INVESTIGATING THE COGNITIVE AND EMOTIONAL FEATURES OF HOARDING DISORDER USING VIRTUAL REALITY

by

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Abstract

Investigating the Cognitive and Emotional Features of Hoarding Disorder using Virtual Reality

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Hoarding disorder was recently recognized as a mental disorder. It is characterized by difficulty discarding objects and excessive clutter limiting the functionality of living spaces in the home. Hoarding represents a considerable public and personal health concern, but there is still much that is unknown about its development and maintenance. Furthermore, current psychological treatments provide only modest outcomes. The present dissertation examined two key aspects of the cognitive-behavioural model of hoarding: *information processing* (i.e., memory, attention, decision making, categorization; Study 1) and *emotional features* (i.e., emotional intensity, experiential avoidance; Study 2). Exploratory questions concerning preference for cluttered spaces were also examined (Study 3). Three novel virtual reality (VR) environments were developed to examine these components with improved ecological validity. Two groups (i.e., with hoarding disorder, $n = 36$; without hoarding disorder, $n = 40$) similar in age and gender were recruited from the community. In Study 1, participants completed a series of standardized and novel VR memory and decision making tasks, and created a categorization strategy for objects in a messy VR home office. Higher attentional difficulties, poorer category efficiency, and poorer trait, but not state, memory confidence was reported in the hoarding group. Indecisiveness was positively correlated with perfectionism. There was no evidence of memory

and decision making impairments specific to the hoarding group. In Study 2, participants engaged in two VR shopping trips following a negative or neutral mood induction. The hoarding group acquired more objects and at a faster rate than the nonhoarding group, and discarded fewer objects following the negative mood induction. There were no group differences on emotional intensity, but the hoarding group demonstrated higher emotional reactivity and experiential avoidance. In Study 3, reactions to different levels of clutter were observed using a VR living room that became progressively more cluttered. There were no differences in subjective or physiological reactivity to increasing clutter levels. The hoarding group reported a preference for slightly more cluttered rooms; however, they also reported higher claustrophobic fear. Results from this research advance our understanding of the cognitive-behavioural components of hoarding and offer implications for future treatment and VR research initiatives.

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Dedication

To Delphine McCabe.

Table of Contents

List of Tables

List of Figures

List of Appendices

Introduction

Hoarding is characterized by persistent difficulty discarding possessions, leading to excessive clutter and impaired functioning within the home. Newly purchased items are often mixed with trash or with items of little value, such that homes become disorganized and difficult to navigate, and in extreme cases, cause fire and other safety hazards. As many as 88% of individuals with hoarding problems also report excessive acquisition, primarily via buying, but also by acquiring free things, and rarely, stealing (Frost, Rosenfield, Steketee, & Tolin, 2013; Pertusa et al., 2010). Lifetime prevalence estimates for hoarding disorder range from 2.3% (Iervolino et al., 2009) to 14% (Ruscio, Stein, Chiu, & Kessler, 2010) in the general population. According to an epidemiologic study that used a community sample of over 700 participants in Baltimore, Maryland, 5.3% of the population of the United States is expected to display pathological hoarding behaviour (Samuels et al., 2008). Prevalence rates were nearly twice as high for those who were widowed versus those who were currently married. The odds of reporting hoarding symptoms were also nearly four times greater in poor versus wealthy households. However, it should be noted that this apparent discrepancy in socioeconomic status between those with and without hoarding problems may be reflective of a reporting bias. Individuals with higher socioeconomic status may own larger properties or storage units, which could mask the impact of difficulty discarding. With respect to other clinical characteristics, hoarding was more likely to co-occur with alcohol dependence and various personality traits such as paranoid, schizotypal, avoidant, obsessive-compulsive, and antisocial. Early childhood adversity, such as parental psychopathology, home break-ins, and excessive physical discipline, was also associated with higher odds of hoarding in adulthood. The odds of reporting hoarding behaviour were nearly three times higher for the oldest age bracket (i.e., 55-94 years) compared

to the youngest age bracket (i.e., 34-44 years), demonstrating that symptoms worsen with age. This is perhaps due to the accumulation of items over time, or due to the natural slowing down that occurs with aging, which could make it more difficult to discard and organize. More recently, Cath, Nizar, Boomsma, and Mathews (2017) estimated an overall prevalence in the Netherlands of 2.12%, which rose by approximately 20% for each additional 5 years of age. They reported no difference in prevalence between males and females. Hoarding has also been identified in Germany (Timpano et al., 2013), Singapore (Ong et al., 2016), Brazil (Fontenelle et al., 2010), Italy (Bulli et al., 2014), and Australia (Darke & Duflou, 2017). Statistics regarding the prevalence of hoarding problems in Canada are not available.

Frost, Steketee, and Williams (2000) reported that 64% of health officers in public health departments in Massachusetts reported having had at least one hoarding-related case in the previous 5 years, with an average rate of 26.3 per 100,000 residents. Complaints were based on the presence of unsanitary living conditions, fire hazard, odour, and odd behaviour, and were typically made by neighbours and fire or police departments, with additional complaints coming from social service agencies and service personnel. Of 58 cases that were reviewed in depth, approximately 20% of the tenants were evicted from their homes. Hoarding was implicated in five house fires and three deaths. Public health officers surveyed in this study rated these hoarding cases as representing a moderate to serious public health concern, and a serious threat to personal health. In Canada, data were collected from Vancouver Fire and Rescue Services regarding inspections of 421 residences where hoarding was indicated (Kwok et al., 2017). Of the residents where this information was available, 59% were male, the mean age was 64 years, 73% lived in multifamily dwellings, and 63% were tenants who were not homeowners. Over 65% of complaints to the fire department came from landlords or community members.

A recent study from Australia investigated the causes of sudden or unnatural death in 61 cases where hoarding was noted in the home (Darke & Duflou, 2017). Of those cases, 86.9% died at an age younger than the average life expectancy, and potential life lost was over 16 years. The vast majority of deceased individuals were single, living alone, and found in the home without having had medical intervention at the time of death. In two cases, hoarding was identified as a direct cause of death (i.e., through fire or falling objects). The most frequent direct cause of death was heart disease. Hypothermia was a direct cause of death in 4.9% of cases and a significant contributing factor in 13.1%. Diabetes and emphysema were commonly noted in autopsy reports, and alcohol was detected in a third of the cases. Notably, fewer than 10% showed the presence medications for diabetes, heart conditions, or psychiatric disorders. Findings such as these underscore the severity of this condition, as well as the potential costs to individuals, families, and communities.

Although previously often considered a subtype of obsessive-compulsive disorder (OCD), hoarding disorder was distinguished as a standalone diagnosis with the publication of the fifth and most recent edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5; American Psychiatric Association, 2013). All six diagnostic criteria must be met for a DSM-5 diagnosis to be made. These include: (1) longstanding difficulty with discarding or giving away possessions, including those of little value; (2) difficulty parting with items, driven by the belief that items must be saved, and by intense emotional distress upon discarding items; (3) possessions are accumulated to the point that active living spaces in the home become cluttered and their intended use is compromised (or, if there is no clutter, this is only due to third-party interventions such as family members who have cleaned up); (4) evidence of clinically significant distress and/or impairment in important areas of functioning (e.g., strained

relationships, difficulty maintaining employment, unsafe home environment due to low cleanliness or physical hazards); (5) the problem is not attributable to a medical condition wherein hoarding is a known symptom (e.g., brain injury); and (6) the symptoms are not better accounted for by another mental disorder (e.g., difficulty discarding possessions due to discarding rituals in OCD or anhedonia in depression). There are two additional specifiers that may optionally be included in the diagnosis depending on the presentation. First, the specifier *with excessive acquisition* can be included if the individual demonstrates tendencies toward bringing more unneeded items into the home despite the lack of adequate space. Second, an insight specifier is generally included. These specifiers include *with good or fair insight* (i.e., the individual recognizes that the hoarding thoughts and behaviours cause problems), *with poor insight* (i.e., the individual does not fully recognize that the hoarding thoughts and behaviours cause problems even when these problems are clear to others), and *with absent insight/delusional beliefs* (i.e., the individual is certain that the hoarding thoughts and behaviours do not cause problems).

Living rooms tend to be the most cluttered, followed by kitchens and bedrooms (Frost et al., 2000). The most commonly hoarded objects include newspapers, magazines, and other paper, followed by canisters, bottles, food, and food garbage. According to the DSM-5 description of the clinical features of hoarding disorder, the main reported reasons for having difficulty parting with items are perceived value attributed to the items, including aesthetic and instrumental value, sentimental attachment, a sense of responsibility for the wellbeing of their items, and fears of being wasteful or of losing important information (American Psychiatric Association, 2013). The accumulation of possessions is intentional, rather than a by-product of other difficulties.

The hallmark result of untreated hoarding is inevitably excessive clutter, defined as "a

large group of usually unrelated or marginally related objects piled together in a disorganized fashion in spaces designed for other purposes (e.g., tabletops, floor, hallway)," (American Psychiatric Association, 2013, p. 248). This is distinct from normative collecting, which is organized and systemic and does not impair functioning in important living areas in the home. The typical course of the disorder is chronic and progressive, with onset in early adolescence, interference in everyday functioning developing in the 20s, and clinically significant impairment appearing in the 30s. Most patients do not seek treatment until later adulthood, and this is usually at the urging of family members rather than being self-motivated. Genetic factors are considered to contribute approximately 50% to the variability of the development of the disorder. It is quite common to see patterns of hoarding among first-degree relatives and across generations (Steketee et al., 2015). Clinically significant impairment may present as difficulty in accomplishing daily tasks such as cooking or sleeping due to the presence of excessive clutter. Indeed, the public health officers described above reported that 92% of cases had restricted access to furniture such as beds and couches, and 80% had restricted access to food preparation areas (Frost et al., 2000).

Frost and Hartl (1996) developed the first cognitive-behavioural model of hoarding. The model is multifaceted with distinct but interacting components. These components include vulnerability factors such as information processing deficits (i.e., decision making, organization, and memory difficulties) and emotional attachment problems (e.g., heightened sentimentality, the belief that being surrounded by treasured objects brings a sense of comfort and security). The model also includes specific behaviours and thinking patterns posited to maintain the disorder, including behavioural avoidance (e.g., procrastinating due to perfectionistic concerns about making mistakes and catastrophic assumptions about the consequences of parting with

possessions, including intense emotional distress), and beliefs about the nature of possessions (i.e., necessity of maintaining control, sense of responsibility, and concerns about lost opportunities or lost information). This model was later updated (Frost & Steketee, 1998), but included the same basic vulnerability factors (i.e., impaired executive functioning and information processing deficits in memory, decision making, categorization/organization, and attention; distorted beliefs about objects; family history), and individual difference factors (i.e., elevated positive emotions associated with low-value possessions, and avoidance of feared negative emotions associated with loss) to predict the three central symptoms of hoarding (i.e., clutter, excessive acquisition, and difficulty discarding).

Based on these models and related empirical support (reviewed below), cognitive-behavioural therapies (CBT) have been developed to treat hoarding (e.g., Steketee, Frost, Wincze, Greene, & Douglass, 2000). CBT has been shown to demonstrate consistently large effect sizes in the treatment of anxiety and related disorders such as panic disorder, social anxiety disorder, posttraumatic stress disorder, generalized anxiety disorder, and OCD (e.g., Olatunji, Cisler, & Deacon, 2010). CBT for hoarding targets information processing deficits, emotional attachment, beliefs about possessions, and behavioural avoidance (Grisham & Barlow, 2005; Wheaton, 2016). It does so by presenting psychoeducation about the cognitive-behavioural model of hoarding, strategies for improving decision making around discarding and acquiring, organization skills training, exposure to difficult emotions, cognitive restructuring, and relapse prevention. Unfortunately, all treatment studies currently published have taken place in the United States, and nearly 90% of all participants have been Caucasian (Fernández de la Cruz, Nordsletten, & Mataix-Cols, 2016). As a result of this lack of diversity in participant samples, it is unknown whether findings can be generalized to other populations and locations, including

Canada.

A recent meta-analysis evaluated the effectiveness of CBT for clinically significant hoarding problems and found a large effect size with respect to decrease of overall hoarding symptom severity (Hedge's g = 0.82), with the strongest effects reported for improvements in difficulty discarding (g = 0.89; Tolin, Frost, Steketee, & Muroff, 2015). Excessive acquiring and clutter showed moderate effect sizes (g = 0.72 and 0.70, respectively), and functional impairment showed the smallest effect, but still in the moderate range (g = 0.52). Treatment moderator analyses showed that groups composed largely of women, with a younger mean age, with a greater number of sessions and home visits, and with more patients taking psychiatric medications had better treatment outcomes. However, posttreatment symptom measures remained significantly above normative mean scores, particularly for measures of overall symptom severity and clutter, which were as many as three standard deviations above population norms at posttreatment. These analyses indicated that although statistically reliable change was detected from pre- to posttreatment, a minority of patients experienced clinically significant symptom reduction. The authors of this meta-analysis suggest that although CBT does demonstrate some degree of effectiveness in treating clinical hoarding problems, there is considerable room for improvement (Tolin et al., 2015). Similar findings were recently replicated in a 12-week outpatient CBT program in Australia (Moulding, Nedeljkovic, Kyrios, Osborne, & Morgan, 2017). These results indicated large effect sizes for changes in overall hoarding symptom severity, and moderate effect sizes for changes in hoarding cognitions (e.g., beliefs about emotional attachment and responsibility), yet only 34% demonstrated clinically significant change.

It can be disheartening that the current gold-standard psychological treatment of hoarding

continues to demonstrate such modest outcomes. Furthermore, a recent effectiveness study showed no significant differences in outcomes between psychologist-led group CBT versus guided self-help groups led by peers with no formal mental health training (Mathews et al., 2016). In their review of the diagnosis, assessment, and treatment of hoarding, Kress, Stargell, Zoldan, and Paylo (2016) encourage therapists to "temper their own clinical expectations for treatment" (p. 88). In an attempt to improve treatment outcomes, other research groups have suggested implementing cognitive remediation as an adjunct to CBT. Cognitive remediation training often consists of interactive computerized tasks designed to improve certain cognitive abilities such as attention, memory, and executive functioning. These tasks progressively increase in the level of difficulty in a way that corresponds to individuals' improvements over time. Cognitive remediation training has been found to improve attention problems in patients with hoarding disorder (DiMauro, Genova, Tolin, & Kurtz, 2014). By integrating some of the more complex aspects of the cognitive-behavioural model such as information processing problems into CBT protocols, outcomes may be improved.

It is clear that innovative approaches to both research and treatment are required to further our understanding of this multifaceted disorder. Virtual reality (VR) is one such approach that was used in the current dissertation, as it allows for a novel interactive hoarding-specific testing environment. Three indicators must be present to elicit a realistic sensory and motoric experience (Lisewski, 2006). These include *presence* (i.e., perception of being physically in another environment), *immersion* (i.e., adequate vividness of the sensory information), and *interactivity* (i.e., ability for the user to influence outcomes in the virtual environment). Although VR relies on advanced computer technology, its effect is dependent on cognitive perceptions of both self and physical environment. Without adequate presence, for instance if there are

technical breakdowns, VR has no benefit over other forms of media in eliciting emotional responses (Pallavicini et al., 2013). It is also important to note that VR, although potentially an improvement in ecological validity over other testing environments, is not a perfect proxy for real life with respect to sensory, motor, and other psychological and emotional experiences.

Demonstrating that VR environments can be effective in testing hoarding-related questions will allow for researchers in this area to improve their research design. Although there are initial costs to consider when first developing a VR laboratory, VR research is ultimately a cost-effective and simple means of investigating hypotheses that were previously very difficult or impossible to examine. It also provides standardization of intricate visuospatial milieus and eliminates the potential physical risk associated with navigating restrictive and cluttered spaces.

The purpose of this dissertation was to further clarify the cognitive-behavioural model of hoarding so as to increase researchers' and clinicians' understanding of the disorder, which could lead to improved and possibly novel treatment options. Study 1 examined the cognitive components of the CBT model of hoarding, specifically testing perceived and actual information processing deficits including attention, memory, decision making, and categorization ability. Study 2 examined the role of emotional features in the CBT model (i.e., emotional intensity, reactivity, and experiential avoidance). Study 3 introduced clutter-level preferences as an additional component, which has been neglected to date but that may warrant further investigation. Each study used the same two samples of individuals (i.e., with or without hoarding disorder), and used VR technology to provide more ecologically valid testing environments than those used in previous studies. All methods described for Studies 1-3 were reviewed and approved by the Ryerson University Research Ethics Board prior to the commencement of data collection. Before any testing using the VR commenced, participants

became acclimated to the VR environment until they expressed a sufficient comfort level during the first of two lab visits. This was done using a similar VR environment to the ones that were used for testing. See Appendix A for a procedural flow chart for the three studies.

Study 1: Perceived and Actual Information Processing Deficits in Hoarding Disorder

Information processing deficits are central to the etiology and maintenance of hoarding disorder according to Frost and colleagues' cognitive-behavioural model of hoarding. Attention, memory, and two aspects of executive functioning, specifically decision making and categorization ability, have received the most empirical attention to date (Timpano, Smith, Yang, & Çek, 2014; Woody, Kellman-McFarlane, & Welsted, 2014). Each of these areas will presently be reviewed in turn. It is important to appreciate that although these components are presented as distinct, there is significant overlap in their functioning. For instance, Engle (2002) argued that memory and attention are inextricably connected, as one's ability to focus is inherently influenced by one's ability to hold information or suppress distraction in working memory. The same can be said for other higher-order executive functioning. Redish (2015) argued that the decision making process depends on memory representations of generalizations that dictate potential future outcomes. As such, these components likely overlap and ability in one likely influences ability in another, regardless of the presence or absence of hoarding problems.

Attention

Attention is a broad area of information processing that has been investigated in relation to hoarding. Findings in this area are somewhat mixed, although a relatively clear picture emerges when examining specific types of attentional problems. While not uniquely related to hoarding (Woerner, Selles, De Nadai, Salloum, & Storch, 2017), symptoms of attention-deficit/hyperactivity disorder (ADHD) are consistently reported to be elevated in people who hoard (Fitch & Cougle, 2013; Grisham, Brown, Savage, Steketee, & Barlow, 2007; Grisham, Norberg, Williams, Certoma, & Kadib, 2010; Moshier et al., 2016). Tolin and Villavicencio (2011) found that inattention, but not hyperactivity or obsessive-compulsive symptoms, was a

significant predictor of clutter, difficulty discarding, and excessive acquisition. Indeed, Hallion, Diefenbach, and Tolin (2015) reported a model in which inattention and poor memory confidence significantly predicted functional impairment in a hoarding disorder sample.

There does not appear to be impairment in selective attention (Moshier et al., 2016; Sumner, Noack, Filoteo, Maddox, & Saxena, 2016; Tolin, Villavicencio, Umbach, & Kurtz, 2011), but findings are mixed with respect to sustained attention. Using similar computerized measures, some researchers have found deficits in sustained attention (Grisham et al., 2007; Raines, Timpano, & Schmidt, 2014; Tolin, Villavicencio et al., 2011) whereas others have not (Fitch & Cougle, 2013; Grisham et al., 2010). Furthermore, some studies that have reported impaired attention have used measures that simultaneously assess memory, thus making the findings difficult to interpret (Ayers et al., 2013; Grisham et al., 2007). Given that the emphasis of the current study was on ecological validity and the relationship between day-to-day functioning and hoarding symptoms, the consistently reported relationship between ADHD symptoms and hoarding was the focus of investigation.

Memory

In one of the first studies examining memory deficits in hoarding, Hartl et al. (2004) reported that people with compulsive hoarding problems recalled less verbal and visual information compared to healthy controls, with medium effect sizes (i.e., Cohen's $d = 0.62$ for verbal memory deficits and 0.68 for visual memory deficits). This finding was not mediated by memory organization strategies, although organization strategies were also found to be impaired in the compulsive hoarding group. Hartl et al. also found that the hoarding group had significantly poorer memory confidence that was not accounted for by actual memory deficits. The hoarding group also perceived a significantly higher need to have possessions in view to act

as reminders, and more catastrophic fears about the consequences of forgetting.

