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Obsessive–Compulsive Symptoms Are Associated With Increased Delay Discounting in a Novel Hand-Washing Task

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Abstract

Delay discounting is a theoretical framework for assessing impulsivity characterized by a tendency to choose SSRs over LLRs. Despite the potential therapeutic value of targeting impulsive choice in the context of obsessive-compulsive (OC) symptoms, little research has been done to examine the link between the 2. In the present study, we examined the role of impulsivity in OC symptoms using a monetary and novel hand-washing delay-discounting task. Participants completed both delay-discounting procedures, as well as the Obsessive-Compulsive Inventory—Revised (OCI-R; Foa et al., 2002). Participants who showed steeper delay discounting in the monetary discounting task also tended to discount steeply in the washing task. In addition, participants showed significantly more delay discounting in the washing than in the monetary task, suggesting contextual control over impulsive behavior. Further, participants with washing compulsions demonstrated greater delay discounting on the washing task than those without washing compulsions. Higher scores on the Washing subscale of the OCI-R uniquely predicted delay discounting in the washing task at a level of marginal significance. Our findings suggest that impulsivity may be implicated in OC symptoms, and indicate the need for a more precise conceptualization of the relationship between impulsivity and compulsivity.

Keywords

delay discounting; impulsivity; obsessive-compulsive disorder; washing

Obsessive-compulsive disorder (OCD) is characterized by the presence of both (a) intrusive, unwanted, recurrent, and persistent thoughts, urges, or images that can cause extreme anxiety or distress and (b) repetitive behaviors or mental acts that individuals feel driven to perform in response to an obsession or in accordance with rigidly applied rules (American Psychiatric Association, 2013).

A transdiagnostic construct implicated in many psychological disorders, including OCD, is impulsivity (Benatti, Dell’Osso, Arici, Hollander, & Altamura, 2014; Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001; Sohn, Kang, Namkoong, & Kim, 2014; Summerfeldt, Hood, Antony, Richter, & Swinson, 2004). Impulsivity and compulsivity have been characterized as two ends of a continuum, ranging from risk aversion (compulsivity) to risk taking (impulsivity), having little consideration of future consequences, the common theme being the presence of repetitive behaviors (Storch, Abramowitz, & Goodman, 2008). However, such a topographical conceptualization of impulsivity and compulsivity belies important functional discrepancies between the two constructs. For example, impulsive behavior tends to be appetitive or positively reinforced, whereas compulsive behavior tends to be negatively reinforced (e.g., escape from or avoidance of an aversive). In other words, impulsive behaviors are usually performed to access a rewarding consequence, whereas compulsive behaviors are usually performed to stop, remove, or avoid an undesirable consequence. As such, it may be more accurate to describe them as separate but related constructs that can co-occur and independently contribute to psychopathology.

In common vernacular, impulsivity can be thought of as acting on a whim with little to no regard for potential long-term consequences (Madden, Petry, & Johnson, 2009). Behaviorally, impulsivity manifests as actions that are “poorly conceived, prematurely expressed, unduly risky or inappropriate to the situation and that often result in undesirable consequences” (Daruna & Barnes, 1993, p. 23). It is often associated with undesirable, socially unaccepted behavior, such as cigarette smoking.

Impulsivity is widely regarded as having multiple dimensions that can be measured in multiple ways (e.g., de Wit, 2009). Two general techniques for assessing impulsivity include self-report measures (e.g., Barratt Impulsiveness Scale [BIS]; Patton, Stanford, & Barratt, 1995) and behavioral tasks (e.g., delay-discounting procedures). In self-report measures, individuals commonly read statements (e.g., “I act on impulse”), and then characterize how often those statements apply to themselves (e.g., *Sometimes*). These measures can be helpful and associated with important outcomes, but can also be subject to a variety of influences that may not be of interest to the experimenter, such as the desire to be seen positively, people’s ability to remember accurately what they typically do, and how they compare with the people they are commonly around (see de Wit, 2009; Odum, 2011a). Behavioral tasks, in contrast, do not require people to evaluate themselves or to estimate how frequently they do something. Instead, people perform a particular task (e.g., press the space bar as quickly as possible after seeing a stimulus on a computer screen) or make choices between different outcomes. In these cases, there is no obviously right or wrong answer (Odum, 2011a).

