abramowitz, J. S., & Tolin, D. F. (2008). The latent structure of obsessive-compulsive symptoms: a taxometric study. *Depression and Anxiety*, *25*, 956–968.

Rachman, S. (1993). Obsessions, responsibility, and guilt. *Behavior Research and Therapy*, *31*, 149–154.

Rachman, S. (1997). A cognitive theory of obsessions. *Behavior Research and Therapy*, *35*, 793–802.

Radomsky, A. S., & Alcolado, G. M. (2010). Don't even think about checking: mental checking causes memory distrust. *Journal of Behavior Therapy and Experimental Psychiatry*, *41*, 345–351.

Radomsky, A. S., Gilchrist, P. T., & Dussault, D. (2006). Repeated checking really does cause memory distrust. *Behavior Research and Therapy*, *44*, 305–316.

Reisberg, D. (2001). Associative theories of long-term memory In: D. Reisberg (Ed.), *Cognition: Exploring the science of the mind* (pp. 235–270). New York: W. W. Norton.

Roediger, H. L., III, Balota, D. A., & Watson, J. M. (2001). Spreading activation and arousal of false memories. In: H. L. Roediger, H. L., III, J. S. Nairne, I. Neath, & A. M. Surprenant (Eds.), *The nature of remembering: Essays in honor of Robert G. Crowder* (pp. 95–115). Washington, DC: American Psychological Association.

Roediger, H. L., III, & McDermott, K. B. (1995). Creating false memories: remembering words not presented in lists. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *21*, 803–814.

Roediger, H. L., III, & McDermott, K. B. (2000). Tricks of memory. *Current Directions in Psychological Science*, *9*, 123–127.

Salkovskis, P. (1985). Obsessional-compulsive problems: a cognitive-behavioral analysis. *Behavior Research and Therapy*, *23*, 571–583.

Salkovskis, P. M. (1989). Cognitive-behavioural factors and the persistence of intrusive thoughts in obsessional problems. *Behavior Research and Therapy*, *27*, 677–682.

Salkovskis, P. (1996). Cognitive behavioural approaches to the understanding of obsessional problems In: R. Rapee (Ed.), *Current controversies in the anxiety disorders* (pp. 103–133). New York: Guilford.

Schneider, W., Eschman, A., & Zuccolotto, A. (2002). *E-Prime user's guide*. Pittsburg: Psychology Software Tool Inc.

Sookman, D., Abramowitz, J. S., Calamari, J. E., Wilhelm, S., & McKay, D. (2005). Subtypes of obsessive-compulsive disorder: implications for specialized cognitive behavior therapy. *Behavior Therapy*, *36*, 393–400.

Taconnat, L., Clarys, D., Vanneste, S., & Isingrini, M. (2006). Effect of distinctive encoding on false recognition, discrimination, and decision critieria in young and elderly adults. *European Journal of Cognitive Psychology*, *18*, 708–729.

Tuna, Ş., Teckan, İ., & Topçuoğlu, V. (2005). Memory and metamemory in obsessive-compulsive disorder. *Behavior Research and Therapy*, *43*, 15–27.

Underwood, B. J. (1965). False recognition produced by implicit verbal responses. *Journal of Experimental Psychology*, *70*, 122–129.

Wheaton, M. G., Berman, N. C., Fabricant, L. E., & Abramowitz, J. S. (2013). Differences in obsessive-compulsive symptoms and obsessive beliefs: a comparison between African Americans, Asian Americans, Latino Americans, and European Americans. *Cognitive Behaviour Therapy*, *42*, 9–20.