Although other researchers have investigated memory impairments in hoarding disorder, these findings are often difficult to interpret. For example, Blom et al. (2011) reported impaired implicit memory in individuals who hoard, but described this finding as more indicative of implicit procedural learning ability than explicit memory. Ayers et al. (2013) and Grisham et al. (2007) reported impaired working memory in people who hoard versus healthy controls. However, it is difficult to differentiate working memory from attention, which makes it challenging to determine if these effects are truly due to memory difficulties or if they are better explained by deficits in attention.

Furthermore, findings that clearly suggest memory deficits have failed to be reliably replicated. For instance, with respect to verbal memory, many studies have been conducted using the newest edition of the *California Verbal Learning Test* (Delis, Kramer, Kaplan, & Ober, 2000), the same used by Hartl et al. (2004), and other tests of verbal and auditory learning. These studies have found no significant differences between participants with and without problematic hoarding (e.g., Fitch & Cougle, 2013; Mackin, Areán, Delucchi, & Mathews, 2011; Moshier et al., 2016; Raines et al., 2014; Sumner et al., 2016; Tolin, Villavicencio et al., 2011). Other studies have similarly shown no impairment in visuospatial memory and working memory (e.g., Mackin et al., 2011; McMillan, Rees, & Pestell, 2013; Sumner et al., 2016). Tolin, Villavicencio et al. (2011) reported a deficit in memory organization strategies, but this finding was no longer significant after controlling for the effects of general distress and anxiety. Mackin et al. (2016) found differences between those with hoarding disorder and healthy controls on a measure of visual delayed memory, such that hoarding participants demonstrated a significantly higher incidence of clinically significant cognitive impairment in this domain.

More consistent findings have been reported with respect to memory confidence. In addition to the finding reported by Hartl et al. (2004), Steketee, Frost, and Kyrios (2003), Fitch and Cougle (2013), and Moshier et al. (2016) reported significantly poorer memory confidence in people with varying severity of hoarding problems relative to healthy controls. Shaw, Timpano, Steketee, Tolin, and Frost (2015) also reported that poor memory confidence was related to hoarding symptom severity. As described earlier, Hallion et al. (2015) outlined the mechanisms by which inattention may lead to functional impairment. They reported a model accounting for 91% of the variance whereby inattention led to poor memory confidence, which in turn led to an increased tendency to save possessions, higher clutter levels, and worse functional impairment. Due to the pattern of findings regarding memory impairments, one purpose of the current study is to explore actual and perceived memory deficits using both standardized visuospatial memory tests such as those used in the studies described above, as well as using a more naturalistic test of incidental memory for objects viewed in a virtual space.

VR has been growing in popularity in recent years as a more ecologically valid way to study memory. For example, Plancher, Tirard, Gyselinck, Nicolas, and Piolino (2012) used VR to compare episodic memory deficits among individuals with amnesic mild cognitive impairment and Alzheimer's disease. Episodic memory consists of remembering personally relevant information, including the subjective experience of events and the times and places in which they occurred (Tulving, 2002). Plancher et al. argued that traditional neuropsychological memory tests that typically rely on verbal memory fail to replicate the types of memory tasks required for daily living, which are highly visual and action-based. As such, their virtual environment allowed for participants to engage in a normal daily activity – driving a car. Participants in their study navigated through two virtual environments in which they either actively "drove" the car

past a number of landmarks, or passively "rode" as a passenger. Participants were asked to report the landmarks as well as their surrounding contextual elements in immediate and 20-minute delayed recall tasks and a recognition task. They were asked to provide information about what was seen (e.g., a post office), when it was seen (e.g., after the train station), and where it was seen (e.g., beside a girl in an orange shirt). Standard neuropsychological memory tests showed the expected effects, such that the Alzheimer's group demonstrated the poorest memory, followed by the amnesic mild cognitive impairment group, both of which performed more poorly than the healthy control group. The VR method was similarly effective in demonstrating that the Alzheimer's group had the worst episodic memory, followed by the amnesic mild cognitive impairment group, and both were impaired relative to a healthy older adult control group. Interestingly, performance on the virtual episodic memory task was correlated with scores on a measure of subjective cognitive difficulties for all groups, whereas a standardized neuropsychological verbal measure of episodic memory was only correlated with subjective difficulties for the healthy control group. This finding demonstrates that testing episodic memory using verbal tests is potentially ineffective in detecting the functional impairment associated with memory deficits in certain clinical populations.

This paradigm is particularly relevant to hoarding disorder, as the visuospatial context of extremely cluttered homes likely plays a role in the daily experience of self-reported memory difficulties. Only one study to date has examined the effects of clutter on memory ability. This study found that there were no differences on verbal memory ability when tested in a cluttered versus uncluttered lab (Raines et al., 2014). As Plancher et al. (2012) suggest, verbal tests are not necessarily reflective of the daily memory demands placed on individuals living with memory deficits. The present study tested episodic memory for objects in a VR cluttered home

environment to investigate if self-reported memory deficits are similarly observable only when tested in ways that are more reflective of daily living.

Decision Making

With respect to aspects of higher order executive functioning and hoarding, researchers have examined decision making in various ways and have reported relatively consistent results. Decision making has been found to be impaired in high-acquiring groups (Preston, Muroff, & Wengrovitz, 2009). On complex measures of rule learning and decision making flexibility such as the *Wisconsin Card Sorting Test* (WCST; Heaton, Chelune, Talley, Kay, & Curtiss, 1993), individuals who hoard tend to show worse performance compared to healthy controls. Specifically, they have been shown to take longer, make more errors overall, as well as make more perseverative errors, and demonstrate worse ability at conceptual levels (Ayers et al., 2013; Mackin et al., 2011; McMillan et al., 2013). Ayers et al. (2013) found that poorer performance on the WCST was strongly positively correlated with hoarding symptom severity.

Some studies have shown that individuals who hoard perform more poorly on tasks such as the *Tower of London* (Owen, Downes, Sahakian, Polkey, & Robbins, 1990) that require planning (Grisham et al., 2010; Morein-Zamir et al., 2014), but others have not replicated this finding (Sumner et al., 2016; Tolin, Villavicencio et al., 2011). Some studies have suggested no decision making deficits, particularly studies that have used tasks such as the *Iowa Gambling Task* (IGT; Bechara, Damasio, Tranel, & Damasio, 1997), which requires respondents to learn a pattern of responding to maximize profit, thereby assessing advantageous decision making and risk-taking (Grisham et al., 2007; Grisham et al., 2010; Morein-Zamir et al., 2014; Pushkarskaya et al., 2017; Tolin & Villavicencio, 2011; Tolin, Villavicencio et al., 2011).

Few studies have examined decision making using real world decision making tasks that

have good face validity for the types of decisions required regularly for people who hoard. In two studies that had participants make discarding decisions about personal and nonpersonal paper items, the hoarding groups took longer to make discarding decisions and discarded fewer items; however, there was an inconsistent pattern of results with respect to differences between personal and nonpersonal items. Specifically, Tolin, Kiehl, Worhunsky, Book, and Maltby (2009) found that participants with problematic hoarding took longer to discard personal junk mail compared to matched healthy controls, but found no difference between groups in the amount of time to discard nonpersonal junk mail. A large scale follow-up study by Tolin et al. (2012) found that participants with problematic hoarding took longer to make discarding decisions for both personal and nonpersonal paper objects relative to healthy controls.

Researchers studying executive function and decision making in OCD have begun using VR to improve the ecological validity of their tests. A virtual version of the Multiple Errands Test (V-MET; Raspelli et al., 2012) has been used to examine planning and complex problem solving abilities. In the V-MET, participants are required to accomplish a number of tasks in a virtual grocery store (e.g., locate specific items, gather information such as store operating hours). Studies using this task have been able to detect that OCD participants take longer to complete complex tasks (La Paglia, La Cascia, Rizzo, Riva, & La Barbera, 2012), and they demonstrate poorer divided attention, greater errors, and greater inefficiencies (La Paglia et al., 2014). Furthermore, the V-MET task identified greater impairments for the OCD group relative to a healthy comparison group in the use of complex strategies even when no differences were found using a standardized neuropsychological test battery (Cipresso et al., 2013). Positive correlations were reported between performance on neuropsychological testing and the V-MET (La Paglia et al., 2012; 2014), which suggests that using virtual tests may be a valid way to

assess more complex executive functioning abilities.

Self-reported indecisiveness has been found to be elevated in people who hoard (Grisham et al., 2010; Steketee et al., 2003), and indecisiveness is positively correlated with hoarding symptom severity (Frost, Kyrios, McCarthy, & Matthews, 2007; Wincze, Steketee, & Frost, 2007). Shaw, Llabre, and Timpano (2015) demonstrated that indecisiveness was a significant predictor of hoarding symptoms using structural equation modeling. Luchian, McNally, and Hooley (2007) reported that during a sorting task, the hoarding group rated the task as more difficult and stressful. Similarly, Tolin et al. (2009; 2012) reported that individuals who hoard showed greater indecisiveness, anxiety, and sadness during a discarding decision making task.

It has been suggested that this indecisiveness stems from perfectionistic beliefs about the negative consequences of making mistakes. Indeed, indecisiveness and perfectionism have been shown to be positively correlated with one another (Frost & Shows, 1993). Perfectionism has also been shown to predict acquisition (Frost et al., 2013). The present study explored potential decision making deficits and indecisiveness using both standardized assessment tools, and in a more ecologically valid virtual decision making task to clarify the relationship between neuropsychological functioning and everyday tasks that are faced by individuals living in cluttered environments.

Organization

The last cognitive feature examined in the present study was organization, or categorization ability. A recent study using eye-tracking technology demonstrated that a nonclinical high hoarding sample showed less cognitive flexibility during a categorizing task compared to participants low in hoarding symptoms (Carbonella & Timpano, 2016). Furthermore, Mackin et al. (2016) reported a significantly greater degree of cognitive

impairment in visual categorization ability respective to healthy controls, even when controlling for age, education, gender, and IQ, although this is in contrast to previous findings that showed no impairment in visual organization ability (Tolin, Villavicencio et al., 2011).

Only three studies identified to date used sorting tasks using actual objects, all of which identified categorization deficits in hoarding groups. In Luchian et al.'s (2007) study, a group of subclinical hoarding students were asked to sort 20 objects of minimal monetary value. The results of this study indicated that the subclinical hoarding group took longer to sort the objects and created more categories than did the control group. Creating greater numbers of categories for objects has been termed *underinclusivity*, when items are considered to be more distinctive and therefore not belonging to the same categories, resulting in a greater number of categories for the same number of objects. For example, when organizing an office, rather than grouping all the books together into one category, an underinclusive categorizing strategy would be more likely to include multiple groups of books based on more specific or minute distinguishing features (e.g., hardcover, paperback, fiction, nonfiction, alphabetical, etc.).

Wincze et al. (2007) reported similar findings. In their study, participants with clinical levels of hoarding, as well as an OCD control group and a nonclinical control group, were asked to sort a box of 20 objects, followed by 20 personalized index cards with words written on them indicative of the types of objects they have in their home. The results of this study showed significant group differences for the personalized index cards only, and not for the nonpersonal objects. Specifically, the hoarding group took significantly longer to sort the index cards and showed greater underinclusivity compared to the healthy control group.

In the third sorting study, Grisham et al. (2010) sought to clarify the categorization impairment reported by Wincze et al. (2007), as it could not be definitively stated that the

categorization impairment was driven by the personal nature of the index cards, or if the difficulty was driven by sorting paper items. As such, in Wincze's study participants completed four sorting tasks: 20 personal objects brought in from the home by participants, 20 nonpersonal objects, 20 personal index cards (i.e., the names of the personal objects that had been brought in written on index cards), and 20 nonpersonal index cards. The hoarding group took significantly longer to sort personal objects compared to the healthy and clinical control groups, which suggests an impaired ability to sort personal objects in a timely manner, which could in turn lead to clutter and disorganization in the home. However, other results were more difficult to interpret. For one, both clinical groups took longer than the healthy control group to sort personal and nonpersonal index cards, which suggests a nonspecific impairment in sorting paper items. Even more difficult to interpret is the finding that the hoarding group and the healthy control group both demonstrated the same level of underinclusivity, whereas the clinical control group created the least number of categories for personal objects and all index cards. This finding is inconsistent with previous findings suggesting that individuals who hoard demonstrate greater underinclusivity than other groups.

It has been suggested that categorization deficits may be explained by poor visuospatial processing, but this hypothesis has not been supported. Hoarding participants consistently fail to demonstrate impaired visuospatial ability relative to healthy controls or to the general population (Grisham et al., 2007, 2010; Mackin et al., 2011). The same lack of impairment has been found for verbal categorization ability (Sumner et al., 2016). An alternative hypothesis is that the emotional distress associated with sorting and organization may contribute to this difficulty and the resulting clutter. Grisham et al. (2010) found that their hoarding group had higher self-reported anxiety before and after all four sorting tasks. Wincze et al. (2007) also noted a positive

correlation between hoarding symptom severity and presorting subjective distress. Although Luchian et al. (2007) found no difference in positive or negative affect before or after sorting nonpersonal objects, it should be noted that this was a subclinical sample; therefore, the emotionality associated with making sorting decisions may have been less intense than it would be for a clinical sample. This appears to be the more likely explanation, especially when considered with findings that have shown greater distress associated with decision making, which will be described in Study 2.

As can be seen from the findings described earlier, previous categorization studies have used a circumscribed number of objects (e.g., 20) and the sorting has been done in a lab setting rather than a home setting. As such, the difficulty in interpreting some of the reported findings may be due in part to the low ecological validity in the methods. Furthermore, attempting to organize an entire cluttered room likely requires greater demands than would the task of organizing 20 items. The present study sought to replicate previous findings and explore difficulties in categorization that are more relevant to the task of organizing a cluttered room or a cluttered home in a more ecologically valid testing environment using a VR paradigm.

Hypotheses

Hypothesis 1: Studies have consistently shown that individuals who hoard report elevated attention difficulties. It was predicted that participants in the hoarding group would report more ADHD symptoms than participants in the nonhoarding group.

Hypothesis 2: Findings are mixed with respect to memory deficits in people who hoard, but these deficits have not yet been studied in ecologically valid environments. It was predicted that participants in the hoarding group would not perform significantly differently than participants in the nonhoarding group on a traditional

neuropsychological memory test; but, that participants in the hoarding group would display poorer memory for objects in a virtual cluttered room than their nonhoarding counterparts.

Hypothesis 3: Low memory confidence has been consistently reported in the hoarding literature. It was predicted that participants in the hoarding group would report lower memory confidence than participants in the nonhoarding group.

Hypothesis 4: As with memory, findings are mixed with respect to decision making deficits in people who hoard. It was predicted that participants in the hoarding group would not perform significantly differently than participants in the nonhoarding group on a traditional neuropsychological decision making test; but, that participants in the hoarding group would display poorer decision making ability when organizing a virtual cluttered room than their nonhoarding counterparts.

Hypothesis 5: The few studies that have examined real world categorization tend to demonstrate underinclusivity in people who hoard. It was predicted that participants in the hoarding group would demonstrate greater underinclusivity than participants in the nonhoarding group when organizing a virtual cluttered room.

Hypothesis 6: Higher order executive functioning such as decision making and categorization ability depends on lower level information processing ability such as attention and memory. As such, it was predicted that attention and memory impairments would mediate the relationship between hoarding symptoms and executive functioning deficits in the hoarding group.

Hypothesis 7: Indecisiveness and perfectionism have both been found to be elevated in individuals who hoard. It was predicted that indecisiveness and perfectionism

would be positively correlated with each other and with hoarding symptoms.

Method

Participants

Adults between the ages of 18-65 were recruited from the Greater Toronto Area to participate in this study. Advertisements were posted on community notice boards and online advertising venues. Interested participants were first screened online to ensure sufficient English proficiency and their appropriateness to participate in a VR study. Contraindications for VR include migraine headaches, seizure disorders, blindness, deafness, neck injury, serious vestibular abnormalities, hypertension, or chronic obstructive pulmonary disease (COPD; Wiederhold & Wiederhold, 2005). Tendency to experience motion sickness was also ruled out to reduce the risk of experiencing simulator sickness. All eligible participants received a $30 incentive following completion of the in-lab testing sessions. The final sample included 40 participants in the nonhoarding group and 36 participants in the hoarding group. See Figure 1 for a flow chart delineating participant eligibility. This sample size was derived from norms of previous studies that have used similar hoarding and comparison group samples. Power analyses suggested that a sample size between 22-33 participants per group would be sufficient to detect significant results at a .05 α level with 0.80 power. These power analyses were based on finding a large effect size for a *t*-test in ADHD scores between a hoarding and community group (Cohen's $d = 1.76$; Grisham et al., 2007), and on finding a small effect size for interactions between cognitive and emotional factors in predicting hoarding symptom severity using regression ($\beta = 0.12$; Shaw, Timpano et al., 2015). See Table 1 for demographic information.

As part of the online screening process, participants also completed the *Saving Inventory-Revised* (SI-R; Frost, Steketee, & Grisham, 2004), the *Clutter Image Rating* (CIR; Frost,

Figure 1. Participant eligibility flow chart.

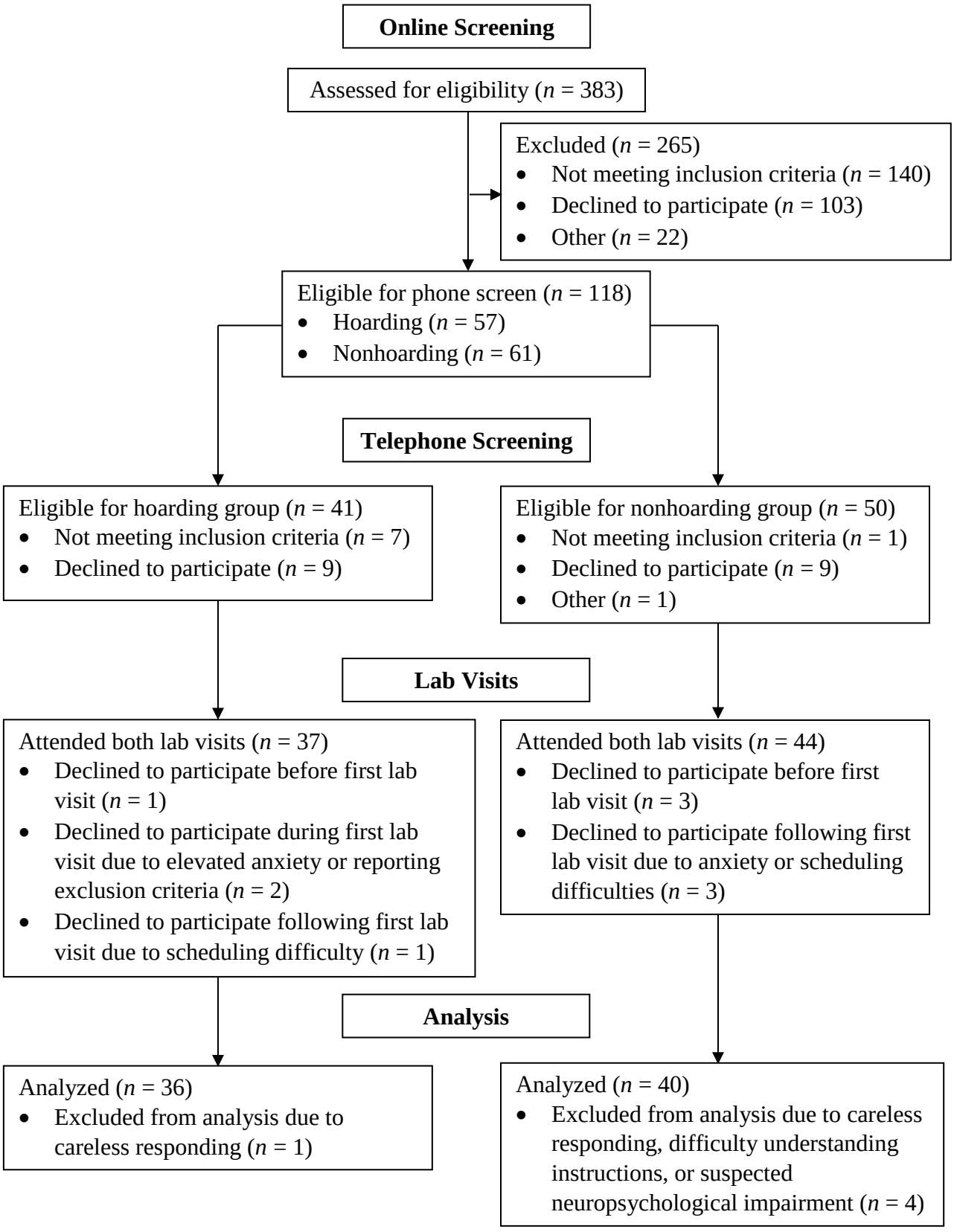


Table 1. Participant demographic information.