One way in which impulsivity has been operationalized from a behavioral perspective is the preference for smaller, sooner rewards (SSRs) over larger, later rewards (LLRs; i.e., delay

discounting; Madden, Bickel, & Critchfield, 2009). Choosing the sooner but smaller reward is considered an impulsive choice because of the loss of the long-term, greater reward, which is “discounted” by the individual, and represents the failure of a future consequence to affect present decisions. Delay discounting offers reliability (Jimura et al., 2011) and predictive validity (Odum, 2011b). Steep discounting of delayed rewards is associated with illicit and licit drug use (Friedel, DeHart, Madden, & Odum, 2014; Madden, Petry, Badger, & Bickel, 1997), increased body fat (Rasmussen, Lawyer, & Reilly, 2010), and lower college grade-point average (GPA; Kirby, Winston, & Santiesteban, 2005). Notably, delay discounting is also linked to psychopathologies such as schizophrenia (Heerey, Robinson, McMahon, & Gold, 2007), pathological gambling (Alessi & Petry, 2003), and borderline personality disorder (Lawrence, Allen, & Chanen, 2010).

Impulsivity as a broader construct has been studied in the context of OCD, though little is known about the specific role of delay discounting. Research on impulsivity more generally has revealed that patients with OCD tend to score higher on the BIS (Patton et al., 1995) than healthy controls (Summerfeldt et al., 2004). Benatti et al. (2014) compared patients with OCD to healthy controls using the BIS and found significantly higher total scores and higher attentional impulsivity scores in the OCD group. Other studies have employed behavioral tasks, such as a stop-signal task (Sohn et al., 2014), and balloon-analog risk test (Sohn et al., 2014), to tap other facets of impulsivity, including response inhibition (motor impulsivity) and risk taking. For example, Sohn et al. (2014) found that patients with OCD demonstrated greater action impulsivity and lower risk-taking tendencies. Results of these studies indicate a possible link between OCD and impulsivity, although there is a paucity of research investigating the relation between OCD and delay discounting.

Delay discounting is a theoretical framework that describes sensitivity to immediate rewards, which decreases as the delay to delivery of rewards increases. In other words, delay discounting assesses choice patterns in which the value of a reward decreases (or is discounted) as time to delivery increases. This framework can also be used to conceptualize responses to distress-provoking obsessions with compulsive behavior. That is, a compulsion can be construed as the selection of short-term rewards (e.g., immediate reduction of anxiety) at the cost of long-term rewards (e.g., living a more meaningful life). However, findings have been mixed on this front. Whereas Pinto, Steinglass, Greene, Weber, and Simpson (2014) found no significant difference in delay discounting between participants with OCD and healthy controls, Sohn et al. (2014) reported greater delay discounting in their OCD group relative to healthy controls. It should be noted that both studies were limited by their use of relatively small sample sizes, as well as a monetary delay-discounting task, which may not provide sufficient contextually relevant cues to assess discounting with outcomes relevant to OCD. Hence, there is a need to examine a clearly operationalized form of impulsivity specific to the OCD presentation (i.e., domain-specific delay discounting) with larger samples to better understand the nuanced role of impulsivity in OCD. That is, there is a need for behavior-specific delay-discounting tasks that provide a measure of impulsivity pertinent to the individual's problem behavior. In the current study, we sought to use a more sensitive measure of impulsivity vis-a-vis OCD—a novel handwashing, delay-discounting task.

The present study examined the link between domain-specific delay discounting and OC behavior, with the aim of further understanding the role of impulsivity in OCD as well as the relationship between impulsivity and compulsivity. To do so, we developed a novel handwashing, delay-discounting task in which participants discounted a compulsive behavior following a hand contamination scenario, the most common type of obsession in OCD. Using this measure of delay discounting, we examined how discounting hand washing would be affected in participants with OC tendencies. Participants completed two different delay-discounting procedures: The first involved the standard hypothetical money task, and the second involved a new compulsive washing paradigm and hypothetical money. The overarching objective of the study was to examine differences in behavioral responses between situations involving a generalized conditioned reinforcer (i.e., money) versus an unconditioned reinforcer (i.e., removal of an aversive stimulus), as well as between individuals with high and low levels of compulsivity. We predicted that (a) participants would discount the reward of money differently only from the reward of hand washing plus money, (b) delay discounting in the monetary and washing procedures would be correlated (Odum, 2011b), (c) participants with high Washing subscale scores on the Obsessive-Compulsive Inventory—Revised (OCI-R; Foa et al., 2002) would show greater delay discounting in both the monetary and washing procedures than those with low Washing scores, and (d) Washing subscale scores on the OCI-R would predict delay discounting in the hand-washing task, but not the monetary task.

Method

Participants

Participants were 245 undergraduate students recruited from an introductory psychology course, each of whom provided informed consent. For participating, they were given course credit and entered into a drawing for a chance to receive one of fifty \$10 Amazon.com gift cards. The Utah State University Institutional Review Board approved all experimental procedures.