	Hoarding Group	Nonhoarding Group
Age (years)	19-63	18-59
M (*SD*)	36.14 (12.63)	33.20 (12.21)
Gender (%)		
Female	63.9	65.0
Male	30.6	35.0
Other	5.6	0.0
Relationship Status (%)		
Single	66.7	52.5
In serious relationship	22.2	37.5
Separated or divorced	11.1	7.5
Widowed	0.0	2.5
Race/Ethnicity (%)		
White/European	50.0	37.5
Asian	22.2	42.5
Black/Afro-Caribbean/African	16.7	12.5
Hispanic/Latin American	2.8	5.0
Biracial/Multiracial	8.3	0.0
Other	0.0	2.5
Currently Enrolled in Educational Program (%)	27.8	35.0
Education Level (%)		
Some high school	2.8	0.0
Completed high school	5.6	2.5
Some college/university	30.6	17.5
Completed college/university	47.2	60.0
Some graduate/professional school	8.3	5.0
Completed graduate/professional school	5.6	15.0
Employment Status (%)		
Not working	38.9	35.0
Working part-time	33.3	20.0
Working full-time	27.8	45.0
Annual Family Income (%)		
< $19,000	19.4	2.5
$20,000-$39,999	30.6	20.0
$40,000-$59,999	19.4	22.5
$60,000-$79,000	5.6	10.0
$80,000-$99,999	8.3	5.0
$100,000-$199,999	8.3	25.0
> $200,000	2.8	5.0
Don’t know/declined	5.6	10.0
Number of people supported by income (range)	1-7	1-6
Median	1	2

Steketee, Tolin, & Renaud, 2008), the *Obsessive-Compulsive Inventory-Revised* (OCI-R; Foa et al., 2002), and the *Depression Anxiety Stress Scales – 21 item version* (DASS-21; Lovibond & Lovibond, 1995). Individuals who scored above recommended clinical cutoffs for hoarding measures (i.e., 41 on the SI-R and 4 on the CIR; Frost et al., 2008; Tolin, Meunier, Frost, & Steketee, 2011) were invited to the second screening phase for possible eligibility in the hoarding group. Individuals who scored below those cutoffs, as well as below recommended clinical cutoffs for OCD and depression screening measures (i.e., 21 on the OCI-R and 10 on the depression subscale of the DASS-21; Foa et al., 2002; Lovibond & Lovibond, 1995), were invited to the second screening phase for possible eligibility in the nonhoarding group. See Table 2 for screening measures descriptive statistics.

The second screening phase involved a telephone interview wherein demographic information was collected and the *Diagnostic Assessment Research Tool* (DART; McCabe et al., 2016), a semistructured clinical interview, was administered. Exclusion criteria for both groups included: active psychotic symptoms within the past 6 months, significant alcohol or substance use problems within the past 3 months, uncontrolled manic or hypomanic symptoms within the past 3 months, and current high risk suicidal or homicidal ideation. In addition to the exclusion criteria outlined above, participants whose symptoms met diagnostic criteria for hoarding disorder were eligible for the hoarding disorder group. Participants without hoarding disorder, current major depressive disorder, or OCD were eligible for the nonhoarding comparison group.

With respect to the nonhoarding group, 87.5% reported no current mental disorder. Five percent had a principal diagnosis of social anxiety disorder, 5% had specific phobias, and 2.5% had comorbid generalized anxiety disorder and a specific phobia. A past diagnosis of major depressive disorder was reported by 7.5%, and 12.5% reported a family history of hoarding

Table 2. Screening measures.

Measure and Subscales	Hoarding Group *M* (*SD*)	Nonhoarding Group *M* (*SD*)	Independent samples *t*-test (all $p < .001$)	Cohen's *d*
SI-R				
Difficulty Discarding	22.56 (2.99)	4.43 (4.08)	21.88	5.07
Acquiring	19.69 (3.61)	4.28 (2.86)	20.76	4.73
Clutter	25.58 (4.54)	3.00 (3.54)	24.30	5.55
Total[a]	67.83 (8.79)	11.70 (9.37)	26.84	6.18
CIR[a]	5.29 (1.15)	1.37 (0.57)	18.53	4.32
DASS-21				
Depression[a]	14.22 (12.39)	1.95 (2.77)	5.81	1.37
Anxiety	10.28 (10.43)	1.55 (2.66)	4.88	0.97
Stress	16.11 (11.83)	4.60 (5.51)	5.34	1.25
OCI-R				
Washing	3.67 (3.59)	0.35 (0.80)	5.43	1.28
Obsessing	5.44 (4.05)	0.60 (0.98)	6.99	1.64
Hoarding	9.44 (1.96)	1.38 (1.71)	19.03	4.38
Ordering	6.61 (3.53)	1.68 (1.85)	7.51	1.75
Checking	5.75 (3.64)	1.08 (1.35)	7.28	1.70
Neutralizing	3.39 (3.38)	0.45 (1.31)	4.98	1.15
Total[a]	34.31 (16.01)	5.52 (5.31)	10.29	2.41

Note. [a] indicates that scores were used to determine eligibility during online screening. SI-R = *Saving Inventory-Revised*; CIR = *Clutter Image Rating*; DASS-21 = *Depression Anxiety Stress Scales – 21 item version*; OCI-R = *Obsessive-Compulsive Inventory-Revised*.

problems. In the hoarding group, 44.4% had a sole diagnosis of hoarding disorder. Hoarding disorder was a principal or sole diagnosis for 77.8% and an additional diagnosis of lesser severity for 22.2%. Of those, 11.1% had a principal diagnosis of OCD, 5.6% had a principal diagnosis of social anxiety disorder, and 5.6% had a principal diagnosis of major depressive disorder. Nearly all participants in the hoarding group endorsed problems with excessive acquisition (91.7%). The majority had fair/good insight (80.6%), followed by those with poor insight (16.7%), and those with absent or delusional insight (2.8%). With respect to comorbidity in the hoarding group, 35.0% had one comorbid diagnosis, 25.0% had two and three each, and 5.0% had either four, five, or seven comorbid diagnoses. The most common comorbid diagnosis was social anxiety disorder (33.3%), followed by OCD (25.0%), specific phobia (22.2%), generalized anxiety disorder (19.4%), current major depressive disorder (13.9%), panic disorder (11.1%), and agoraphobia (8.3%). One quarter of this group had a past diagnosis of major depressive disorder, and exactly half reported a family history of hoarding problems.

Measures

Diagnostic interview. An early draft version of the DART (McCabe et al., 2016) was used to assess inclusion and exclusion criteria for the hoarding and nonhoarding groups. The DART is a newly developed semistructured interview that contains modules for assessing DSM-5 criteria for a variety of disorders. For the present study, the following modules were administered in this order: psychotic symptom screener, alcohol and substance use disorders, current and past major depressive disorder, suicidal and homicidal ideation screener, bipolar disorder, hoarding disorder, OCD, social anxiety disorder, panic disorder, agoraphobia, posttraumatic stress disorder, generalized anxiety disorder, and specific phobia. The DART was administered by the primary researcher, a senior level clinical psychology PhD student with

experience in psychodiagnostic assessment.

As this is a new assessment tool, approximately one quarter of these assessments were audio recorded and reviewed by an independent rater (a doctoral student in clinical psychology trained to administer the DART) to assess reliability. Interrater reliability was excellent; 81.8% of ratings were a perfect match, 13.6% matched with respect to all diagnoses but had disagreement regarding principal diagnosis, and 4.6% reported the same principal diagnosis, but one of the raters interpreted a comorbid diagnosis as subclinical whereas the other rated it as having met diagnostic criteria. There was no disagreement with respect to the presence or absence of hoarding disorder. The major depressive disorder, suicidal/homicidal ideation screener, hoarding disorder, and OCD modules were readministered in person by the same interviewer during the first lab visit to obtain test-retest reliability for the key inclusion and exclusion criteria. Test-retest reliability was also excellent; 87.9% of ratings were matched perfectly between both administrations. There were two instances when hoarding disorder was present during the telephone screening but was not detected during the DART readministration. There were three instances when a past diagnosis of major depressive disorder, and once for current major depressive disorder, was not detected during the telephone screening but was reported during readministration. In addition, there were three instances when OCD was endorsed during the telephone screening but denied during the readministration. These cases were still included in the final analyses. The diagnostic information presented earlier in the *Participants* section is based on data obtained during the telephone screening. In addition, the hoarding symptom scores obtained during the online screening are similar to or well above what has been reported in other studies that have used DSM-5 clinical hoarding samples (e.g., Frost et al., 2013; Morein-Zamir et al., 2014), which suggests that the assessment tools used in the

present study successfully identified participants with hoarding disorder.

Demographics. During the telephone screening, participants provided information about their age, gender, relationship status, ethnicity, education, employment status, and socioeconomic status (see Appendix B). This information was used to characterize the samples and assess for matching.

Clinical symptoms. Participants completed three measures of clinical symptoms. These include symptoms of hoarding disorder, OCD, and general depression and anxiety. The SI-R (Frost et al., 2004) measures three factors reflecting components of compulsive hoarding: difficulty discarding, excessive acquisition, and excessive clutter. This measure contains 23 self-report items that are answered based on a 0 to 4 rating scale with specific response options varying by question. For example, "To what extent do you have difficulty throwing things away" with responses ranging from "Not at all" to "Very much so," and "How often do you feel compelled to acquire something you see (e.g., when shopping or offered free things)" with responses ranging from "Never feel compelled" to "Almost always feel compelled." This measure is validated for use in research with clinical and community samples, with 41 suggested as a clinical cutoff. Higher scores indicate more severe hoarding symptoms. For the nonhoarding group in the present study, total scores ranged from 0-34 and Cronbach's α was .94. For the hoarding group, total scores ranged from 48-87 and Cronbach's α was .87. Subscale α values were .91 and .81 (difficulty discarding), .78 and .75 (excessive acquisition), and .91 and .92 (clutter) for the nonhoarding and hoarding groups, respectively.

The CIR (Frost et al., 2008) is another measure of hoarding symptoms, specifically clutter. Participants are presented with nine images each of a bedroom, living room, and kitchen, with the level of clutter increasing progressively across each image. These rooms are cluttered

with the types of objects typically found in the homes of people who hoard (e.g., newspapers, junk mail, bottles, etc.). Participants are asked to select an image that most closely resembles their own bedrooms, living rooms, and kitchens. A composite score is created by calculating the mean of these ratings, with 4 out of 9 suggested as a clinical cutoff. The CIR has been found to show good convergent and discriminant validity. It also reduces the problem of clutter overestimation that has been reported using the SI-R clutter subscale. Good internal consistency has been reported for both client and therapist ratings, with α ranging from .80 to .89, as well as a .94 interobserver correlation between client and experimenter (Frost et al., 2008). Scores ranged from 1.0-3.0 for the nonhoarding group, and 4.0-8.3 for the hoarding group. Cronbach's α were .92 and .81 for each group, respectively.

The OCI-R (Foa et al., 2002) is a shortened version of the original *Obsessive-Compulsive Inventory* (Foa, Kozak, Salkovskis, Coles, & Amir, 1998). This 18-item measure assesses the distress associated with obsessive-compulsive symptoms across six domains including washing, obsessing, hoarding, ordering, checking, and mental neutralizing. This measure has shown good internal reliability with subscale and total scale Cronbach's α ranging from .83 to .90, as well as good test-retest reliability and convergent validity. The OCI-R has also been found to be psychometrically sound for use in nonclinical college samples (Hajcak, Huppert, Simons, & Foa, 2004). Higher scores indicate more severe OCD symptoms. Total scores ranged from 0-20 for the nonhoarding group, and 9-64 for the hoarding group. Cronbach's α were .81 and .94 for each group. Cronbach's α for each subscale were as follows, presented in the order of nonhoarding followed by hoarding groups: .67 and .91 (washing), .58 and .93 (obsessing), .71 and .50 (hoarding), .81 and .90 (ordering), .65 and .84 (checking), .68 and .78 (neutralizing).

The DASS-21 is a shortened version of the 42-item *Depression Anxiety Stress Scales*

(Lovibond & Lovibond, 1995), which assesses depression, anxiety, and general distress. Participants indicate how much each statement applied to themselves over the past week using a 0-3 point scale. Raw scores are doubled for the DASS-21 results to be comparable to the full DASS scales, with higher scores indicating greater distress. The three DASS-21 subscales (i.e., depression, anxiety, stress) have shown low to moderate intercorrelations, with Pearson's *r* values ranging from .28 to .53, and strong convergent and internal consistency, with Cronbach's α ranging from .87 to .94 (Antony, Bieling, Cox, Enns, & Swinson, 1998). Depression scores ranged from 0-8 for the nonhoarding group, and 0-38 for the hoarding group. Anxiety scores ranged from 0-10 for the nonhoarding group, and 0-38 for the hoarding group. Stress scores ranged from 0-20 for the nonhoarding group, and 0-38 for the hoarding group. Cronbach's α for each subscale were as follows, for the nonhoarding group and hoarding group respectively: .70 and .95 (depression), .54 and .90 (anxiety), .79 and .93 (stress).

Memory. Visuospatial memory ability was assessed using the *Rey-Osterrieth Complex Figure Test* (RCFT; Meyers & Meyers, 1995; Osterrieth, 1944). Participants were presented with the RCFT figure and were first instructed to copy the figure as exactly as possible (copy condition). Participants were then presented with questionnaires as a filler task. They were then asked to draw the figure again from memory with no visual cues following a 3-minute delay (immediate recall condition), and again following a 30-minute delay (delayed recall condition). Immediately following delayed recall, participants were presented with a series of smaller figures and asked to identify which of these elements were parts of the original complex figure. Recall accuracy scores are determined based on the accuracy of 18 individual figure segments. Each segment receives a score for accuracy and placement, with a maximum score of 36. Recognition scores are calculated based on how many correct elements are identified, with a

maximum score of 24. Interrater reliability has been reported as .91-.98 (Lezak, 1995). Higher scores indicate better memory. Time to complete each task was also measured using a stopwatch, with time rounded down to the nearest second. There is an optional scoring procedure to determining visual organization that was not used in the present study, as memory accuracy rather than organization was the main focus. The test has been shown to discriminate between healthy individuals and individuals with mild brain damage, as well as individuals with memory impairment who are and are not able to live independently. Test-retest reliability ranges from .60-.76 (Lezak, 1995). In the present study, T scores accounting for age-based performance were used in the analyses rather than raw scores. T scores range from 0-100, with 50 indicating average performance relative to other people within a 5-year age range. Immediate recall T scores ranged from 19-67 for both groups. Delayed recall T scores ranged from 19-64 for the hoarding group and 19-66 for the nonhoarding group. Recognition T scores ranged from 19-74 for the hoarding group, and 24-88 for the nonhoarding group.

To assess incidental episodic memory and state memory confidence, a method adapted from the VR memory test validated by Plancher, Gyselinck, Nicolas, and Piolino (2010) was used (see Appendix C). As in the study by Plancher et al., participants were not told that their memory would later be tested. Participants were instructed on how to use the VR equipment and were encouraged to virtually walk around a messy room while completing a categorization task that will be described below. Participants then completed two free recalls and a recognition test. Following a 3-minute delay during which time participants completed filler questionnaires just as in the RCFT, participants were asked to recall all of the elements they saw in a specific area of the room (i.e., objects that were on the couches; immediate recall). Participants orally reported as many of the 23 elements that they could remember, along with their perceptual details (i.e.,

colour, shape, size), and spatial details (i.e., location). The same free recall task was completed following a 30-minute delay (delayed recall). Memory performance was evaluated based on how many correct responses were provided for *elements* (i.e., correctly identifying the object), *perceptual details* (i.e., correctly identifying perceptual information), and *spatial details* (i.e., correctly identifying the object's location). Possible total scores range from 0-69. Higher scores indicate greater incidental memory for objects in a cluttered room. Total scores for immediate recall ranged from 0-40 for the hoarding group, and 5-42 for the nonhoarding group. Total scores for delayed recall ranged from 0-40 for the hoarding group, and 5-40 for the nonhoarding group.

Following delayed recall, participants were asked to identify virtual objects that either were or were not in the virtual room (recognition task). Wearing the VR headset, participants were shown 10 trials of three objects, eight of which were in the virtual room and 22 of which were foils. Four foils were the same as objects that were in the virtual room, but differed with respect to colour only. Participants then rated how confident they were that each object either was or was not in the virtual room on a 6-point Likert scale, ranging from 1 ("sure it was not in the room") to 6 ("sure it was in the room") as per the memory confidence paradigm used by Yonelinas (2001). With respect to recognition, one point was awarded for each correct answer (e.g., answers of 4-6 on the confidence measure), with higher scores indicating better recognition memory. Possible recognition scores range from 0-30. Memory confidence was measured as the overall confidence ratings for correct answers, with higher scores indicating greater memory confidence. Possible memory confidence scores range from 1-6. VR recognition scores ranged from 18-27 for the hoarding group, and 20-27 for the nonhoarding group. Memory confidence scores ranged from 5.16-6.00 for the hoarding group, and 5.09-6.00 for the nonhoarding group.

The *Memory and Cognitive Confidence Scale* (MCCS; Nedeljkovic & Kyrios, 2007) was

used to measure trait memory confidence. The MCCS was developed to test beliefs about the quality of one's memory in OCD. People with OCD often experience pervasive doubt about their memory, which contributes to symptoms of the disorder, particularly repetitive checking rituals. The MCCS is a 28-item measure rated on a 5-point Likert scale. It contains four subscales: confidence in general memory (e.g., "I have little confidence in my memory generally"), confidence in decision making/planning abilities (e.g., "I have doubts about my decision making ability"), confidence in concentration (e.g., "I have a poor concentration ability"), and cognitive perfectionism ("I expect myself to be 100% certain about my decisions"). Higher scores indicate lower memory confidence. The full scale and each subscale have shown acceptable test-retest reliability and internal consistency with Cronbach's α ranging from .79 to .93. The MCCS has shown good convergent and discriminant validity with various OCD symptoms in both clinical and nonclinical samples. Total scores ranged from 28-89 for the nonhoarding group and 28-124 for the hoarding group, and Cronbach's α were .92 and .96, respectively. Cronbach's α for each subscale for the nonhoarding and hoarding groups respectively were .92 and .95 (general), .86 and .95 (decision making), .89 and .88 (concentration), and .74 and .79 (cognitive perfectionism).

Attention. Day-to-day attention difficulties were assessed using the *ADHD Self-Report Scale* (ASRS; Kessler et al., 2005). This widely used scale was developed by the World Health Organization as an ADHD screening tool for the general population. This is a 6-item self-report scale that assesses adult inattention and hyperactivity. Participants rated the frequency of various ADHD symptoms over the past 6 months on a Likert scale ranging from 0 ("never") to 4 ("very often"). This screener has been found to have 97.9% classification accuracy for clinical cases of ADHD. ASRS scores ranged from 1-23 for the hoarding group with a Cronbach's α of .87, and 0-

15 for the nonhoarding group with a Cronbach's α of .71.

Decision making. Decision making was assessed using a computerized version of the Psychology Experiment Building Language IGT (PEBL-IGT; Bechara, 2007; Bechara et al., 1997; Mueller & Piper, 2014), which measures decision making ability and tendency toward risky or disadvantageous decision making. Participants are provided with a hypothetical $2000 and are instructed to maximize their profit by selecting cards one at a time from four decks (A-D). They are told that they will have 100 trials to do so. They are not told that selecting cards from Decks A and B is more risky, in that they yield an average profit of $100 but also have a higher average of net losses. On the other hand, Decks C and D are more conservative, such that the cards have an average profit of only $50, but lower net losses, resulting in greater profit overall if more cards are selected from these decks. Decks A and B are termed *disadvantageous* and Decks C and D are termed *advantageous*. A total score is derived by subtracting the number of trials wherein a card was selected from a disadvantageous deck from the number of trials wherein a card was selected from the advantageous decks. Higher scores indicate better decision making ability.

In a recent review of studies testing the construct validity of the IGT, Buelow and Shur (2009) reported consistent findings across lesion studies and functional neuroimaging studies that suggest that poor performance on the IGT is reflective of disturbances in the frontal lobe of the brain, which is responsible for higher order decision making. Buelow and Shur also suggest that the IGT is a reliable measure of emotion-driven decision making, which is likely particularly relevant in hoarding disorder, as there is assumed to be a strong emotional component to acquisition and discarding decisions. Furthermore, IGT performance has been found to be impaired in clinical samples of OCD (Whitney, Fastenau, Evans, & Lysaker, 2004). In the

present study, scores ranged from -58 to 100 for the hoarding group, and -90 to 80 for the nonhoarding group.

The *Frost Indecisiveness Scale* (FIS; Frost & Shows, 1993) is a 15-item self-report indecisiveness measure that asks participants to rate their level of agreement with items on a 5-point Likert scale from "strongly disagree" to "strongly agree." Sample items include "I try to put off making decisions" and "Once I make a decision, I stop worrying about it" (reverse scored). Higher scores indicate more indecisiveness. The FIS has been shown to have high internal consistency (Cronbach's $\alpha = .90$) and good convergent validity, as demonstrated by positive correlations with obsessions and compulsive behaviours such as doubting and checking. Scores ranged from 15-57 for the nonhoarding group, and 19-66 for the hoarding group. Cronbach's α were .91 and .93, respectively.

Decision making ability was also assessed using the virtual task described below, wherein participants were required to make decisions about an organizational strategy for a cluttered home office. Impaired decision making was assessed as a greater amount of time required to complete the task. Time in seconds to complete the organizing task ranged from 315-1794 for the hoarding group, and 310-2184 for the nonhoarding group.

Organization. Underinclusivity was measured in three ways based on the virtual organizing task. A greater total number of categories created, smaller average number of objects per category, and greater proportion of categories containing only one object were assessed as indicators of underinclusivity.

Perfectionism. Perfectionism was measured using the *Frost Multidimensional Perfectionism Scale* (FMPS; Frost, Marten, Lahart, & Rosenblate, 1990) and the *Hewitt and Flett Multidimensional Perfectionism Scale* (HMPS; Hewitt & Flett, 1991). The FMPS is a 35-item

self-report measure of six facets of perfectionism, including concern over mistakes (CM), personal standards (PS), parental expectations (PE), parental criticism (PC), doubts about actions (DA), and organization (O). Subscale scores are calculated by summing the items within each domain, with higher scores indicating greater perfectionism. A total score can also be obtained by summing all the items excluding those captured by O, as this subscale does not correlate well with the other subscales. The FMPS has been shown to have good internal reliability with Cronbach's α of .91, as well as good convergent validity. FMPS total scores ranged from 48-135 for the hoarding group, and 44-114 for the nonhoarding group. Cronbach's α for each subscale were as follows, reported with the hoarding group first followed by the nonhoarding group: CM (.92, .91), PS (.86, .79), PE (.93, .87), PC (.91, .88), DA (.71, .64), O (.90, .94), total (.94, .90).

The HMPS is a 45-item self-report measure that assesses *self-oriented perfectionism* (i.e., desire to achieve high personal standards; SOP), *other-oriented perfectionism* (i.e., expecting high standards of achievement from others; OOP), and *socially prescribed perfectionism* (i.e., perception that others have high expectations for one's own performance; SPP). Subscale scores can be derived by summing the items on each subscale, with higher scores indicating greater perfectionism. Good reliability coefficients have been reported for each of the subscales with Cronbach's α ranging from .82 to .87. Intercorrelations between the subscales range from .25 to .40 indicating some degree of overlap between these dimensions, but not to the extent that the constructs are interchangeable (Hewitt & Flett, 1991). In the present study, scores for SOP ranged from 37-102 for the hoarding group (Cronbach's α = .94), and 35-95 for the nonhoarding group (α = .88). Scores for OOP ranged from 36-82 for the hoarding group (α = .75), and 19-87 for the nonhoarding group (α = .93). Scores for SPP ranged from 29-92 for the hoarding group (α = .86), and 29-80 for the nonhoarding group (α = .82).

VR Experiential Measures. Individuals differ with respect to their ability to become immersed in experiences such as VR. The *Immersive Tendencies Questionnaire* (ITQ; Witmer & Singer, 1998) was used to assess participants' general abilities to become emotionally and cognitively immersed in external experiences such as watching television or playing video games. The present study used the 18-item version of the ITQ. Items are answered on a 7-point Likert scale with higher scores indicating greater overall tendency to experience immersion. Content validity, construct validity, and internal consistency have been shown to be good (Cronbach's $\alpha = .76$). In the present study, scores ranged from 42-100 for the hoarding group ($\alpha = .79$), and 40-119 for the nonhoarding group ($\alpha = .84$).

The *Presence Questionnaire* (PQ; Witmer & Singer, 1998; Witmer, Jerome, & Singer, 2005) similarly measures sense of immersion, but whereas the ITQ measures trait immersion tendencies, the PQ measures sense of presence during a recent encounter with VR. The present study used the 22-item version of the PQ, answered on a 7-point Likert scale with higher scores indicating greater sense of presence in the VR environment. This scale has shown good convergent and discriminant reliability as well as strong internal consistency (Cronbach's $\alpha = .84$). In the present study, the PQ was administered three times, following each VR experience in Studies 1-3. Scores for the hoarding group ranged from 28-133, and α ranged from .90-.96. Scores for the nonhoarding group ranged from 52-133, and α ranged from .91-.94.

Adverse experiences during the VR task were also assessed using the *Simulator Sickness Questionnaire* (SSQ; Kennedy, Lane, Berbaum, & Lilienthal, 1993), which measures severity of current physical symptoms, similar to those experienced during motion sickness. It consists of 16 items answered on a 4-point Likert scale with higher scores indicating more severe physical symptoms within three domains: oculomotor (e.g., eye strain, blurred vision), disorientation

(e.g., vertigo), and nausea. Scores are calculated by multiplying the sum of each subscale by appropriate weights put forth by Kennedy et al. (1993). The SSQ was similarly administered three times. Scores for the hoarding group ranged from 0.00-142.12 (α = .92-.95). Scores for the nonhoarding group ranged from 0.00-115.94 (α = .78-.91).

Participants were also asked to describe the ways in which the VR experience was similar to or different than their everyday experiences using a measure developed for the present study, *VR Realism* (see Appendix D). Participants were first asked to rate the degree of similarity between the VR experience and their real life experience with respect to emotional and cognitive qualities, and then to briefly describe specific differences and similarities using three open-ended questions. Qualitative descriptions of similarities and differences were not analyzed in this dissertation, but were collected for use in possible future iterations of these VR environments. This measure was similarly administered three times. Scores for the hoarding group ranged from 0-16 (α = .91-.94). Scores for the nonhoarding group ranged from 1-16 (α = .60-.79).

Apparatus

VR. The VR environments that were used in Studies 1-3 were developed by an interdisciplinary team from the Transmedia Research Centre and the Department of Psychology at Ryerson University. They included both visual and auditory simulation and were pilot tested to ensure high immersion. For this study, participants wore an Oculus Rift™ consumer-release version head-mounted display (HMD), model number 301-00200-03. This model has a 110° field of view with adjustable viewer/focus, 1080 x 1200 built-in resolution, 90 Hz refresh rate, 6DoF. It has built-in headphones, integrated controller connectivity, and is tethered to PC. The PC used to run the software was a Dell Alienware X51 running Windows 10, with an Intel Core i5-6400 (3.3 GHz speed) and 16 GB DDR4 RAM. The video card was Nvidia GeForce GTX 970

with 4GB GDDR5 RAM. Participants were shown a graphical VR environment of a cluttered home office. The graphical environment was built in Unity® using a combination of Unity Asset Store and custom 3D models. Participants were able to view the room in 360° by turning their heads and chairs. They were also able to simulate walking through the room using a Microsoft Xbox™ handheld controller on which they were trained how to use prior to beginning testing. Movement speed was not restricted, although participants were instructed to move at slow speeds and to turn their body rather than turning the environment using the handheld controller to minimize the risk of simulator sickness.

Procedure

In addition to the screening measures that were completed online prior to the lab visits, participants completed all other self-report measures during the delay periods for the RCFT and VR memory measures. They completed the RCFT at the beginning of Lab Visit 1 and the IGT at the beginning of Lab Visit 2, prior to the VR organization task (see Appendix A). Following the IGT, participants learned how to use the handheld controller to control their movements in the VR environment. They then put on the HMD and were presented with the VR home office environment described earlier. They were instructed to try maneuvering through the VR environment prior to beginning testing until they indicated that they felt comfortable with the handheld controller and with the VR environment. This familiarization process is standard for VR research (e.g., Plancher et al., 2012). Participants were read the following instructions: "Please look around this room. As you look around, try to come up with different categories that you can use to sort the objects in this room. Tell me the name of the category, and which objects fall into that category. You can also let me know which objects, if any, should be thrown away. Take as long as you'd like." Total number of categories and number of objects within each

category were recorded by the researcher. There were a total of 269 objects available to be categorized. Time to complete the task was recorded in seconds using a stopwatch. Once participants indicated that they had completed the task, they removed the HMD and completed the PQ, SSQ, and *VR Realism* to assess their experience with the technology. They then completed the virtual memory test of immediate memory, delayed memory, recognition, and memory confidence.

Results

Data Cleaning

Data were initially screened for missing values. Any subscales that were missing less than 20% of the data points were replaced with subscale means. If more than 20% was missing from a single subscale, the values were left as missing data. Data were then screened for outliers, which were determined by identifying any scores that were greater or less than three standard deviations from the mean. Outliers were replaced with values one point higher (or lower) than the group mean (Field, 2013). Overall, very few missing data points and outliers were identified.

Pilot Testing

The VR memory test was pilot-tested using three individuals without hoarding problems to determine an appropriate way to assess incidental memory that most reflected the RCFT procedure. Initially, pilot testers were asked to recall as many objects as possible from the entire virtual home office. This testing demonstrated that attempting to recall every object in the room took a great deal of time. Qualitative feedback indicated that this task was more cognitively demanding than recalling the designs from the RCFT. As such, participants in the study were asked to recall only the objects in one specified area within the room (i.e., on the couches). This reduced the burden as well as time demands of trying to recall every object. The area of the room

that was selected had a similar number of elements to the RCFT (i.e., 23 and 18, respectively), which also improved similarity between the tasks.

Preliminary Analyses

The hoarding and nonhoarding groups did not differ significantly on any demographic variables (see Tables 1 and 2). . The groups did differ significantly on each of the clinical symptom measures. Independent samples *t*-tests were used to assess group differences on VR specific measures (see Table 3). There were no group differences on immersive tendencies, sense of presence, or realism of the VR environment; however, participants in the hoarding group experienced significantly greater simulator sickness than those in the nonhoarding group. With respect to the organizing task, there was no significant difference between the hoarding (M = 111.06, SD = 53.33) and nonhoarding group (M = 122.33, SD = 59.95) for the total number of objects that were sorted, $t(71) = 0.84$, $p = .402$.

Primary Analyses

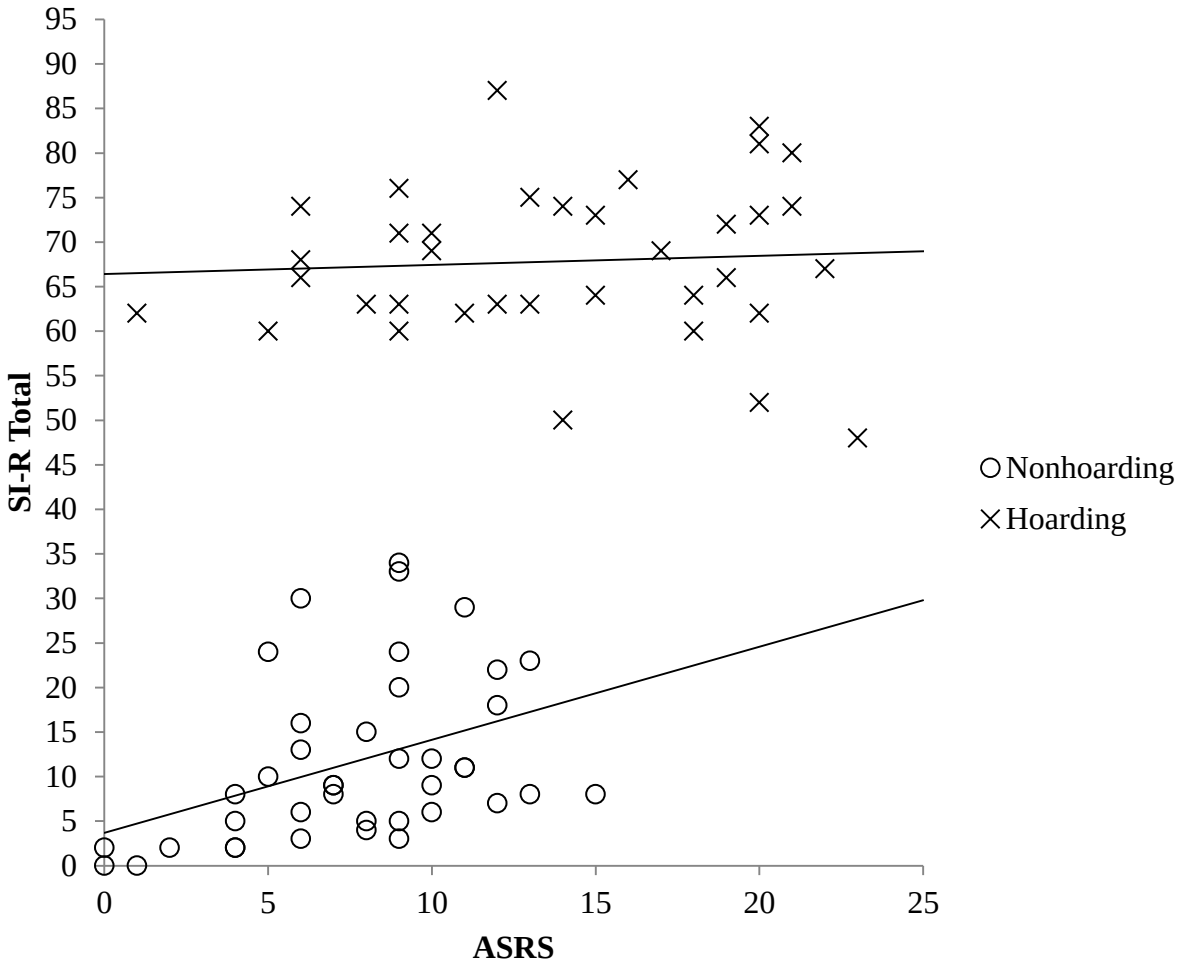
Hypothesis 1 stated that participants in the hoarding group would report higher ADHD symptoms than those in the nonhoarding group. ASRS scores showed no significant correlations with hoarding symptom scores in the hoarding group. ASRS scores were significantly positively correlated with difficulty discarding ($r = .41$, $p = .008$), excessive acquisition ($r = .34$, $p = .013$), and SI-R total scores ($r = .40$, $p = .010$) in the nonhoarding group. Controlling for DASS-21 depression, anxiety, and stress subscale scores, the partial correlations between difficulty discarding ($r = .39$, $p = .018$) and SI-R total scores ($r = .35$, $p = .035$) remained significant for the nonhoarding group. See Figure 2 for an illustration of the relationship between hoarding symptoms and ADHD symptoms across groups. When controlling for these general distress variables, a negative correlation emerged between ASRS scores and CIR scores in the hoarding

Table 3. Group differences on VR measures.

	Hoarding Group *M* (*SD*)	Nonhoarding Group *M* (*SD*)	*t*	*df*	*p*	Cohen's *d*
ITQ	72.67 (14.80)	68.08 (16.26)	1.27	73	.207	0.30
Study 1						
SSQ	49.15 (40.75)	30.10 (27.57)	2.36	60.56	.022	0.55
PQ	92.31 (24.12)	99.36 (19.09)	-1.41	73	.163	-0.32
Realism	10.80 (3.84)	10.38 (3.42)	0.49	72	.624	0.12
Study 2						
SSQ	34.30 (28.52)	15.93 (18.03)	3.28	55.98	.002	0.77
PQ	94.86 (22.84)	96.68 (20.86)	-0.36	74	.718	-0.08
Realism	10.92 (4.40)	11.50 (3.47)	-0.64	74	.521	-0.15
Study 3						
SSQ	44.15 (36.21)	16.36 (15.14)	4.28	45.86	< .001	1.00
PQ	100.06 (18.83)	97.63 (19.09)	0.56	74	.579	0.13
Realism	11.69 (3.93)	11.26 (2.93)	0.54	72	.593	0.12

Note. ITQ = *Immersive Tendencies Questionnaire*; SSQ = *Simulator Sickness Questionnaire*; PQ = *Presence Questionnaire*.

Figure 2. Correlation between hoarding symptom severity and ADHD symptoms across groups.



Note. SI-R = *Saving Inventory-Revised*; ASRS = *ADHD Self-Report Scale*.

group (r = -.49, p = .004). An independent samples t-test assessing overall group differences on ADHD symptoms indicated that ASRS scores were significantly higher in the hoarding group (M = 13.92, SD = 5.73) than the nonhoarding group (M = 7.68, SD = 3.61), t(57.8) = -5.61, p < .001, Cohen's d = -1.30. This group difference remained significant when controlling for the effects of DASS-21 depression, anxiety and stress in a subsequent univariate analysis of covariance (ANCOVA), F(1,71) = 9.09, p = .004, η^2 = 0.01.

Hypothesis 2 stated that the hoarding and the nonhoarding group might not perform differently on the RCFT, but that there would be group differences on the virtual memory test. See Table 4 for correlations between hoarding symptom measures and RCFT and VR memory scores. These correlations demonstrate positive correlations between hoarding symptom measures and VR immediate and delayed recall in the nonhoarding group only. There were also two significant correlations in this group between SI-R difficulty discarding and both immediate and delayed RCFT recall. Two multivariate analyses of variance (MANOVAs) were conducted to detect group differences. For the first MANOVA, group (i.e., hoarding vs. nonhoarding) was entered as a fixed factor, and RCFT immediate, delayed, and recognition memory accuracy were entered as dependent variables. The overall MANOVA demonstrated significant group differences, F(3,72) = 3.02, p = .035, η_p^2 = 0.11. Posthoc tests indicated that this effect was driven by significant group differences on immediate and delayed recall. The hoarding group performed significantly poorer on immediate recall (M = 37.75, SD = 12.76) than the nonhoarding group (M = 46.23, SD = 11.84), F(1,74) = 9.01, p = .004, η^2 = 0.01. The hoarding group also performed significantly poorer on delayed recall (M = 37.89, SD = 13.19) than the nonhoarding group (M = 45.60, SD = 11.49), F(1,74) = 7.42, p = .008, η^2 = 0.01. There was no significant difference between the hoarding (M = 45.25, SD = 14.96) and nonhoarding group

Table 4. Correlations between hoarding symptoms and memory ability.