Measures

Impulsivity measure: Monetary delay-discounting task.—The purpose of the delay-discounting procedures was to determine how participants value a consequence as it becomes temporally distant. In the hypothetical monetary delay-discounting task, participants chose between a small, immediate amount of money and a larger, delayed amount of money (adapted from the procedure used by Bickel, Odum, & Madden, 1999). The small rewards were dollar amounts presented in descending fixed-sequence order (100.00, 99.00, 97.50, 95.0, 92.50, 90.00, 85.00, 80.0, 75.00, 70.00, 65.00, 60.00, 55.00, 50.00, 45.0, 40.00, 35.00, 30.00, 25.00, 20.00, 15.00, 10.0, 7.50, 5.00, 2.50, and 1.00), and the delayed amount was constant at \$100. Values were presented in that order at each delay, and the indifference point for each delay was defined as the last immediate value chosen. The delays tested were 1 day, 1 week, 1 month, 6 months, and 2 years, in that order.

Compulsivity and impulsivity measure: Hand-washing delay-discounting task.—In addition to the hypothetical monetary discounting task, a novel delay-discounting

procedure involving hand washing and hypothetical money was used to assess a tradeoff between receiving money and washing one's hands. Symptom-specific delay-discounting tasks that model clinically relevant behaviors and outcomes have been used previously (e.g., Bickel et al., 1999; Coffey, Gudleski, Saladin, & Brady, 2003; Johnson & Bruner, 2012; Johnson, Johnson, Herrmann, & Sweeney, 2015; Madden et al., 1997), however, delay discounting has never been examined in the context of obsessive-compulsive symptoms. Participants were shown the following scenario and asked to imagine they were in this situation:

After using a public restroom, you are about to leave and as you grab the door handle to exit you notice a sticky, gooey substance is on the handle and is now on your hand. On the floor next to the door you see a used and discarded tissue with the same mucus-like substance that is now on your hand. This substance is not seriously harmful to your health and has no adverse consequences other than the unpleasantness normally associated with another person's mucus on your hand. Before you are able to remove this substance imagine you are presented with the following choices.

After reading this, participants were presented with choices similar to the monetary delay-discounting procedure. The first trial was a choice to receive \$99 and the option to wash right away or to receive \$100, after a 1-min delay before washing. The second trial was a choice to receive \$97.50 and the option to wash right away or to receive \$100 after a 1-min delay before washing. The same immediate and delayed (\$100) monetary amounts were presented as in the monetary discounting task (i.e., the immediate rewards were presented in descending order, and the delayed reward remained constant at \$100). Delays tested were 1 min, 7 min, 30 min, 3 hours and 12 hours. The indifference point was the last immediate value selected at each delay. See the Appendix for the exact choices presented.

Demographic questions.—Participants answered basic background demographic questions, such as age, sex, years of education, and estimated college GPA.

Obsessive Compulsive Inventory—Revised (OCI-R).—The OCI-R consists of 18 items designed to screen for individuals with OCD symptoms and various subtypes of the disorder (e.g., a Washing subtype question: "I wash my hands more often and longer than necessary;" Foa et al., 2002). Respondents are asked to rate the extent to which various OCD symptoms have distressed or bothered them in the past month on a 5-point scale from 0 (*not at all*) to 4 (*extremely*). The OCI-R comprises six subscales: Washing, Obsessing, Ordering, Checking, Neutralizing, and Hoarding. Each subscale is represented by three items. The OCI-R has demonstrated moderate-to-excellent internal consistency, good-to-excellent test-retest reliability, convergent validity, and known-groups validity in both clinical and nonclinical samples (Abramowitz & Deacon, 2006; Foa et al., 2002; Hajcak, Huppert, Simons, & Foa, 2004). Alpha coefficients in the present sample were .89 for the full scale, and between .68 and .85 for the six subscales, consistent with figures obtained by Hajcak et al. (2004) in their college sample.

Procedure

Participants completed the study using Utah State University's online Sona Systems at their convenience. After consenting to participate in the study, participants were provided with brief instructions on the delay-discounting tasks and asked to simply choose the hypothetical outcomes that they would prefer (similar to instructions provided by Odum, Baumann, & Rimington, 2006). Following the instructions, participants completed two delay-discounting tasks—the hypothetical monetary discounting task and the hand-washing discounting task. The order of discounting-task presentations was counterbalanced across participants. Following the discounting tasks, participants provided basic demographic information and then completed the OCI-R (Foa et al., 2002).

Data Analyses

First, prior to statistical analyses, the median indifference points (i.e., the last immediate monetary value chosen) for both delay-discounting procedures were plotted as a function of the delays tested. We visually assessed whether indifference points across the monetary and novel hand-washing task decreased as delays increased. This function describes whether increasing delays influence the subjective value of both the monetary and hand-washing outcomes.