	Hoarding Group					Nonhoarding Group				
	CIR	SI-R Discarding	SI-R Acquiring	SI-R Clutter	SI-R Total	CIR	SI-R Discarding	SI-R Acquiring	SI-R Clutter	SI-R Total
RCFT										
Immediate Recall	-.03 (.10)	-.17 (-.06)	-.16 (.13)	-.09 (-.11)	-.17 (-.13)	.10 (.12)	.34* (.30)	.24 (.18)	.13 (.08)	.27 (.22)
Delayed Recall	-.09 (.02)	-.19 (-.14)	-.13 (-.15)	-.08 (-.14)	-.16 (-.19)	.09 (.09)	.37* (.34*)	.30 (.26)	.14 (.09)	.31 (.27)
Recognition	-.09 (-.03)	-.09 (-.09)	-.07 (-.08)	.09 (.09)	-.01 (-.01)	.07 (.13)	.28 (.24)	.12 (.08)	.17 (.20)	.22 (.21)
VR										
Immediate Recall	.06 (.01)	.21 (.14)	.10 (-.01)	.29 (.21)	.26 (.16)	.46** (.49**)	.47** (.50**)	.37* (.39*)	.36* (.41*)	.45** (.49**)
Delayed Recall	.03 (-.04)	.19 (.11)	-.03 (-.16)	.27 (.20)	.19 (.08)	.38* (.41*)	.42** (.45**)	.31 (.32)	.31 (.36*)	.39* (.43**)
Recognition	-.20 (-.20)	-.01 (-.08)	.02 (-.11)	.12 (.01)	.07 (-.07)	.13 (.12)	.29 (.26)	.26 (.23)	.27 (.22)	.31 (.27)

Note. CIR = *Clutter Image Rating*; SI-R = *Saving Inventory-Revised*; RCFT = *Rey-Osterrieth Complex Figure Test*. Values in parentheses represent correlation coefficients when controlling for the effects of depression, anxiety, and stress scores from the *Depression, Anxiety, Stress Scales – 21 item version*.

* $p < .05$, ** $p < .01$

(M = 48.35, SD = 12.92) on recognition performance, $F(1,74) = 0.94$, $p = .336$, $\eta^2 < 0.01$. A subsequent multivariate analysis of covariance (MANCOVA) controlling for the effects of DASS-21 depression, anxiety, and stress subscales demonstrated no significant difference between the hoarding and nonhoarding group on RCFT memory accuracy, $F(3,69) = 1.18$, $p = .324$, $\eta_p^2 = 0.05$.

For the second MANOVA, group was entered as the fixed factor, and VR immediate, delayed, and recognition accuracy were entered as dependent variables. The overall MANOVA demonstrated no significant group differences, $F(3,71) = 0.78$, $p = .510$, $\eta_p^2 = 0.03$. This group difference remained nonsignificant when controlling for the effects of DASS-21 subscales and SSQ scores, $F(3,67) = 2.00$, $p = .122$, $\eta_p^2 = 0.08$.

Hypothesis 3 predicted that the hoarding group would report lower memory confidence than the nonhoarding group. See Table 5 for correlations between hoarding symptom measures and memory confidence measures. An independent samples t-test was conducted to assess group differences in VR memory confidence. There was no significant difference between the hoarding (M = 5.72, SD = 0.25) and nonhoarding groups (M = 5.71, SD = 0.24), $t(74) = -0.19$, $p = .853$, Cohen's $d = -0.04$. A subsequent ANCOVA was conducted, with group as the fixed factor, DASS-21 and SSQ scores as covariates, and VR memory confidence as the dependent variable. This ANCOVA indicated no significant difference between groups on VR memory confidence, $F(1,70) = 1.37$, $p = .246$, $\eta^2 < 0.01$. A MANOVA was then conducted to assess group differences on trait memory confidence as measured by the MCCS. This MANOVA indicated a significant overall difference between groups, $F(4,71) = 7.95$, $p < .001$, $\eta_p^2 = 0.31$. Planned contrasts revealed significant group differences on all subscales (see Table 6). A subsequent MANCOVA controlling for the effects of DASS-21 scores indicated a significant difference overall between

Table 5. Correlations between hoarding symptoms and memory confidence.

	Hoarding Group					Nonhoarding Group				
	CIR	SI-R Discarding	SI-R Acquiring	SI-R Clutter	SI-R Total	CIR	SI-R Discarding	SI-R Acquiring	SI-R Clutter	SI-R Total
MCCS: General	-.19 (-.39*)	.15 (.20)	.17 (.11)	.25 (.16)	.25 (.20)	.13 (.20)	.45** (.42**)	.30 (.22)	.24 (.22)	.38* (.33*)
MCCS: Decision	-.32 (-.50**)	.07 (-.01)	.08 (-.11)	.23 (.07)	.18 (-.01)	.04 (.07)	.36* (.33*)	.38* (.31)	.24 (.20)	.36* (.32)
MCCS: Concentration	-.33 (-.43*)	.09 (.06)	.14 (.03)	.22 (.10)	.20 (.08)	-.10 (-.02)	.25 (.24)	.27 (.23)	.08 (.11)	.22 (.22)
MCCS: Perfectionism	-.11 (-.19)	-.14 (-.03)	-.23 (-.22)	-.15 (-.20)	-.22 (-.22)	.28 (.33*)	.18 (.17)	.17 (.15)	.20 (.25)	.21 (.21)
MCCS: Total	-.26 (-.48**)	.10 (.12)	.11 (.01)	.22 (.10)	.19 (.10)	.13 (.24)	.47** (.46**)	.38* (.32)	.27 (.29)	.42** (.41*)
VR Memory Confidence	.03 (.10)	-.08 (.05)	-.15 (-.05)	-.09 (-.02)	-.14 (-.01)	.09 (.10)	.13 (.19)	.11 (.17)	.24 (.33*)	.26 (.26)

Note. CIR = *Clutter Image Rating*; SI-R = *Saving Inventory-Revised*; MCCS = *Memory and Cognitive Confidence Scale*. Values in parentheses represent correlation coefficients when controlling for the effects of depression, anxiety, and stress scores from the *Depression, Anxiety, Stress Scales – 21 item version*.

* $p < .05$, ** $p < .01$

Table 6. Planned contrasts to detect group differences in memory confidence.

	Hoarding Group *M (SD)*	Nonhoarding Group *M (SD)*	Contrast Estimate	Standard Error	Significance	95% CI	
						Lower Bound	Upper Bound
MCCS: General	42.42 (14.70)	28.38 (9.45)	-14.04 (-8.52)	2.81 (2.95)	< .001 (.005)	-19.63 (-14.41)	-8.45 (-2.63)
MCCS: Decision	15.89 (5.50)	10.50 (4.19)	-5.39 (-2.68)	1.12 (1.17)	< .001 (.025)	-7.61 (-5.02)	-3.17 (0.34)
MCCS: Concentration	12.97 (4.29)	8.30 (3.70)	-4.67 (-3.11)	0.92 (0.98)	< .001 (.002)	-6.50 (-5.07)	-2.85 (-1.15)
MCCS: Perfectionism	13.89 (3.83)	11.55 (3.76)	-2.34 (-2.46)	0.87 (1.02)	.009 (.019)	-4.08 (-4.49)	-0.60 (-0.42)

Note. MCCS = *Memory and Cognitive Confidence Scale*. Values in parentheses are controlling for the effects of depression, anxiety, and stress scores from the *Depression, Anxiety, Stress Scales – 21 item version* and *Simulator Sickness Questionnaire* scores.

groups, $F(4,68) = 4.08$, $p = .005$, $\eta^2 = 0.19$. Planned contrasts similarly revealed significant group differences across all MCCS subscales (see Table 6).

Hypothesis 4 stated that there would be no group difference in performance on a neuropsychological test of decision making, but that the hoarding group would demonstrate decision making deficits when organizing a virtual cluttered room, as demonstrated by taking longer to complete the task. There were no significant correlations in either group between hoarding symptom measures and IGT scores or VR decision making. However, when controlling for the effects of DASS-21 scores, significant partial correlations were present in the hoarding group only. There was a positive correlation between IGT scores and SI-R clutter ($r = .36$, $p = .044$) and SI-R total scores ($r = .39$, $p = .029$). An independent samples *t*-test was run to detect group differences on IGT. The hoarding group ($M = 8.56$, $SD = 35.66$) performed significantly poorer than the nonhoarding group ($M = 26.60$, $SD = 37.49$) on the IGT, $t(74) = 2.14$, $p = .035$, Cohen's $d = 0.49$. This difference was nonsignificant when controlling for the effects of DASS-21 subscales, $F(1,69) = 1.03$, $p = .407$, $\eta^2 = 0.03$. A second *t*-test was run to detect group difference on VR decision making performance. There was no significant difference between the hoarding ($M = 821.09$, $SD = 376.09$) and the nonhoarding group ($M = 800.85$, $SD = 463.01$), $t(71) = -0.20$, $p = .840$, Cohen's $d = -0.05$. This group difference remained nonsignificant when controlling for the effects of DASS-21 subscales and SSQ scores, $F(1,67) = 0.07$, $p = .788$, $\eta^2 = 0.03$.

Hypothesis 5 stated that the hoarding group would demonstrate greater underinclusivity relative to the nonhoarding group. There were no significant correlations between underinclusivity measures and hoarding symptom measures in the nonhoarding group. There were significant negative correlations in the hoarding group between average number of objects

per category and SI-R clutter (r = -.41, p = .015) and SI-R total scores (r = -.45, p = .007), and between the proportion of total categories containing only one object and CIR scores (r = -.35, p = .042). The latter correlation became nonsignificant when controlling for the effects of DASS-21 scores (r = -.31, p = .085). However, when controlling for these general distress factors, average number of objects per category emerged as significantly negatively correlated with each SI-R subscale score in the hoarding group. Specifically, this indicator of underinclusivity was negatively correlated with difficulty discarding (r = -.38, p = .036), acquiring (r = -.39, p = .028), clutter (r = -.44, p = .014), and total scores (r = -.55, p = .001). A MANOVA to detect group differences was then conducted with group as the fixed factor and underinclusivity indicators entered as dependent variables. This MANOVA demonstrated a significant overall difference between groups, $F(3,69) = 3.50$, p = .020, $\eta_p^2 = 0.13$. Planned contrasts, however, revealed no significant group differences on any single indicator. A subsequent MANCOVA was conducted to control for the effects of DASS-21 subscales and SSQ scores. This MANCOVA demonstrated a significant overall difference between groups, $F(3,65) = 3.37$, p = .024, $\eta_p^2 = 0.13$. Planned contrasts revealed that the group difference driving this effect was the proportion of categories containing only one object. The hoarding group had a significantly greater proportion of their total categories containing only one object (M = 0.18, SD = 0.14) compared to the nonhoarding group (M = 0.13, SD = 0.11), contrast estimate = -0.08, SE = 0.04, p = .021, 95% CI [-0.15, -0.01]. There were no significant differences between groups in the total number of categories created or average number of objects per category.

Hypothesis 6 stated that attention and memory impairments would mediate the relationship between hoarding symptoms and deficits in executive functioning in the hoarding group. No memory or decision making impairments were found, and were therefore not

investigated further. Separate mediation analyses using regression were conducted in each group to assess for the mediation effects of attention problems on the relationship between hoarding and underinclusivity, specifically indicated by proportion of categories containing only one object. Both predictor variables were centred prior to running the regressions. First, a regression was run to test whether underinclusivity as measured by proportion of categories containing only one object was indeed a predictor of hoarding symptom severity (i.e., SI-R total scores). This regression was nonsignificant for the hoarding group, $F(1,32) = 0.01$, $p = .979$, and the nonhoarding group, $F(1,37) = 2.51$, $p = .122$. Underinclusivity was also not a significant predictor of ADHD symptoms for either the hoarding group, $F(1,32) = 0.02$, $p = .892$, or the nonhoarding group, $F(1,37) = 0.08$, $p = .778$. No further analyses were run to test this mediation model.

Hypothesis 7 assessed the relationship between hoarding symptoms, indecisiveness, and perfectionism. Indecisiveness measured using the FIS was not significantly correlated with hoarding symptom measures in either group. Controlling for the effects of DASS-21 scores, CIR scores emerged as negatively correlated with FIS scores in the hoarding group ($r = -.49$, $p = .004$). See Table 7 for summaries of the correlations between FIS, perfectionism, and hoarding symptom measures. Controlling for DASS-21 scores, FIS scores were positively correlated with doubts about actions in both groups. A MANOVA was conducted, with group as the fixed factor and all perfectionism subscales as dependent variables. This MANOVA indicated a significant overall difference between groups, $F(9,65) = 8.92$, $p < .001$, $\eta_p^2 = 0.55$. Planned contrasts revealed significant group differences for FMPS concern over mistakes, parental criticism, parental expectations, doubts about actions, and organization, and HMPS socially-prescribed perfectionism. A subsequent MANCOVA was conducted to control for the effects of DASS-21

Table 7. Correlations between hoarding symptoms, fear of decision making, and perfectionism.

	Hoarding Group						Nonhoarding Group					
	FIS	CIR	SI-R Discard	SI-R Acquire	SI-R Clutter	SI-R Total	FIS	CIR	SI-R Discard	SI-R Acquire	SI-R Clutter	SI-R Total
FMPS												
CM	.25	-.04	.20	.13	.24	.24	.30	.16	.20	.31	.07	.21
	(.03)	(-.20)	(.19)	(.08)	(.19)	(.21)	(.28)	(.23)	(.19)	(.31)	(.12)	(.22)
PS	-.17	-.10	-.08	-.25	-.15	-.21	.10	.18	.05	.17	.04	.09
	(-.22)	(-.15)	(-.03)	(-.22)	(-.13)	(-.18)	(.05)	(.23)	(.01)	(.15)	(.04)	(.06)
PE	.10	.12	.26	.07	.29	.27	-.34*	.16	-.08	-.06	.04	-.03
	(-.02)	(.06)	(.24)	(.02)	(.27)	(.24)	(-.30)	(.15)	(-.04)	(-.01)	(.07)	(.01)
PC	.35*	.14	.39*	.20	.48**	.46**	-.24	.13	-.01	-.01	-.07	-.03
	(.25)	(.07)	(.39*)	(.15)	(.46**)	(.45*)	(-.23)	(.16)	(.03)	(.03)	(-.01)	(.02)
DA	.70***	-.10	-.09	.02	.17	.06	.47**	.04	.25	.22	-.02	.17
	(.58**)	(-.36*)	(-.26)	(-.17)	(.03)	(-.14)	(.41*)	(.10)	(.20)	(.15)	(-.04)	(.12)
O	-.30	-.08	.01	-.10	-.01	-.05	.04	-.20	-.21	-.13	-.21	-.21
	(-.23)	(-.04)	(.05)	(-.05)	(.05)	(.03)	(.14)	(-.21)	(-.22)	(-.10)	(-.20)	(-.20)
Total	.25	.01	.19	.04	.26	.22	.08	.21	.12	.20	.04	.13
	(.07)	(-.13)	(.19)	(-.02)	(.22)	(.18)	(.05)	(.27)	(.11)	(.20)	(.08)	(.14)
HMPS												
SO	-.08	.08	.13	-.06	.03	.04	.09	.32*	.32*	.25	.18	.28
	(-.13)	(-.06)	(.23)	(-.03)	(.05)	(.10)	(.07)	(.38*)	(.30)	(.25)	(.22)	(.29)
OO	.09	.13	.42*	.24	.19	.34*	-.14	.25	.33*	.26	.20	.30
	(-.13)	(.14)	(.43*)	(.20)	(.13)	(.31)	(-.17)	(.31)	(.33*)	(.27)	(.26)	(.32*)
SP	.51**	.16	.16	.12	.32	.27	.15	.11	.12	.08	-.02	.07
	(.18)	(.11)	(.09)	(-.01)	(.25)	(.16)	(.18)	(.18)	(.12)	(.09)	(.05)	(.10)

Note. CIR = *Clutter Image Rating*; SI-R = *Saving Inventory-Revised*; FIS = *Frost Indecisiveness Scale*; FMPS = *Frost Multidimensional Perfectionism Scale*; CM = *Concern over Mistakes subscale*; PS = *Personal Standards subscale*; PE = *Parental Expectations subscale*; PC = *Parental Criticism subscale*; DA = *Doubts about Actions subscale*; O = *Organizing subscale*; HMPS = *Hewitt and Flett Multidimensional Perfectionism Scale*; SO = *Self-Oriented Perfectionism subscale*; OO = *Other-Oriented Perfectionism subscale*; SP = *Socially Prescribed Perfectionism subscale*. Values in parentheses represent correlation coefficients when controlling for the effects of depression, anxiety, and stress scores from the *Depression, Anxiety, Stress Scales – 21 item version*.

* $p < .05$, ** $p < .01$, *** $p < .001$

subscale scores. This MANCOVA indicated a significant difference overall between groups, $F(9,62) = 3.84$, $p = .001$, $\eta_p^2 = 0.36$. Planned contrasts revealed significant group differences for FMPS concern over mistakes, doubts about actions, organization, and HMPS socially prescribed perfectionism (see Table 8).

An independent samples *t*-test indicated that the hoarding group reported significantly higher FIS scores ($M = 48.89$, $SD = 12.42$) than the nonhoarding group ($M = 33.23$, $SD = 10.39$), $t(74) = -5.98$, $p < .001$, Cohen's $d = -1.37$. This was followed by a univariate ANCOVA testing group differences on FIS scores controlling for the effects of DASS-21 scores, and all perfectionism subscales that differed significantly between groups when DASS-21 scores had been included as covariates. This analysis indicated that there was no longer a significant difference between groups on FIS scores, $F(1,66) = 0.58$, $p = .450$, $\eta^2 = .009$.

A second MANCOVA was then run including FIS scores and DASS-21 scores as additional covariates to test whether indecisiveness may account for variance in perfectionism scores between groups. The MANCOVA remained significant, $F(9,61) = 2.58$, $p = .014$, $\eta_p^2 = .28$. Planned contrasts indicated that the addition of FIS scores led to concern over mistakes being no longer significantly different between groups; however, doubts about actions, organization, and socially-prescribed perfectionism subscales remained significantly different (see Table 9), suggesting that problems in decision making in hoarding may be accounted for by perfectionism and general distress.

Discussion

The purpose of Study 1 was to examine the role of information processing in the context of hoarding symptoms. Specifically, differences in attention, memory, decision making, and categorization were examined between those with and without a diagnosis of hoarding disorder.

Table 8. Planned contrasts to detect group differences in perfectionism.

	Hoarding Group *M (SD)*	Nonhoarding Group *M (SD)*	Contrast Estimate	Standard Error	Significance	95% CI Lower Bound	95% CI Upper Bound
FMPS							
Concern over mistakes	28.03 (9.28)	19.90 (7.58)	-8.13 (-5.63)	1.95 (2.33)	< .001 (.018)	-12.01 (-10.28)	-4.25 (-0.98)
Personal standards	23.17 (6.48)	22.68 (4.97)	-0.50 (-0.90)	1.33 (1.67)	.709 (.590)	-3.14 (-4.22)	2.14 (2.42)
Parental expectations	16.71 (5.89)	13.65 (5.36)	-3.06 (-2.31)	1.30 (1.65)	.021 (.167)	-5.66 (-5.61)	-0.47 (0.99)
Parental criticism	11.80 (5.05)	8.70 (4.18)	-3.10 (-2.15)	1.07 (1.35)	.005 (.115)	-5.22 (-4.84)	-0.98 (0.54)
Doubts about actions	12.89 (3.37)	7.80 (2.96)	-5.09 (-3.39)	0.73 (0.81)	< .001 (< .001)	-6.54 (-5.01)	-3.63 (-1.77)
Organization	18.11 (5.74)	24.18 (4.99)	6.06 (4.87)	1.24 (1.56)	< .001 (.003)	3.59 (1.76)	8.53 (7.98)
HMPS							
Self-oriented	71.86 (19.04)	66.10 (15.04)	-5.76 (-4.79)	3.94 (4.90)	.148 (.332)	-13.61 (-14.57)	2.10 (4.98)
Other-oriented	59.34 (11.33)	56.35 (13.28)	-2.99 (-1.43)	2.87 (3.64)	.301 (.697)	-8.72 (-8.69)	2.73 (5.84)
Socially prescribed	64.29 (14.95)	47.80 (11.94)	-16.49 (-10.87)	3.11 (3.69)	< .001 (.004)	-22.68 (-18.22)	-10.29 (-3.51)

Note. FMPS = *Frost Multidimensional Perfectionism Scale*; HMPS = *Hewitt & Flett Multidimensional Perfectionism Scale.* Values in parentheses are controlling for the effects of depression, anxiety, and stress scores from the *Depression, Anxiety, Stress Scales – 21 item version.*

Table 9. Planned contrasts to detect group differences in perfectionism, controlling for the effects of depression, anxiety, stress, and indecisiveness.

	Hoarding Group *M (SD)*	Nonhoarding Group *M (SD)*	Contrast Estimate	Standard Error	Significance	95% CI Lower Bound	95% CI Upper Bound
FMPS							
Concern over mistakes	28.03 (9.28)	19.90 (7.58)	-4.61	2.48	.067	-9.56	0.34
Personal standards	23.17 (6.48)	22.68 (4.97)	-1.34	1.78	.455	-4.90	2.22
Parental expectations	16.71 (5.89)	13.65 (5.36)	-3.20	1.75	.072	-6.69	0.29
Parental criticism	11.80 (5.05)	8.70 (4.18)	-2.19	1.45	.135	-5.07	0.70
Doubts about actions	12.89 (3.37)	7.80 (2.96)	-2.23	0.78	.005	-3.78	-0.68
Organization	18.11 (5.74)	24.18 (4.99)	4.64	1.67	.007	1.30	7.98
HMPS							
Self-oriented	71.86 (19.04)	66.10 (15.04)	-5.30	5.27	.318	-15.80	5.50
Other-oriented	59.34 (11.33)	56.35 (13.28)	-3.24	3.86	.405	-10.95	4.47
Socially prescribed	64.29 (14.95)	47.80 (11.94)	-9.24	3.92	.021	-17.07	-1.42

Note. FMPS = *Frost Multidimensional Perfectionism Scale*; HMPS = *Hewitt & Flett Multidimensional Perfectionism Scale*.

Memory confidence, fear of decision making, and perfectionism were also examined. Preliminary analyses showed that these two groups were not significantly different with respect to age, gender, and all demographic variables. As expected, the hoarding group also reported higher scores on all clinical symptom measures.

What made this study unique among studies of cognitive functioning in hoarding was the use of VR to explore the question of whether ecological validity has an impact upon results. Some hypotheses were supported, some were not supported, and some were partially supported. These will each be reviewed in turn. Preliminary analyses identified many important findings to support the use of VR in this field of research.

One such finding was that there were no differences between groups on overall immersive tendencies, sense of presence, or sense of realism with respect to the VR environments. This suggests that VR may be a viable proxy for examining information processing in hoarding, and potentially in other clinical areas as well. In addition, there was no difference between groups with respect to total number of objects that were categorized. Both groups assigned categories to a mean of 110.06-122.33 objects out of a total 269 virtual objects (i.e., 41.29% to 45.48% of the total available objects). This is important, as it suggests that this test was useful for assessing patterns of categorizing and decision making without the risk of a ceiling effect. It also suggests that individuals with hoarding problems are capable of creating an organizing system without necessarily becoming overwhelmed and stopping early when the total number of objects to be sorted is controlled.

Unfortunately, the hoarding group did report significantly greater simulator sickness symptoms following this VR experience. When participants were trained on how to use the handheld controller, they were instructed to move slowly because moving quickly would be

more likely to cause them to experience nausea. Research has shown that reports of simulator sickness may respond to such demand effects, such that ratings are higher when participants are primed to expect symptoms (Young, Adelstein, & Ellis, 2007). However, both groups were provided with the same instruction, which suggests that the group difference was not due to demand effects. SSQ scores were also not significantly correlated with DASS-21 scores within either group in the present study (r = .14-.29 for the hoarding group, and .02-.19 for the nonhoarding group, all p > .09). Although the SSQ is designed to assess simulator sickness, upon examining the specific items it is possible that this questionnaire may also assess an overall sense of unease or increased anxiety (e.g., general discomfort, difficulty concentrating, sweating, nausea, and dizziness can also be symptoms of anxiety). This is important to note, as decision making has been found to cause anxiety and stress in hoarding samples (Grisham et al., 2010). The following results of must be interpreted with consideration to this potential confound of group differences on simulator sickness.

Hypothesis 1 stated that there would be higher ADHD symptoms in the hoarding group compared to the nonhoarding group. There were no zero-order correlations between hoarding symptom measures (i.e., CIR and SI-R) and ASRS scores in the hoarding group; however, there were significant positive correlations between ADHD symptoms and hoarding symptoms in the nonhoarding group. Visual examination of Figure 2 suggests that this pattern of results could be due to a ceiling effect within the hoarding group, such that there was not a great deal of variance on SI-R scores. Furthermore, the distribution of CIR scores had a limited range and was extremely positively skewed for the nonhoarding group, making it difficult to interpret correlations with this scale. When comparing between groups, the hoarding group did report significantly elevated levels of ADHD symptoms relative to the nonhoarding group with a large

effect size. This difference remained significant even when controlling for the effects of general distress variables, although with a small effect size. These results were expected based on consistent findings in the literature (Fitch & Cougle, 2013; Grisham et al., 2007; Grisham et al., 2010; Moshier et al., 2016). This pattern of results illustrates that although, overall, the hoarding group reported higher ADHD symptoms relative to the nonhoarding group, that this distribution of scores is quite broad. This suggests that individuals with hoarding problems may be more likely to experience ADHD symptoms, but that this should be assessed on a case-by-case basis and addressed accordingly in treatment using a case formulation approach whenever possible.

Hypothesis 2 stated that memory impairments would only be identified using the VR paradigm and not the traditional memory testing paradigm. This hypothesis was developed based on the work by Plancher et al. (2010; 2012), which has successfully used VR to assess memory problems in a more ecologically valid way. In the present study, this hypothesis was not supported. In fact, the reverse was found. The hoarding group performed significantly poorer than the nonhoarding on the RCFT with a medium to large effect size. However, this difference became nonsignificant when accounting for general distress variables. Furthermore, no memory impairments were found using the VR methodology. Although this finding was in contrast to this hypothesis, it nonetheless provides valuable information. This study now contributes to the growing literature suggesting that memory impairments are not specifically related to hoarding symptomatology within this population (e.g., Mackin et al., 2011; McMillan et al., 2013; Sumner et al., 2016). What does appear to be specific to hoarding is poor trait memory confidence. Indeed, hypothesis 3 results showed poorer trait memory confidence in the hoarding group compared to the nonhoarding group even when controlling for general distress with medium to large effect sizes. Interestingly, there was no difference between groups on state memory

confidence, and both groups reported high mean confidence levels (i.e., over 5 on a 6-point scale). Although the measure of VR memory confidence has not been validated outside of this study, this constellation of finding may hold important clinical implications. For example, if individuals with hoarding disorder hold stronger beliefs about global memory problems, but are equally confident as their nonhoarding counterparts when asked about specific objects, this discrepancy could be leveraged in psychoeducation and behavioural experiments to increase trait memory confidence. Shaw, Timpano, et al. (2015) found that poorer memory confidence was associated with more severe hoarding symptoms (notably, this relationship was only present in the nonhoarding group in the present study). It is plausible, then, that increasing memory confidence may lead to a reduction in hoarding symptom severity, increased comfort with discarding, and increased likelihood of effectively using appropriate storage solutions. Increasing confidence may disrupt certain memory beliefs (Hartl et al., 2004) by allowing individuals to feel more certain that they will be able to remember what objects they own, and importantly that the memories that are attached to objects will not be lost when these objects are outside of their field of view or even discarded.

Similar to hypothesis 2, hypothesis 4 anticipated no group differences on a standardized test of decision making, but differences on VR decision making reflective of the decision making problems with respect to organizing observed in extremely cluttered homes. The same pattern of results as in hypothesis 2 was demonstrated in hypothesis 4. Specifically, impairment with a medium effect size was demonstrated on the IGT, but this group difference became nonsignificant when controlling for general distress variables. There was also no group difference on VR decision making. Similarly to other studies that have used the IGT (Grisham et al., 2007; Grisham et al., 2010; Morein-Zamir et al., 2014; Pushkarskaya et al., 2017; Tolin &

Villavicencio, 2011; Tolin, Villavicencio et al., 2011), there was no evidence of decision making impairment that was specifically accounted for by the presence of hoarding problems. The hoarding group also did not take significantly longer to complete the categorization task in the present study. This is in contrast to other studies that have demonstrated hoarding participants taking longer on decision making tasks such as the WCST (Mackin et al., 2011) or tasks requiring in vivo discarding (Tolin et al., 2012). This is also inconsistent with findings from the OCD literature that has demonstrated longer task completion times for their clinical samples using VR decision making procedures (La Paglia et al., 2012). When controlling for general distress variables, there was also a significant correlation in the unexpected direction between hoarding symptom severity and performance on the IGT in the hoarding group. These correlations showed better decision making ability was associated with higher overall hoarding symptom severity (SI-R total scores) and clutter specifically (SI-R clutter subscale scores). These correlations suggest that there is likely a unique phenomenon that occurs during decision making in the context of discarding personal objects, as there is no evidence for a global deficit that would account for these symptoms. It is also possible that these positive correlations hint at a relationship between conservativism and clutter. High scores on the IGT can also be interpreted as an indicator of low implicit risk-taking (Starcke, Tuschen-Caffier, Markowitsch, & Brand, 2009). Excessive clutter may also be an indicator of low risk-taking. For people with hoarding problems, allowing the build-up of excessive clutter may reflect a decreased tendency to risk losing value from discarding objects, or risk of exposing oneself to difficult emotions associated with loss. The mixed results seen in this and other decision making studies highlight the importance of identifying a valid and reliable way of assessing this construct in this population. It is also important to note the risk of Type I error, given the high number of analyses that were

run.

Hypothesis 5 stated that there would be a higher degree of underinclusivity in the hoarding group compared to the nonhoarding group. In other words, the hoarding group was predicted to demonstrate poorer category efficiency. This study offered a more ecologically valid environment for testing categorization ability compared to other studies that have examined this phenomenon. This hypothesis was largely supported and the findings corroborate other research in this area (Luchian et al., 2007; Wincze et al., 2007). Average number of objects per category was negatively correlated with overall hoarding symptom severity, as well as difficulty discarding, excessive acquisition, and clutter in the hoarding group. These findings demonstrate that as hoarding symptom severity increases, average number of objects per category decreases (i.e., underinclusivity increases). Although when comparing group means, the hoarding group did not create a larger number of categories or demonstrate a smaller average number of objects per category than the nonhoarding group, they did have a significantly greater proportion of categories that contained only one object. Medium to large effect sizes indicated that this group difference remained important even when controlling for general distress variables. This pattern of results may suggest that deficient categorizing ability in hoarding may not necessarily be observable when comparing average performance, but that a greater proportion of objects do appear to have unique qualities that cannot be combined with other categories of objects, thus resulting in poorer category efficiency. This sense of uniqueness may also make it more difficult to make discarding decisions, as the loss may feel more significant (e.g., loss of an entire category versus loss of a single object within a larger category). Furthermore, as symptoms become more severe, category sizes become smaller. These two indicators of underinclusivity showed unique relationships to hoarding, thus supporting the importance of this construct in our

understanding of how hoarding symptoms are maintained and may evolve over time as symptoms become more intractable. Testing underinclusivity in a less constrained environment (e.g., without limiting the number of objects to be categorized) demonstrated that participants in the hoarding group were able to organize the same number of objects in the same amount of time as the nonhoarding group. However, they demonstrated poorer efficiency and usefulness in their categories. This may explain why in their real lives, organizing quickly feels overwhelming. Future research should test whether there is a stronger emotional impact on discarding one item within a larger category versus discarding the same item framed in a way such that it represents an entire category. If this is the case, when considering treatment implications, it may be helpful to collaboratively develop "rules" about the minimum number of objects that can be grouped together for them to be considered a true category to limit the potential negative impact of this tendency toward underinclusivity.

Hypothesis 6 stated that attention and memory deficits would account for deficits in decision making and categorization ability in the hoarding group. This hypothesis was not supported. First, there were no specific impairments found in either memory or decision making in the hoarding group, which has already been discussed. Two regressions demonstrated that underinclusivity was neither a predictor of hoarding symptom severity nor ADHD symptoms, therefore negating the need for further mediation analysis. This finding indicates that attentional problems and underinclusivity are equivocal with respect to their unique relationship to hoarding symptom severity. These nonsignificant regression analyses also suggest that there could be an additional third variable that was not included that may account for the increased effect of underinclusivity in hoarding.

Hypothesis 7 stated that indecisiveness and perfectionism would be correlated with one

another and with hoarding symptoms. When controlling for the effects of general distress variables, indecisiveness was positively correlated with only one facet of perfectionism, specifically doubts about actions, in both groups. Indecisiveness was also negatively correlated with clutter in the hoarding group only. A series of statistical analyses demonstrated that the hoarding and nonhoarding groups differed significantly on indecisiveness and various facets of perfectionism. When controlling for the effects of either, the group difference on indecisiveness became nonsignificant, whereas the group differences on perfectionism (i.e., doubts about actions, organization, and socially prescribed perfectionism) remained. This suggests that group differences on indecisiveness may be accounted for by group differences in perfectionism. The specific facets of perfectionism also provide interesting insights into certain problems faced by individuals with hoarding problems. First, the hoarding group reported elevated doubts about actions, which may contribute to fear of decision making and decision making difficulties in everyday life. Second, and unsurprisingly, the hoarding group reported significantly lower scores on organization. Finally, the hoarding group reported elevated scores on socially prescribed perfectionism. This elevation makes sense given the higher rates of social isolation and social anxiety that commonly co-occur alongside hoarding problems. In the current study, 33% of the hoarding group compared to 5% of the nonhoarding group reported symptoms meeting criteria for a comorbid diagnosis of social anxiety disorder. Considering how this information may be applicable to improving hoarding treatment, it may be important to explicitly target perfectionistic concerns and social evaluative concerns as a means of improving confidence in decision making ability.

Study 2: Emotional Intensity, Experiential Avoidance, and Hoarding Symptoms

Excessive acquisition and failure to discard large numbers of possessions of limited value are key components of problematic hoarding. As such, patterns of acquisition and discarding have been of interest to researchers in this area. According to the cognitive-behavioural model of hoarding (Frost & Hartl, 1996; Frost & Steketee, 1998), individuals with problematic hoarding demonstrate difficulty discarding objects of little value due to a fear of sadness and sense of overwhelming loss upon discarding. Thus, hoarding is posited to be maintained in part by a process of negative reinforcement, such that the avoidance of painful emotions leads to an increased inability to discard objects of little worth. In recent years, there has been growing interest in this cycle of negative reinforcement. For example, Ayers, Castriotta, Dozier, Espejo, and Porter (2014) demonstrated that experiential avoidance (i.e., avoidance of uncomfortable internal experiences such as thoughts, memories, and emotions) predicted difficulty discarding, whereas situational avoidance (i.e., self-distraction, denial of the problem, and behavioural disengagement) predicted clutter.

In Foa and Kozak's (1986; Foa, Huppert, & Cahill, 2006) emotional processing model, emotions (e.g., sadness) are considered action tendencies that exist within information networks alongside feared stimuli (e.g., discarding treasured objects) and their relevant contextual factors (e.g., certain rooms in the home). Experiential avoidance occurs when certain parts of that information network are avoided (e.g., avoiding thinking about the sadness that would follow discarding treasured items), thus interfering with new learning about the feared stimulus (e.g., that one might be able to cope with such emotions). As such, there is no emotional processing of new information that could lead to the development of a competing information network, and thus no change in the original associated affect or behaviours (e.g., the individual continues to

avoid discarding for fear of being unable to cope with overwhelming emotions).

In a review of experiential avoidance in anxiety disorders, Salters-Pedneault, Tull, and Roemer (2004) described the findings of basic research on the effects of experiential avoidance. First, experiential avoidance has cognitive outcomes such as immediate and delayed rebound effects following thought suppression. The target thought that the individual is trying to avoid actually increases in frequency following attempted suppression. There is also some evidence to suggest that experiential avoidance leads to changes in the interpretation of suppressed thoughts and emotions such that they are perceived as more negative, and perceived self-efficacy about the controllability of one's thoughts and emotions deteriorates. Furthermore, memory and learning have been found to be impaired during experiential avoidance.

Salters-Pedneault et al. (2004) also summarized research showing that experiential avoidance leads to increased physiological arousal, including increased skin conductance response (SCR) and increased heart rate (HR), as well as other cardiovascular and respiratory effects. Similar effects have been found for emotional outcomes, such that experiential avoidance tends to lead to an increase in emotional reactivity to emotionally-provocative stimuli such as film clips, as well as slower recovery to euthymic mood. The authors argue that these paradoxical effects of experiential avoidance impair decision making, such that individuals are unable to process relevant information if thoughts and feelings are being suppressed, as one might end up acting in accordance to the more intense rebound emotional experience rather than the initial uncomfortable experience.

In support of this suggestion, Gratz, Tull, and Gunderson (2008) reported that the relationship between anxiety sensitivity, a cognitive bias wherein individuals apply catastrophic interpretations to benign symptoms of anxiety, and borderline personality disorder symptoms

was fully mediated by experiential avoidance. This finding demonstrates that experiential avoidance mediates the relationship between certain clinical symptoms and uncomfortable emotional experiences, as has similarly been posited to occur in hoarding. In addition, anxiety sensitivity, which is conceptually similar to experiential avoidance in that they both represent an unwillingness to tolerate uncomfortable internal experiences, and distress intolerance have been found to be related to hoarding symptom severity in nonclinical samples (Coles, Frost, Heimberg, & Steketee, 2003; Timpano, Buckner, Richey, Murphy, & Schmidt, 2009). Furthermore, anxiety sensitivity has been shown to be a significant predictor of hoarding symptoms. The mechanism by which anxiety sensitivity leads to greater hoarding symptom severity appears to occur via emotional attachment to objects, such that objects are believed to be able to help soothe intense emotions (Phung, Moulding, Taylor, & Nedeljkovic, 2015). Indeed, Tolin et al. (2012) reported a significant negative correlation between the number of personal items discarded in a discarding task and the intensity of negative emotions such as anxiety and sadness, indicating an important role of emotions, and likely the desire to avoid uncomfortable emotions, in hoarding-specific contexts.

Experiential avoidance has been increasingly studied in problematic hoarding. The first study that directly examined the relationship between experiential avoidance and hoarding found a moderate positive correlation between saving cognitions and self-reported experiential avoidance tendencies in an unselected student sample (Wheaton, Abramowitz, Franklin, Berman, & Fabricant, 2011). This study also found that experiential avoidance tendencies accounted for significant variance in the prediction of excessive acquisition and clutter, even when accounting for the effects of gender, depression, and saving cognitions. Conversely, in a subsequent study using a clinical sample of individuals with hoarding disorder, Wheaton, Fabricant, Berman, and

Abramowitz (2013) reported that experiential avoidance did not account for any unique variance in predicting hoarding symptoms. Experiential avoidance was, however, significantly related to symptoms of depression, anxiety, and general distress. Fernández de la Cruz et al. (2013) similarly found that although experiential avoidance was elevated in hoarding participants relative to healthy controls, it was not correlated with hoarding symptom severity.