Second, we calculated ordinal area under the curve (AUC) for both the monetary and the hand-washing delay-discounting procedures (Borges, Kuang, Milhorn, & Yi, 2016). AUC measures the proportion of the total area underneath the discounting function and ranges from 0 to 1, with lower values indicating steeper delay discounting (i.e., more impulsive decision-making). We selected ordinal AUC as a metric for delay discounting for several reasons. First, ordinal AUC offers a theoretically neutral measure of discounting, rather than imposing theoretical assumptions given the novel nature of our task. Second, ordinal AUC offers an accessible and easily understandable metric of discounting (i.e., values between 0 and 1) without relying only on complex model fitting. Third, in some cases model fitting might not fit individual subject data, and given the novel nature of the task, we opted for ordinal AUC to avoid unnecessary data elimination as a result of imposing theoretical assumptions on the nature of the data. Once the indifference points and delays were normalized, the actual AUC can be calculated (Myerson, Green, & Warusawitharana, 2001) using the formula $x_2 - x_1[(y_1 + y_2)/2]$, where x_2 and x_1 represent successive delays and y_1 and y_2 represent the indifference points associated with those delays. We used a variation of the original AUC formula to adjust for the differences in delays used across tasks and to evenly weight short and long delays (see Borges et al., 2016).

We also examined the data for nonsystematic responders using Johnson and Bickel's (2008) criteria. We identified 29 and 44 nonsystematic responders in the hand-washing and standard discounting tasks, respectively. Despite relatively high variability in ordinal AUC values for the hand-washing discounting task, we elected to retain nonsystematic responders in our analyses to account for less predictable patterns of responding, given that we did not have a priori assumptions regarding discounting patterns in the novel hand-washing task.

Statistical analyses were performed using R (Version 3.4.0; R Core Team, 2013) and the R packages tidyverse (Wickham, 2017), effsize (Torchiano, 2017), Hmisc (Harrell & DuPont, 2017), and lm.beta (Behrendt, 2014). Using ordinal AUC, we conducted a Spearman correlation to examine the relation between discounting of hand washing paired with money and money alone. A Wilcoxon signed-ranks test was also used to compare degree of delay discounting within individuals across tasks. In addition, to examine the data of individuals with extreme washing scores in conjunction with the novel hand-washing delay-discounting task, we dichotomized the Washing subscale scores and compared individuals with scores of 5 and above ($n = 48$; high-W group) to those with scores of 4 and below ($n = 197$; low-W group). Mann-Whitney U tests were used to compare the ordinal AUC of those who scored high and low on the Washing subscale for both the monetary and hand-washing delay-discounting tasks. The same analyses were applied to those who scored high ($n = 46$) and low ($n = 199$) on the overall OCI-R. Cutoff scores of 28 and 5 were used for the full OCI-R scale and OCI-R Washing subscale, respectively, to approximate OCI-R mean scores among patients with OCD (Foa et al., 2002).

Third, we conducted extra sums-of-squares F tests (GraphPad Prism, La Jolla, CA) to allow for a detailed comparison of delay discounting across monetary and hand-washing tasks for those who scored high and low on the OCI-R Washing subscale and the full OCI-R (see Johnson et al., 2015). These analyses regressed indifference points for each task against delay. Nonlinear regressions were performed using a two-parameter, hyperbolic discounting equation (Myerson & Green, 1995): $100/(1 + kx)^s$, where x is the independent variable (hr), k is the parameter proportional to the discount rate, and s is a parameter describing the nonlinear scaling of the dependent variable. The free parameters k and s were unconstrained in the regression analyses. The F tests compared the difference in nonlinear regression-model error when one curve was the best fit to all discounting data collapsed across groups (i.e., when free parameters were shared), versus when a separate curve was best fit for each group (i.e., free parameters unshared). A significant p value demonstrated significantly less error when separate curves were best fit to each respective task, indicating that the tasks differed in degree of discounting. The same comparisons as described above were evaluated using the extra sums-of-squares F tests (comparisons of monetary and hand-washing delay discounting for those who scored high and low on the Washing subscale, as well as high and low on the full OCI-R scale).

A bivariate Spearman correlation matrix with all participants was also used to identify significant relationships of GPA and OCI-R (Foa et al., 2002) subscales with ordinal AUC for each delay-discounting task. In addition, Mann-Whitney U tests were used to determine sex differences in delay discounting for both procedures. Finally, hierarchical linear regression analyses were conducted to determine the unique predictors of delay discounting, with GPA and sex entered in the first step, and relevant OCI-R subscale scores entered in the second step.

Results

Participant Descriptives

Forty-three percent of our sample was male, and the mean age was 20.75 ($SD = 3.94$) years. The mean GPA was 3.27 ($SD = 0.51$). Means and standard deviations for the OCI-R were as follows: 18.68 (10.80; total), 3.52 (2.88; Obsessing), 4.29 (2.80; Ordering), 2.61 (2.19; Checking), 1.98 (2.39; Neutralizing), 3.72 (2.50; Hoarding), and 2.55 (2.51; Washing).