The studies by Wheaton et al. (2013) and Fernández de la Cruz et al. (2013) did have a number of important limitations that may have influenced the findings, including small sample sizes, which could have negatively impacted the power of their analyses to detect significant relationships. In addition, experiential avoidance tendencies and hoarding symptoms were measured only using retrospective self-report, which may include substantial respondent bias. Furthermore, experiential avoidance was measured in both of these studies using the *Acceptance and Action Questionnaire* (Bond et al., 2011), a very brief scale that includes items that may not actually be indicative of this construct. Sample items include "I am in control of my life," "It seems like most people are handling their lives better than I am," and "Worries get in the way of my success." These items have poor face validity with respect to assessing the avoidance of uncomfortable internal experiences. Given other evidence suggesting an important role of experiential avoidance in hoarding, and the theoretical importance of the construct, it warrants further exploration with improved measures and methods.

Timpano, Shaw, Cougle, and Fitch (2014) found that poorer distress tolerance (i.e., lower tolerance for negative emotions) and higher emotional intensity were positively correlated with hoarding symptoms. Specifically, emotional intolerance for sadness, fear, and anger was positively correlated with overall hoarding symptom severity but not clutter. Perhaps not surprisingly, given the assumption that the inability to discard is due to fear of losing the object

and fear of experiencing negative emotions, the strongest correlation emerged between intolerance of fear and difficulty discarding ($r = .29$, $p < .001$). With respect to emotional intensity, fear was only significantly correlated with difficulty discarding, whereas sadness and disgust were both significantly correlated with excessive acquisition.

Distress intolerance may also interact with mood states to predict difficulty discarding. In a study using a negative or neutral mood induction and an in vivo discarding task, Norberg, Keyan, and Grisham (2015) found that distress intolerance, object attachment, and depression scores predicted a smaller proportion of discarded personal items in the sad mood condition only. Similarly, low distress tolerance was associated with increased saving during an imagined discarding task only under stressful conditions in a nonclinical hoarding sample (Shaw & Timpano, 2016). Shaw, Llabre et al. (2015) used structural equation modeling in a large nonclinical sample to demonstrate that affect intolerance (i.e., anxiety sensitivity, distress tolerance, disgust sensitivity, and intolerance of uncertainty) was positively associated with hoarding symptom severity, particularly for those with high levels of emotional attachment to objects. Other studies have shown mixed findings with respect to distress tolerance. Specifically, Mathes et al. (2017) reported that although distress intolerance was associated with hoarding symptoms, it did not emerge as a significant predictor; rather intolerance of uncertainty predicted hoarding symptoms.

Building on this line of research, Shaw, Timpano, et al. (2015) reported a significant interaction between self-reported fear of decision making and emotional reactivity such that individuals who were high in both exhibited greater overall hoarding symptom severity and increased difficulty discarding. A similar interaction was found between memory confidence and emotional reactivity, such that those with low memory confidence and high emotional reactivity

endorsed more severe hoarding symptoms and elevated acquisition tendencies. Moreover, greater emotional reactivity and more intense emotional reactions to imagined discarding were positively correlated with overall hoarding symptom severity, controlling for age, gender, anxiety, and depression. Regardless of some inconsistencies in these findings, they highlight the role that intense emotions may play in both difficulty discarding and acquisition processes.

Although there has been some research in this area, less is known about the role that emotions play in acquisition patterns. Using a nonclinical sample, Preston et al. (2009) presented participants with images of 107 objects of varying value and utility. Participants then completed three rounds of acquiring and discarding. They had a short prescribed amount of time to make a decision about each object, presented one at a time on a computer screen. In round one, they were instructed to keep as many items as they wished to hypothetically take home. In round two, they were asked to discard as many items as would be necessary for the remaining items to fit into a grocery cart. In round three, they were asked to keep only the number of objects that would fit into a paper grocery bag. Statistical analyses revealed three acquisition clusters: high acquirers, intermediate acquirers, and low or Spartan acquirers. The high acquirer group was significantly different than the other two groups on measures of hoarding symptom severity, obsessive-compulsive symptom severity, indecisiveness, and decision making. This cluster also tended to place greater value on objects compared to the other clusters.

Frost and Hartl's (1996) original cognitive-behavioural model of compulsive hoarding identified intense emotional attachment to objects driven by sentimentality, and viewing objects as safety signals as key maintaining factors. Indeed, Steketee et al. (2003) found that beliefs about emotional comfort, uniqueness of objects, and fear of loss represented core elements of emotional attachment to possessions that accounted for a large portion of overall hoarding

cognitions. Findings from more recent investigations of emotional attachment to objects in hoarding have supported this suggestion. Individuals who hoard have been shown to be more emotionally overinvolved with inanimate objects, and more likely to seek comfort or care from inanimate objects than do those who do not hoard (Nedelisky & Steele, 2009). Paradoxically, this same study showed that individuals who hoard are actually less effective in using inanimate objects for comfort in times of need.

Given certain anticipated challenges in the present study, specifically that participants were exposed to novel virtual objects rather than personal objects to which they have already formed emotional attachments, principles of anthropomorphism were used in an effort to quickly induce attachment. Anthropomorphism, or the application of human-like tendencies onto nonhuman agents, is associated with greater care and concern for nonhuman agents, greater sense of responsibility (Waytz, Cacioppo, & Epley, 2010), and greater emotional attachment and desire to acquire objects (Timpano & Shaw, 2013). Anthropomorphism is also positively correlated with hoarding symptoms and hoarding cognitions (Neave, Tyson, McInnes, & Hamilton, 2016). According to the three-factor theory (Epley, Waytz, & Cacioppo, 2007), anthropomorphism is most likely to occur in the presence three conditions. These include elicited agent knowledge (i.e., inferred mental representations about human-like characteristics of nonhuman agents), effectance motivation (i.e., motivation to have mastery over one's environment by being able to predict agents' actions), and sociality motivation (i.e., motivation for social contact, connection, and approval). Studies have supported this model (Epley, Waytz, Akalis, & Cacioppo, 2008), and have also shown that anthropomorphism can be experimentally induced by manipulating these factors (Chandler & Schwarz, 2010; Waytz et al., 2010). A novel anthropomorphism script was developed for use in the present study based on these principles to

elicit attachment to virtual objects.

The purpose of the present study was to demonstrate that experiencing and attempting to avoid experiencing painful emotions is associated with more severe hoarding symptoms, and that these lead to increased acquisition and difficulty discarding. It also tested whether significant interactions exist between emotional and cognitive features in the cognitive-behavioural model to predict hoarding symptoms. The present study aimed to be more ecologically valid than previous studies in a number of ways. First, the amount of time allotted to make acquiring and discarding decisions was self-determined by the participant rather than the researcher, as this more accurately reflects the decision making process in participants' daily lives. In addition, due to the nature of the virtual stimuli, objects were presented in a more realistic way (e.g., the photographs of items in the Preston et al. [2009] study were not to scale, such that each item took up the same amount of space on a computer screen), which could influence participants' ability to determine which objects could realistically fit into a shopping cart or grocery bag. Finally, the measurement of certain constructs, such as experiential avoidance, was improved relative to previous studies in this area.

Hypotheses

Hypothesis 1: Based on the central role that negative reinforcement is thought to play in the maintenance of hoarding problems, it was predicted that emotional intensity, emotional reactivity, and experiential avoidance would be positively correlated with hoarding symptom severity.

Hypothesis 2: Similarly, in line with the function of negative reinforcement in hoarding problems, negative mood intensity was expected to predict situational avoidance in a virtual discarding task for the hoarding group only.

Hypothesis 3: Emotional processing theory posits that avoidance of emotionally provocative stimuli interferes in learning new adaptive behavioural patterns. As such, experiential avoidance was predicted to mediate the relationships between negative mood intensity and (a) virtual object acquisition and (b) difficulty discarding virtual objects for the hoarding group only.

Hypothesis 4: Research has suggested that an important interaction exists between emotional and cognitive facets of hoarding, such as fear of decision making. It was predicted that a significant interaction between high emotional reactivity and high fear of decision making would predict difficulty discarding.

Hypothesis 5: Another cognitive facet that has been shown to interact with emotional facets of hoarding is memory confidence. It was predicted that a significant interaction between high emotional reactivity and low memory confidence would predict greater acquisition.

Method

Participants

The same participants described in Study 1 were used in Study 2.

Measures

Hoarding symptom scores were derived from scores on the SI-R and CIR. Fear of decision making was assessed using the FIS. Memory confidence was assessed using the MCCS. VR-specific measures assessed sense of presence (PQ), simulator sickness (SSQ), and realism (*VR Realism*; all described in Study 1).

Emotional intensity and reactivity. The *Positive and Negative Affect Schedule* (PANAS; Watson, Clark, & Tellegen, 1988) consists of two 10-item subscales measuring

positive affect (PA) and *negative affect* (NA) as either a trait or a state measure. High PA is characterized by high energy, concentration, and pleasurable engagement, whereas low PA is reflective of low energy and sadness. High NA represents negative mood states such as anger, contempt, and fear, whereas low NA reflects calmness. These two constructs had typically been considered orthogonal; however, some research has demonstrated a significant negative correlation between state PA and NA (Schmukle, Egloff, & Burns, 2002). As the present study was interested in present-moment emotional intensity following a mood induction and a discarding task rather than dispositional emotional intensity, the state rather than trait PA and NA subscales were used. For this version of the PANAS, participants were asked to rate on a 5-point Likert scale to what extent they felt 20 positive and negative emotions "right now, that is, in the present moment." These subscales have been found to have good internal consistency, with Cronbach's α of .89 and.85, as well as good convergent, discriminant, and item validity. The PANAS was administered four times during this study (i.e., baseline, following mood induction, following induced attachment, following imagined discarding). Subscale scores in the present study ranged from 10-50 for each group. Cronbach's α for the PA subscale ranged from .91-.94 for the nonhoarding group, and .88-.95 for the hoarding group. Cronbach's α for the NA subscale ranged from .79-.93 for the nonhoarding group and .84-.93 for the hoarding group.

State emotional reactivity was measured using PANAS PA and NA difference scores between induced attachment and imagined discarding. Trait emotional reactivity was measured using the *Emotion Reactivity Scale* (ERS; Nock, Wedig, Holmberg, & Hooley, 2008). The ERS is a 21-item measure of everyday experiences of emotionality, including sensitivity (e.g., "I tend to get emotional very easily"), arousal/intensity (e.g., "When I experience emotions, I feel them very strongly/intensely"), and persistence (e.g., "When I am angry/upset, it takes me much

longer than most people to calm down"). Participants rated how much each statement was representative of them on a 5-point Likert scale, with responses ranging from 0 ("Not at all like me") to 4 ("Completely like me"). Higher scores indicate higher emotional reactivity and can be calculated for the total scale and for each individual subscale. This measure has been shown to have strong internal consistency (Cronbach's α ranging from .81 to .94, with the highest reliability for the total scale score), and good criterion validity. It has also been shown to have strong internal consistency in a clinical hoarding sample (total scale α = 0.96; Shaw, Timpano, et al., 2015). Total scores ranged from 0-63 for the nonhoarding group and 3-80 for the hoarding group, with Cronbach's α of .96 and .97, respectively. Subscale α for the nonhoarding and hoarding groups were as follows: .92 and .94 (sensitivity), .90 and .91 (arousal/intensity), and .80 and .88 (persistence).

Experiential avoidance. The *Multidimensional Experiential Avoidance Questionnaire* (MEAQ; Gámez, Chmielewski, Kotov, Ruggero, & Watson, 2011) measures one's dispositional tendency to try to avoid uncomfortable affective experiences, such as emotions, thoughts, and memories. This is a 62-item scale that assesses six factors of experiential avoidance by rating one's agreement with each statement on a 6-point Likert scale. These factors include behavioural avoidance (e.g., overt avoidance of uncomfortable situations), distress aversion (e.g., negative attitudes about distress), procrastination (e.g., putting off distressing tasks), distraction/suppression (e.g., attempting to ignore distress), repression/denial (e.g., turning off distressing emotions or lacking awareness of distress), and distress endurance (e.g., willingness to endure distress to live according to one's values; these items are reverse-scored). The scale authors suggest that the behavioural avoidance and distress aversion subscales represent the most central items that reflect of the operational definition of experiential avoidance. The MEAQ has

been found to have good internal consistency, with Cronbach's α ranging from .79 to .88 for each subscale in a clinical sample, and total score α of .91-.94 in student and clinical samples. The MEAQ has also shown good convergent validity with other measures of experiential avoidance and other types of avoidance, and good discriminant validity with respect to other constructs such as neuroticism and negative affect. Total scores ranged from 92-246 for the nonhoarding group, and 88-314 for the hoarding group. Cronbach's α for each group were .92 and .93. Subscale α for each group respectively were as follows: .83 and .92 (behavioural avoidance), .88 and .86 (distress aversion), .78 and .90 (procrastination), .86 and .93 (distraction/suppression), .85 and .85 (repression/denial), and .84 and .85 (distress endurance).

As per the procedure described by Timpano, Shaw et al. (2014), participants were also asked to rate their level of *emotional intolerance* on a 6-point Likert scale following each mood induction video, described in the procedure below. These questions assess the ability to tolerate the triggered feelings, fearfulness of the triggered feelings, perceived danger of the triggered feelings, and the need to distract oneself or turn away. The sum of these scores represents a composite measure of emotional intolerance and experiential avoidance, with higher scores indicating higher experiential avoidance. This measure was administered twice, following each mood induction. Scores ranged from 4-20 for the nonhoarding group, and 4-24 for the hoarding group. Cronbach's α ranged from .83-.92 for the nonhoarding group, and .89-.90 for the hoarding group.

Excessive acquisition. Time spent acquiring (rounded down to the nearest second), number of objects acquired, and rate of acquisition during the acquisition phase indicate acquisition patterns. Acquiring time ranged from 45-262 seconds for the nonhoarding group, and from 27-561 seconds for the hoarding group. Number of objects acquired ranged from 1-16 for

the nonhoarding group, and from 1-32 for the hoarding group. For a more nuanced examination of acquisition patterns, acquisition rate was computed by dividing the number of objects acquired by seconds to complete this phase. Higher numbers indicate a faster rate of acquisition. Acquisition rates ranged from 0.01-0.08 objects per second for the nonhoarding group, and 0.01-0.11 objects per second for the hoarding group.

Difficulty discarding. Number of objects discarded and number remaining during each phase, as well as amount of time in seconds to complete each discarding phase (rounded down to the nearest second) were recorded. Time to complete discarding phase 1 (i.e., grocery cart) ranged from 1-57 seconds for the nonhoarding group, and from 1-228 seconds for the hoarding group. Time to complete discarding phase 2 (i.e., plastic grocery bag) ranged from 1-52 seconds for the nonhoarding group, and from 1-186 seconds for the hoarding group. Total time spent discarding ranged from 2-103 seconds for the nonhoarding group, and from 2-280 seconds for the hoarding group. Participants who completed the discarding phases very quickly typically did not discard any items during that phase, or quickly articulated the 1-2 items to be discarded.

Fewer objects discarded provided one indicator of difficulty discarding. Number of objects discarded during phase 1 ranged from 0-3 for the nonhoarding group, and from 0-11 for the hoarding group. Number of objects discarded during phase 2 ranged from 0-6 for the nonhoarding group, and from 0-15 for the hoarding group. Total number of objects discarded ranged from 0-8 for the nonhoarding group, and from 0-21 for the hoarding group.

Discarding rate was also calculated to provide a more nuanced measure of difficulty discarding. As was described with acquisition rate, discarding rate was computed by dividing the number of objects discarded by seconds to complete each discarding phase. An average discarding rate was computed by taking the mean of each of the two discarding phase rates.

Lower numbers indicate a slower rate of discarding, indicating greater difficulty discarding. Discarding rates during phase 1 ranged from 0.00-0.50 objects per second for the nonhoarding group, and from 0.00-0.33 objects per second for the hoarding group. Discarding rates during phase 2 ranged from 0.00-1.00 objects per second for the nonhoarding group, and from 0.00-3.00 objects per second for the hoarding group. Average discarding rates ranged from 0.00-0.50 objects per second for the nonhoarding group, and 0.00-1.50 objects per second for the hoarding group.

Situational avoidance. Situational avoidance was measured as the number of objects remaining following the two discarding phases. Higher numbers of objects remaining following each phase represents higher situational avoidance. Number of objects remaining following phase 1 ranged from 1-13 for the nonhoarding group, and from 1-27 for the hoarding group. Number of objects remaining following phase 2 ranged from 0-8 for the nonhoarding group, and from 0-15 for the hoarding group. In addition, the proportion of total objects remaining relative to total number of objects acquired was calculated as an additional measure of situational avoidance. Larger numbers indicate a greater proportion of objects remaining, or greater situational avoidance. Proportion of objects remaining ranged from 0-100% for both groups.

Induced attachment. Following both discarding tasks, participants were instructed to select their favourite object from those that were remaining. Participants were then read aloud a script about their chosen object. The script was meant to impart human-like qualities to induce attachment via anthropomorphism (see Appendix E). Specifically, the script aimed to elicit agent knowledge (e.g., ascribing personality characteristics to the object, such as its humorous, warm, and vulnerable nature), enhance effectance motivation (e.g., describing the object's life history and future goals and ambitions), and enhance sociality motivation (e.g., describing the ways in

which the object was mistreated by previous owners and would like to be used and appreciated by future owners). This script was pilot tested to ensure that it did indeed increase self-reported attachment levels to novel objects.

Object attachment was assessed using a revised version of the *Object Attachment Questionnaire* (OAQ-R; J. R. Grisham, personal communication, March 29, 2016). This is an 18-item self-report measure that assesses attachment, comfort, anthropomorphising, identity attachment, and inflated responsibility for a specific object. Participants rate their level of agreement on a 7-point Likert scale ranging from 1 (Not at all/Strongly disagree) to 7 (Very much/Strongly agree). The original OAQ has demonstrated good internal consistency (Cronbach's α ranging from .92-.94) and validity in discriminating clinical from nonclinical hoarding groups, and has been used to assess attachment to nonpersonal items introduced in a lab setting (Grisham et al., 2009; Timpano & Shaw, 2013). Scores ranged from 18-106 in the nonhoarding group, and 30-120 in the hoarding group. Cronbach's α for each group were .95 and .93, respectively.

Apparatus

Mood inductions. For the negative mood induction condition, participants viewed four film clips to induce fear, sadness, anger, and disgust. These were the same film clips used by Timpano, Shaw et al. (2014), which have reliably induced feelings of fear, sadness, anger, and disgust (Gross & Levenson, 1995). They include a basement chase scene from *Silence of the Lambs* (fear), a scene of a boy crying at his father's death from *The Champ* (sadness), a scene of police abusing protesters from *Cry Freedom* (anger), and a scene of an arm amputation from a medical video called *Amputation* (disgust). Participants in the neutral mood induction condition viewed four affectively neutral film clips from a home renovation television show that were

matched with the negative film clips in duration, as has been done in previous studies using mood induction paradigms (e.g., Josephson, Rose, & Singer, 1999).

VR. Participants were immersed in two 360° photographed environments of distinct vantage points of the same thrift store with a wide variety of objects, with white noise audio overlay to enhance realism. Participants wore a HMD and were able to fully view the static environments by turning their heads and bodies. The researcher was able to view what the participant was seeing in real-time through a computer monitor.

Psychophysiological measures. HR and SCR were monitored as additional measures of emotional reactivity. HR and SCR were sampled continuously at 2000 Hz throughout the mood induction and experimental task using a Biopac MP150 system and were recorded and analyzed using Acqknowledge 3.9.1 software. HR and SCR data were visually inspected to ensure proper equipment functioning. HR was recorded using three pregelled Biopac 35 mm disposable electrodes (EL503) placed below the collarbone and below the ribs on each side. SCR was recorded using two pregelled Biopac 2.5 cm x 4.5 cm disposable electrodes placed on the palmar region of the distal phalanges of the second and third fingers of the nondominant hand. During data analysis, mean heartbeats per minute was used to determine HR, and number of sweat response events was used to determine SCR.