Monetary Delay Discounting Versus HandWashing Delay Discounting

Figure 1 presents the median indifference points as a function of delay for both the monetary and the hand-washing delay-discounting tasks. The value of both money and hand washing decreased with increased time to receipt. A significant positive correlation between discounting of hand washing paired with money and money alone as measured by ordinal AUC was revealed ($p = .38$, $p < .001$). In addition, participants discounted delayed hand washing paired with money (AUC median = .68, IQR = .55) significantly more steeply than money alone (AUC median = .84, IQR = .21; $p < .001$; Cliff's $\delta = -0.99$). The extra sums-of-squares F tests also confirmed significantly steeper delay discounting of hand washing paired with money, relative to money alone, $F(2, 2446) = 126.7$, $p < .0001$.

High Versus Low Washing Subscale Scores

Figure 2 shows the median-indifference points for the hand-washing and monetary delay-discounting tasks for participants with low scores (< 5) on the OCI-R (Foa et al., 2002) Washing subscale (low-W group) as well as participants with high scores (≥ 5) on the Washing subscale (high-W group). Generally, median-indifference points decreased as delay increased in both the hand-washing delay-discounting task (top panel) and the monetary delay-discounting task (bottom panel).

In the hand-washing discounting task, high-W participants showed steeper discounting than low-W participants (see Figure 2, top panel). In other words, those with higher scores on the Washing subscale of the OCI-R were less willing to wait to wash their hands, even with the \$100 reward associated with waiting. For example, high-W participants viewed the immediate reward of hand washing and \$0 as subjectively equivalent to a delayed reward of \$100 after 180 seconds without washing. Those in the high-W group discounted hand washing more steeply (AUC median = .52, interquartile range [IQR] = .60) than those scoring lower on the Washing subscale (low-W group; AUC median = .71, IQR = .53) at a marginally significant level ($W = 5,532.5$, $p = .068$; Cliff's $\delta = 0.17$). The extra sums-of-squares F test also revealed that hand-washing delay was discounted significantly more steeply for those who scored high as opposed to low on the Washing subscale, $F(2, 1,221) = 7.77$, $p = .0004$.

A Mann-Whitney U test indicated that the money alone, however, was not discounted significantly differently between the high-W and low-W groups (ordinal AUC median = .88, IQR = .20 for high-W group vs. median = .84, IQR = .21 for low-W group; $W = 4,223$, $p = .252$), suggesting that there was no significant difference across these groups in levels of impulsivity as measured by the monetary task (see Figure 2 bottom panel). This lack of

difference in discounting was also confirmed by the extra sums-of-squares F test $F(2, 1,221) = 2.038, p = .131$).

High Versus Low OCI-R Scores

No significant differences in delay discounting were found between participants with high OCI-R (Foa et al., 2002) scores (≥ 28) and those with low OCI-R scores (<28) for either the hand-washing or monetary delay-discounting procedures in either the Mann-Whitney U tests using ordinal AUC, or extra sums-of-squares F tests ($ps > .93$).

Predictors of Delay Discounting

Bivariate correlations revealed that ordinal AUC (monetary) was significantly associated with GPA ($p < .001$), whereas ordinal AUC (hand washing) was significantly associated with GPA, Ordering, and Washing ($ps < .05$; see Table 1). Specifically, lower GPA was related to steeper delay discounting for both the monetary and hand-washing tasks, whereas higher Ordering and Washing subscale scores were linked to greater delay discounting in the hand-washing procedure. Neither age nor the other OCI-R subscales were significantly related to ordinal AUC across both tasks ($ps > .05$). A significant sex difference was observed for delay discounting in the hand-washing task, with women (median = 0.56, IQR = .53) showing steeper delay discounting than men (median = 0.74, IQR = .41; $W = 9,292, p < .001$; Cliff's $\delta = 0.26$). No sex difference was found for delay discounting in the monetary task ($p = .75$).

Based on these findings, we ran a follow-up hierarchical linear regression analysis using ordinal AUC (hand washing) as the dependent variable, GPA and sex as predictor variables in the first step, and Ordering and Washing scores in the second step. Only GPA and sex emerged as significant, unique predictors of delay discounting in the hand-washing task ($ps < .05$), accounting for 11.1% of the total variance (see Table 2). Washing scores were a marginally significant predictor of ordinal AUC (hand washing; $p = .05$). Lower GPA, female sex, and higher Washing scores (more severe washing symptoms) were associated with greater delay discounting (higher impulsivity) in the handwashing procedure, controlling for Ordering scores.

Discussion

Several notable results emerged from the present study, which included examinations of delay discounting—a specific form of impulsivity—in college students using monetary and novel handwashing delay-discounting procedures. First, delay discounting on the hand-washing task and the money task were significantly and positively correlated. Second, participants exhibited significantly steeper delay discounting in the handwashing compared with the monetary delay-discounting task. Third, participants with high washing scores showed steeper delay discounting in the hand-washing task than those with low washing scores. Fourth, there were no significant differences between groups with high and low washing scores on the monetary delay-discounting task or between groups with high and low OCI-R (Foa et al., 2002) scores on either of the delay-discounting tasks. Finally, lower GPA predicted greater delay discounting in the monetary task, but lower GPA, female sex,

and more severe self-reported washing compulsions predicted greater delay discounting in the hand-washing task.

Delay discounting across both tasks was significantly and positively correlated, and participants demonstrated steeper delay discounting (e.g., more impulsivity) when they chose between monetary rewards and washing their hands following contamination, relative to monetary rewards alone. These results indicate that how steeply an individual discounts outcomes in one domain is likely to be related to how steeply they discount outcomes in other domains (see Odum, 2011b for discussion). These results also suggest, however, that generating clinically relevant scenarios and outcomes may allow for greater sensitivity in detecting the relation between impulsivity and specific individual pathologies. For example, participant body fat is more strongly related to delay discounting for food than to delay discounting for money (Rasmussen et al., 2010). These results provide further support for the interplay of impulsivity and compulsivity in maintaining OC behavior.

Participants with high washing scores discounted hand washing combined with the larger, later monetary reward significantly more steeply than those with low washing scores. In other words, participants with high washing scores showed similar levels of impulsivity for the monetary delay-discounting task, but more impulsivity for the hand-washing delay-discounting task, relative to those with low scores. Given that participants with significant washing compulsions performed differently on the symptom-specific delay-discounting procedure, different variables may be implicated in a monetary binary decision delay-discounting task versus a washing-specific delay-discounting task among these individuals. These findings support the use of symptom-specific discounting tasks to elucidate the relationship between impulsivity and psychological conditions. In these cases, greater discrepancy in delay-discounting performance across tasks may be expected.

The lack of significant difference in degree of delay discounting between participants with high and low OCI-R scores suggests that overall OC-symptom severity was not related to delay discounting in our sample. In addition, there were no significant differences between participants with high washing scores and those with low washing scores in levels of delay discounting in a monetary delay-discounting task (i.e., impulsivity in a neutral context). These findings add to the literature on impulsivity and compulsivity, and may initially appear to indicate a weak relationship between the two constructs. However, as our other results show, an issue with simply conflating findings on impulsivity is that there are multiple ways to define the construct, and different facets of impulsivity may not be consistently correlated (Sohn et al., 2014). The current experiment shows that even within the narrower definition of delay discounting, different relations can emerge depending on specifics of the task (e.g., significant overall OC symptoms vs. significant washing compulsions and monetary vs. hand-washing delay discounting). As such, it may not be prudent to expect uniform findings across settings, disorder presentations, and operationalizations of impulsivity. Instead, future research might focus on clinically relevant operationalizations of impulsivity that contribute to the maintenance of symptoms (e.g., steeper delay discounting of monetary rewards in an anxiety-provoking setting), rather than levels of impulsivity that do not require clinical attention (e.g., average levels of delay

discounting in a neutral setting). The former area of research may be better suited to guide treatment goals as well as to identify processes of therapeutic change.

The difference in significant predictors for each of the delay-discounting tasks, along with the significant difference in discounting for hand washing relative to money, and the steeper discounting in the hand-washing task for those who scored high on the Washing subscale of the OCI-R—at the level of marginal significance— suggest that different contextual variables may be controlling discounting behavior across these tasks. One of those variables might have been the role of negative reinforcement in the hand- washing—but not the monetary—discounting task. In the hand-washing task, the removal of mucus via hand washing could have had a negatively reinforcing value, altering the function of the impulsive behavior (i.e., washing immediately) in this paradigm, whereas no source of negative reinforcement was hypothesized to be present in the monetary task. Thus, these results suggest that aspects of compulsivity, in addition to impulsivity, were assessed during the handwashing task, and that compulsivity (escape from an aversive stimulus) was especially relevant for individuals who scored high on the Washing subscale.

That lower GPA was associated with greater delay discounting in both tasks is consistent with previous literature, and expected, given that the rewards tied to academic effort are often delayed (Kirby et al., 2005). The additional assessment of compulsivity in the handwashing paradigm might partially explain why female sex predicted delay discounting in the hand washing, but not the monetary, task. Although previous research has not found significant differences in delay discounting between sexes, women appear to demonstrate greater punishment sensitivity than men in terms of their emotional responses (e.g., anxiety) to aversive stimuli (Cross, Copping, & Campbell, 2011). It is possible that greater sensitivity to the threat of contamination in our study paradigm resulted in steeper discounting among female participants. Furthermore, consistent with our prediction, higher washing scores predicted greater delay discounting in the washing task. Given that individuals with high washing scores would likely perceive contamination as more aversive than those with low scores, the former would be expected to show higher levels of escape (i.e., washing). Furthermore, the perception of greater threat of contamination could have increased the salience of the immediate reward of washing, while decreasing the salience of the delayed reward of more money, leading to a steeper degree of discounting in individuals with more severe washing compulsions.

Our findings preclude broad statements on the relationship between impulsivity and OC behavior, as any such relationship may be specifically related to the match between context and the individual's particular presentation of OCD (e.g., dirt, for fear of contamination, driving, for fear of running someone over). Similarly, although delay discounting across domains is clearly related, some delay-discounting research has also shown stronger relations of clinically relevant behavior to discounting scenarios of clinical relevance than money alone (Jarmolowicz, Bickel, & Gatchalian, 2013; Johnson & Bruner, 2012; Lawyer & Schoepflin, 2013; Rasmussen et al., 2010; Tsukayama & Duckworth, 2010). Hence, a possible direction for future research is exploring delay discounting across various domains, as well as across OC subgroups, to delineate the boundaries with which the relationship between delay discounting and OC symptoms holds.

With regard to treatment implications, the greater degree of discounting in a symptom-specific context relative to money alone suggests that individuals, including those with significant washing symptoms, do not inherently lack the ability to select the LLR over the SSR. Rather, the specific context of contamination might diminish the relative subjective value of a delayed, larger monetary reward because of other variables, such as the perceived aversive nature of anxiety and need to reduce anxiety. In other words, the LLR that was initially viewed as rewarding in a neutral context lost its value in an anxiety-provoking one. Moreover, although money was used as the LLR in the present study, such findings may be extrapolated to reflect real-life decisions associated with OC behavior in which individuals consistently select the SSR of immediate escape from or avoidance of an aversive stimulus (e.g., contamination) over the LLR of value-consistent behavior (e.g., spending time with family). Based on this postulation, clarification of values to promote the salience of LLRs across settings may be useful in treatment. Therefore, a value-guided therapy, like acceptance and commitment therapy (ACT), which increases the salience of LLR via verbal processes, may be useful in the treatment of OCD, particularly for individuals with steep delay discounting. In fact, a previous experimental study by Morrison, Madden, Odum, Friedel, and Twohig (2014) found that a one-session acceptance-based training focusing on acceptance and values clarification decreased delay discounting, supporting the applicability of ACT and similar therapies to individuals with OCD who have difficulties with self-control in specific contexts.

These findings also contribute to the extensive literature on the role of delay discounting in various other mental health conditions and problematic behaviors (e.g., Alessi & Petry, 2003; Bickel et al., 1999; Madden et al., 1997; Sohn et al., 2014), demonstrating the transdiagnostic impact of this form of impulsivity (Bickel, Jarmolowicz, Mueller, Koffarnus, & Gatchalian, 2012). Though the differential presentation of delay discounting across tasks warrants further replication and investigation, the present study suggests that clinicians working with various disorders may benefit from assessing and targeting delay discounting in treatment. In addition, our findings highlight the intricacies of research on the relationship between impulsivity and compulsivity, suggesting that both constructs may independently contribute to the maintenance of psychopathology as well as that their relationship may vary as a function of context. It thus seems reductive to posit an “impulsivity or compulsivity” framework in understanding mental health conditions, as the continuum model states. Instead, researchers and clinicians may find more utility in an “impulsivity and compulsivity” framework, recognizing the ways in which both constructs interrelate and collaboratively influence clinical presentations across mental health conditions.

The present findings should be considered in the context of its limitations. First, in the current procedure, we used hypothetical rather than actual scenarios, and it is possible that the results we obtained would not be generalizable to real-life situations or do not accurately reflect individual's reactions to an anxiety-provoking situation. Research has shown no difference, however, in delay discounting when comparing real and hypothetical outcomes (e.g., Lagorio & Madden, 2005; Madden, Begotka, Raiff, & Kastern, 2003) and treatment studies on OCD commonly utilize both in vivo and imaginal exposures (e.g., Olatunji et al., 2013; Simpson et al., 2008). Some evidence also indicates that imaginal exposures yield similar effects to in vivo exposures (Foa, Steketee, & Grayson, 1985).

Second, previous studies (e.g., Bickel et al., 1999; Mellis, Woodford, Stein, & Bickel, 2017) that showed large differences across groups of current, never-, and ex-smokers in monetary delay discounting used monetary values of \$1,000, rather than \$100 as used in the present study. It is possible that such differences in delay discounting are larger and more reliably elucidated with larger amounts of money than those used in the present study. The present results, combined with previous findings, warrant additional investigation into the task parameters and various subscale scores that may influence the sensitivity of delay-discounting measures for individuals with OC symptoms.

A third limitation is that the same delays were not used across the monetary and hand-washing tasks. This limitation might be particularly relevant for the AUC analyses, in which it is best to standardize the range of delays used when comparing across experiments (Myerson et al., 2001). Although by using the ordinal scaling transformation of delays within the ordinal AUC analyses, we were able to adjust for the differences in delays used, an exact comparison would use the same delays across each task. It is possible, therefore, that the differences in discounting revealed in the present study were actually underestimated. Although larger differences between monetary and hand-wash discounting may be revealed if the same delays were used, the present results, which remain consistent across all analyses used (i.e., *F* tests, ordinal AUC analyses) suggest that the current conclusions would not change. Future research should address this issue.

Last, we used an analogue sample of college students, which raises the possibility that findings will not generalize to clinical samples, though analogue studies have been found to be relevant to understanding OC symptoms in clinical populations because of the dimensional nature of OC symptoms (Abramowitz et al., 2014). Nonetheless, future studies using in vivo procedures and clinical samples may provide more direct evidence for the role of delay discounting in the maintenance of OCD.

Appendix

Hand-Washing Delay-Discounting Task Instructions

After using a public restroom, you are about to leave and as you grab the door handle to exit, you notice a sticky, gooey substance on the handle and is now on your hand. On the floor next to the door, you see a used and discarded tissue with the same mucus-like substance that is now on your hand. This substance is not seriously harmful to your health and has no adverse consequences other than the unpleasantness normally associated with another person's mucus on your hand. Before you are able to remove this substance imagine you are presented with the following choices.

Table A1 *Choices Presented to Participants in the Hand-Washing Delay-Discounting Task*

Dollar condition	Delay time and reward
100.00 now and the option to wash right	away \$100 and a delay of 1 min [*] before washing
99.00 now and the option to wash right away	

Dollar condition	Delay time and reward
97.50 now and the option to wash right away	
95.00 now and the option to wash right away	
92.50 now and the option to wash right away	
90.00 now and the option to wash right away	
85.00 now and the option to wash right away	
80.00 now and the option to wash right away	
75.00 now and the option to wash right away	
70.00 now and the option to wash right away	
65.00 now and the option to wash right away	
60.00 now and the option to wash right away	
55.00 now and the option to wash right away	
50.00 now and the option to wash right away	
45.00 now and the option to wash right away	
40.00 now and the option to wash right away	
35.00 now and the option to wash right away	
30.00 now and the option to wash right away	
25.00 now and the option to wash right away	
20.00 now and the option to wash right away	
15.00 now and the option to wash right away	
10.00 now and the option to wash right away	
7.50 now and the option to wash right away	
5.00 now and the option to wash right away	
2.50 now and the option to wash right away	
1.00 now and the option to wash right away	
No money and the option to wash right away	

*The delays used were 1 min, 7 min, 30 min, 3 hr, and 12 hr.

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Figure 1. Median indifference points as a function of delay for the monetary delay-discounting task (circles) and the hand-washing delay-discounting task (squares).

Figure 2. Median indifference points as a function of delay for the hand-washing discounting task (top panel) and the monetary discounting task (bottom panel) for those who scored high (5 and above) and low (4 and below) on the Hand Washing subscale of the Obsessive-Compulsive Inventory—Revised.

Table 1

Bivariate Spearman Correlations With Ordinal AUC (Monetary) and Ordinal AUC (Hand Washing)

Variable	Ordinal AUC (monetary)	Ordinal AUC (hand washing)
Age	-.057	-.014
GPA	.290 ***	.212 ***
OCI-R total	-.007	-.096
OCI-R Obsessing	-.024	.025
OCI-R Ordering	-.042	-.129 *
OCI-R Checking	.034	-.008
OCI-R Neutralizing	-.001	-.028
OCI-R Hoarding	-.107	.007
OCI-R Washing	.106	-.179 **

Note. AUC = area under the curve; GPA = grade point average; OCI-R = Obsessive-Compulsive Inventory— Revised.

*
 $p < .05$.

**
 $p < .01$.

 $p < .001$.

Table 2

Hierarchical Regression Model With Area Under the Curve for the Hand-Washing Delay-Discounting Task as the Dependent Variable

Independent variable	R^2	R^2	$F(df)$	p for R^2	$b(SE)^a$	β^a	p^a
Step 1	.091	.091	13.18 (2, 242)	<.001			
GPA					.134 (.037)	.221	<.001
Sex					-.128 (.038)	-.205	<.001
Step 2	.111	.021	8.65 (2, 240)	<.001			
Ordering ^b					-.006 (.008)	-.053	.500
xsWashing ^b					-.017 (.009)	-.137	.054

Note. SE = standard error.

^aCoefficients reported are for the final model.

^bSubscale scores on the Obsessive-Compulsive Inventory—Revised.