Procedure

In addition to the pretest measures described in Study 1, participants completed measures of trait emotional reactivity (i.e., ERS) and trait experiential avoidance (i.e., MEAQ). Participants were then assigned to either a negative mood induction condition or a neutral mood induction condition. Condition assignment was counterbalanced such that half the participants completed the experimental task following a negative mood induction in Lab Visit 1, and again

following the neutral mood induction in Lab Visit 2, and vice versa for the other half. The psychophysiological measures were attached such that HR and SCR were measured throughout the mood inductions and the experimental task. Participants then completed the baseline PANAS to rate their current positive and negative affect (Time 1). After current affect ratings were obtained, participants viewed the appropriate set of film clips. After viewing all four negative or neutral mood induction film clips, participants again reported their current affect ratings using the PANAS (Time 2), as well as their level of experiential avoidance during the videos as per Timpano, Shaw et al. (2014).

Following the mood inductions, participants then viewed one of the two 360° filmed thrift store environments through the HMD. Presentation of each of these virtual environments was also counterbalanced across participants such that half viewed the first environment at Lab Visit 1 and the other half viewed the first environment at Lab Visit 2, and vice versa for the second environment. A Latin square design was used to ensure appropriate counterbalancing of both mood inductions and virtual environments. Amount of time required to make acquiring and discarding decisions was measured using a hand-held stopwatch. Time was rounded down to the nearest second. The timer began once the participant indicated that the instructions were understood, and ended once the participant indicated that he or she had finished each task. The acquisition and discarding task was modeled after that described by Preston et al. (2009). In the acquisition phase, participants were asked to identify any objects that they would like to hypothetically take home. As they named objects, they were recorded by the researcher by circling the identified objects in a bright colour using Photoshop™ on a separate screen invisible to the participant. Once they were satisfied with their selection, they were shown in VR an updated version of the image that contained the circled objects. In the first discarding phase they

were asked to "leave behind" whichever objects, if any, would be necessary for the remaining items to fit in a grocery cart. They did so by naming the objects to be left behind while the researcher erased the respective circles using Photoshop™ on a separate screen invisible to the participant. The researcher used a stopwatch to measure how much time was required to make discarding decisions. In the second discarding phase, the updated image was shown with circles removed from the objects that were left behind. Participants were then asked to leave behind whichever objects, if any, would be necessary for the remaining items to fit in a plastic grocery bag. The researcher again used a stopwatch to assess the amount of time required to make discarding decisions. These acquisition and discarding instructions were identical during both Lab Visits 1 and 2.

In the final stage of this task during Lab Visit 1 only, participants were asked to select their favourite remaining object. Participants were then read the anthropomorphizing script while viewing the object to induce attachment to this selected item. Participants then removed the HMD to complete the OAQ-R and a third PANAS to assess current affect following attachment (Time 3). Following this procedure, participants were informed that they were required to immediately discard the object. When they indicated their readiness to proceed, they closed their eyes and described out loud the way that they would discard the object while trying to imagine that it was really happening. Participants then completed a final PANAS (Time 4) to assess current affect and emotional reactivity to discarding a valued object. Following the experimental task during Lab Visit 2, participants completed the VR measures (PQ, SSQ, *VR Realism*).

Results

Pilot Testing

The anthropomorphism manipulation was pilot-tested using five individuals without

hoarding problems to ensure that it was effective for increasing object attachment. Prior to testing, a small group of nonclinical participants selected a random novel object and completed a premanipulation OAQ-R. They were then read the anthropomorphism script, and completed a postmanipulation OAQ-R. Mean scores indicated increases in object attachment following the script. Qualitative feedback indicated a strong emotional impact of the manipulation for each participant. These findings indicated that the anthropomorphism script was appropriate for use in inducing attachment without revision.

Preliminary Analyses

There were no group differences on sense of presence or realism of the VR environment; however, as in Study 1, participants in the hoarding group experienced significantly greater simulator sickness than those in the nonhoarding group (see Table 3). A paired samples *t*-test showed that there was no difference in the number of objects acquired from either vantage point of the store (M_A = 6.42, SD_A = 5.36, M_B = 6.37, SD_B = 6.38), $t(72) = 0.10$, $p = .920$. The difference remained nonsignificant when examining acquiring within the hoarding, $t(34) = -0.33$, $p = .746$, and nonhoarding groups, $t(37) = 1.08$, $p = .289$. There was, however, a significant difference in the number of objects acquired between the first ($M = 7.63$, $SD = 7.02$) and second lab visits ($M = 6.16$, $SD = 5.75$), $t(75) = 2.92$, $p = .005$, Cohen's $d = 0.23$. Interestingly, when analyzed within the groups, this difference only remained significant for the hoarding group. Whereas the nonhoarding group did not differ with respect to number of objects acquired during the first ($M = 3.68$, $SD = 2.72$) versus second lab visit ($M = 3.47$, $SD = 2.76$), $t(37) = 0.53$, $p = .598$, the hoarding group acquired significantly fewer objects during the second lab visit ($M = 7.89$, $SD = 5.41$) than the first lab visit ($M = 11.03$, $SD = 7.71$), $t(34) = 3.48$, $p = .001$, Cohen's $d = 0.47$.

To test for general behavioural differences between the groups, A MANOVA was used to test for group differences in acquisition, discarding, and final clutter levels. This MANOVA showed significant overall group differences, $F(13,59) = 2.96$, $p = .002$, $\eta_p^2 = 0.40$. See Table 10 for results of planned contrasts. This analysis was run again using a MANCOVA to control for the effects of DASS-21 and SSQ scores. Similarly, this MANCOVA showed significant group differences with the same pattern of planned contrast results, $F(13,54) = 3.24$, $p = .001$, $\eta_p^2 = 0.44$ (see Table 10).

An independent samples *t*-test also showed significant group differences on OAQ-R scores. The hoarding group reported significantly higher attachment ($M = 81.03$, $SD = 22.51$) than the nonhoarding group ($M = 49.90$, $SD = 22.19$), $t(74) = -6.07$, $p < .001$, Cohen's $d = 1.39$. A follow-up univariate ANCOVA controlling for the effects of depression, anxiety, stress, and simulator sickness continued to show significant group differences on object attachment. $F(1,70) = 22.86$, $p < .001$,$\eta^2 = 0.03$.

Next, to test the mood induction manipulation, paired samples *t*-tests were used to assess changes in negative mood intensity as measured by the PANAS. For the neutral mood condition, there was no significant change in negative affect between baseline ($M = 12.49$, $SD = 3.97$) and following the mood induction ($M = 11.74$, $SD = 4.01$), $t(75) = 1.68$, $p = .098$. There was, however, a significant decrease in positive affect from baseline ($M = 27.14$, $SD = 9.55$) following the neutral mood induction ($M = 24.55$, $SD = 9.81$), $t(75) = 3.39$, $p = .001$, Cohen's $d = 0.27$. This is not surprising, as the neutral mood videos were intended to be boring rather than to elicit any strong emotions. As expected, there was a significant increase in negative affect between baseline ($M = 13.05$, $SD = 5.82$) and following the negative mood induction ($M = 17.07$, $SD = 7.41$), $t(75) = -5.07$, $p < .001$, Cohen's $d = -0.60$. The negative mood induction also caused a

Table 10. Preliminary analyses for Study 2.

	Hoarding Group *M (SD)*	Nonhoarding Group *M (SD)*	Contrast Estimate	Standard Error	Significance	95% CI Lower Bound	95% CI Upper Bound
Acquisition[a]							
Time	204.17 (105.17)	126.66 (44.62)	-77.51 (-63.05)	18.65 (24.65)	< .001 (.013)	-114.69 (-112.25)	-40.34 (-13.84)
Number acquired	9.46 (6.10)	3.58 (2.45)	-5.88 (-5.75)	1.07 (1.42)	< .001 (< .001)	-8.02 (-8.57)	-3.74 (-2.92)
Acquisition rate	0.05 (0.02)	0.03 (0.01)	-0.02 (-0.02)	0.01 (0.01)	< .001 (< .001)	-0.03 (-0.04)	-0.01 (-0.01)
Discarding: Phase 1[a]							
Time	33.36 (35.28)	12.70 (11.47)	-20.66 (-21.83)	6.04 (8.02)	.001 (.008)	-32.70 (-37.84)	-8.62 (-5.82)
Number discarded	2.07 (2.12)	0.62 (0.80)	-1.45 (-1.52)	0.37 (0.49)	< .001 (.003)	-2.19 (-2.50)	-0.72 (-0.55)
Discarding rate	0.06 (0.05)	0.05 (0.08)	-0.01 (-0.01)	0.02 (0.02)	.491 (.962)	-0.04 (-0.04)	0.02 (0.04)
Discarding: Phase 2[a]							
Time	36.83 (36.37)	10.67 (9.69)	-26.16 (-24.09)	6.12 (8.15)	< .001 (.004)	-38.36 (-40.35)	-13.96 (-7.83)
Number discarded	3.65 (2.86)	1.16 (0.89)	-2.49 (-2.53)	0.49 (0.65)	< .001 (< .001)	-3.46 (-3.82)	-1.52 (-1.24)
Discarding rate	0.17 (0.25)	0.16 (0.15)	-0.01 (-0.09)	0.05 (0.06)	.831 (.132)	-0.11 (-0.22)	0.09 (0.03)
Discarding: Overall[a]							
Total time	67.76 (60.77)	23.37 (20.05)	-44.39 (-46.10)	10.42 (13.88)	< .001 (.001)	-65.16 (-73.81)	-23.61 (-18.40)

Total number	5.72 (4.50)	1.78 (1.51)	-3.95	0.77	< .001	-5.49	-2.40
			(-4.06)	(1.03)	(< .001)	(-6.11)	(-2.00)
Mean discarding rate	0.11 (0.12)	0.10 (0.08)	-0.01	0.02	.670	-0.06	0.04
			(-0.05)	(0.03)	(.137)	(-0.11)	(0.02)
Situational Avoidance[a]							
Phase 1: Remaining	7.29 (4.70)	2.96 (1.96)	-4.33	0.83	< .001	-5.98	-2.67
			(-4.11)	(1.08)	(< .001)	(-6.28)	(-1.93)
Phase 2: Remaining	3.84 (2.61)	1.80 (1.41)	-2.03	0.49	< .001	-3.00	-1.06
			(-1.76)	(0.63)	(.006)	(-3.02)	(-0.51)
Proportion remaining	0.48 (0.21)	0.53 (0.26)	0.06	0.06	.297	-0.05	0.17
			(0.08)	(0.07)	(.275)	(-0.06)	(0.23)

Note. [a]One hoarding and two nonhoarding participants' data removed from these analyses because they were outliers. Values in parentheses are controlling for the effects of depression, anxiety, and stress scores from the *Depression, Anxiety, Stress Scales – 21 item version* and *Simulator Sickness Questionnaire* scores.

significant decrease in positive affect from baseline (M = 26.88, SD = 9.55) to post (M = 22.94, SD = 7.92), $t(75) = 6.30$, $p < .001$, Cohen's d = 0.45. With respect to experiential avoidance, this was also higher during the negative mood induction (M = 10.64, SD = 5.09) than the neutral mood induction (M = 5.97, SD = 3.09), $t(75) = -7.77$, $p < .001$, Cohen's d = -1.11.

With respect to psychophysiological measures, HR was significantly slower during the neutral mood induction (M = 70.09, SD = 9.44) compared to baseline (M = 73.85, SD = 9.43), $t(58) = 9.72$, $p < .001$, Cohen's d = 0.40. Similarly, HR was significantly slower during the negative mood induction (M = 69.54, SD = 10.18) compared to baseline (M = 73.34, SD = 10.42), $t(63) = 10.35$, $p < .001$, Cohen's d = 0.37. There was no difference in SCR during the neutral mood induction (M = 8.63, SD = 8.77) compared to baseline (M = 7.42, SD = 4.82), $t(56) = -1.10$, $p = .278$. There was, however, a significant increase in SCR during the negative mood induction (M = 18.02, SD = 21.52) compared to baseline (M = 7.92, SD = 5.77), $t(61) = -4.07$, $p < .001$, Cohen's d = -0.64.

With respect to the group differences in acquisition and discarding patterns between mood induction conditions, paired samples t-tests revealed no significant differences in either group for time spent acquiring, number of objects acquired, acquisition rates, time spent discarding, total number of objects remaining following discarding, proportion of initially acquired objects remaining following discarding, and average discarding rate. For the nonhoarding group, there was also no difference in the total number of objects discarded between mood induction conditions. However, the hoarding group discarded significantly fewer objects following the negative mood induction (M = 4.40, SD = 3.88) versus the neutral mood induction (M = 7.04, SD = 5.83), $t(34) = 3.78$, $p = .001$, Cohen's d = 0.53.

Primary Analyses

Hypothesis 1 stated that emotional intensity, emotional reactivity, and experiential avoidance would be positively correlated with hoarding symptom severity. There were no significant correlations between emotional intensity and hoarding symptom measures in the hoarding group. In the nonhoarding group, HR during the negative mood induction was positively correlated with SI-R acquiring scores (r = .38, p = .030). This correlation remained significant when controlling for the effects of DASS-21 scores (r = .39, p = .031). A MANOVA was then run to detect group differences on emotional intensity variables (i.e., positive and negative affect following negative mood induction, HR and SCR during negative mood induction). No group differences were found, $F(4,48) = 1.08$, p = .379, $\eta_p^2 = 0.08$. A MANCOVA similarly found no group differences when controlling for DASS-21 scores, $F(4,45) = 0.03$, p = .880, $\eta_p^2 = 0.03$.

See Table 11 for correlations between hoarding symptoms and state emotional reactivity. Correlations with trait emotional reactivity can be seen in Table 12. A MANOVA was run to detect group differences in state (i.e., reactivity in positive and negative affect to the negative mood induction and to imagined discarding) and trait emotional reactivity variables (i.e., ERS scores).The overall MANOVA was significant, $F(5,70) = 6.36$, $p < .001$, $\eta_p^2 = 0.31$. See Table 13 for planned contrasts. However, group differences became nonsignificant when controlling for DASS-21 scores in a MANCOVA, $F(5,67) = 1.96$, p = .096, $\eta_p^2 = 0.13$. However, planned contrasts demonstrated that the hoarding group continued to demonstrate significantly greater reactivity in negative affect following imagined discarding and reported significantly higher scores on the persistence subscale than the nonhoarding group (see Table 13).

Experiential avoidance during the negative mood induction was not significantly

Table 11. Correlations between hoarding symptoms and state emotional reactivity.

	Hoarding Group					Nonhoarding Group				
	CIR	SI-R Discarding	SI-R Acquiring	SI-R Clutter	SI-R Total	CIR	SI-R Discarding	SI-R Acquiring	SI-R Clutter	SI-R Total
Negative Mood Induction										
PA	.19 (.25)	.25 (.17)	.12 (.25)	.28 (.02)	.19 (.19)	-.15 (-.42*)	-.13 (-.46*)	-.07 (-.37)	-.02 (-.29)	-.09 (-.41*)
NA	.20 (.16)	-.09 (-.02)	.12 (.28)	.06 (.07)	.20 (.16)	.11 (.13)	-.08 (-.08)	.01 (-.04)	-.01 (-.06)	-.04 (-.07)
BPM	-.39* (.25)	-.08 (-.07)	-.30 (.22)	-.28 (.17)	-.39* (-.02)	-.06 (-.29)	.05 (.01)	-.06 (.06)	-.03 (-.19)	-.01 (-.05)
SCR	.32 (-.56**)	-.02 (-.18)	-.03 (-.26)	.06 (.24)	.32 (-.35)	-.15 (-.15)	.01 (.03)	.04 (-.16)	-.11 (-.05)	-.02 (-.05)
Imagined Discarding										
PA	.17 (-.01)	-.08 (-.31)	.27 (.09)	.19 (-.16)	.17 (.02)	.20 (.02)	-.04 (-.30)	-.06 (-.32)	.27 (-.01)	.06 (-.23)
NA	-.20 (-.31)	.05 (.22)	.06 (-.20)	-.06 (-.27)	-.20 (.13)	.05 (.16)	.38** (.44*)	.32* (-.43*)	.05 (.16)	.28 (.38)

Note. CIR = *Clutter Image Rating*; SI-R = *Saving Inventory-Revised*; PA = change in Positive Affect subscale scores of the *Positive and Negative Affect Schedule*; NA = change in Negative Affect subscale scores of the *Positive and Negative Affect Schedule*; BPM = heartbeats per minute; SCR = skin conductance response. Values in parentheses represent correlation coefficients when controlling for the effects of depression, anxiety, and stress scores from the *Depression, Anxiety, Stress Scales – 21 item version.*

* $p < .05$, ** $p < .01$

Table 12. Correlations between hoarding symptoms and emotional reactivity.

	Hoarding Group					Nonhoarding Group				
ERS	CIR	SI-R Discarding	SI-R Acquiring	SI-R Clutter	SI-R Total	CIR	SI-R Discarding	SI-R Acquiring	SI-R Clutter	SI-R Total
Sensitivity	-.28	.05	.02	.12	.08	.16	.34*	.29	.23	.32*
	(-.44*)	(-.16)	(-.27)	(-.10)	(-.22)	(.27)	(.29)	(.18)	(.19)	(.26)
Arousal	-.26	.20	.17	.06	.17	.20	.33*	.28	.22	.31
	(-.45**)	(-.01)	(-.06)	(-.14)	(-.11)	(.31)	(.28)	(.16)	(.15)	(.23)
Persistence	-.35*	.19	.15	.08	.17	.28	.43**	.44**	.32	.44**
	(-.55**)	(.03)	(-.04)	(-.11)	(-.06)	(.36*)	(.38*)	(.37*)	(.29)	(.39*)
Total	-.30	.13	.10	.09	.13	.21	.37*	.33*	.26	.36*
	(-.49**)	(-.08)	(-.16)	(-.12)	(-.16)	(.33*)	(.33*)	(.23)	(.22)	(.30)

Note. ERS = *Emotion Reactivity Scale*; CIR = *Clutter Image Rating*; SI-R = *Saving Inventory-Revised*. Values in parentheses represent correlation coefficients when controlling for the effects of depression, anxiety, and stress scores from the *Depression Anxiety Stress Scales – 21 item version*.

* $p < .05$, ** $p < .01$

Table 13. Planned contrasts to detect group differences in emotional reactivity.

	Hoarding Group *M (SD)*	Nonhoarding Group *M (SD)*	Contrast Estimate	Standard Error	Significance	95% CI Lower Bound	95% CI Upper Bound
PANAS							
Positive affect reactivity to discarding	-2.17 (5.61)	-1.80 (4.85)	0.37 (0.83)	1.20 (1.49)	.761 (.578)	-2.02 (-2.14)	2.76 (3.81)
Negative affect reactivity to discarding	3.06 (6.26)	0.27 (1.49)	-2.78 (-2.62)	1.02 (1.27)	.008 (.043)	-4.81 (-5.16)	-0.75 (-0.09)
ERS							
Sensitivity	22.14 (10.72)	11.55 (8.74)	-10.59 (-4.01)	2.23 (2.31)	< .001 (.087)	-15.04 (-8.60)	-6.14 (0.59)
Arousal	17.14 (7.21)	10.33 (6.69)	-6.81 (-2.29)	1.60 (1.69)	< .001 (.179)	-9.99 (-5.66)	-3.64 (1.08)
Persistence	10.56 (4.06)	5.78 (3.55)	-4.78 (-2.53)	0.87 (0.96)	< .001 (.011)	-6.52 (-4.45)	-3.04 (-0.61)

Note. PANAS = *Positive and Negative Affect Schedule*; ERS = *Emotion Reactivity Scale*. Values in parentheses are controlling for the effects of depression, anxiety, and stress scores from the *Depression Anxiety Stress Scales – 21 item version.*

correlated with hoarding symptom measures in either group. See Table 14 for correlations between hoarding symptom measures and trait experiential avoidance. A MANOVA was run to detect group differences in state (i.e., emotional intolerance during negative and neutral mood inductions) and trait (i.e., MEAQ scores) experiential avoidance variables. The overall MANOVA was significant, $F(8,67) = 6.34$, $p < .001$, $\eta_p^2 = 0.43$. See Table 15 for planned contrasts. These demonstrated significant group differences on emotional intolerance during the neutral mood induction, and trait MEAQ scores on behavioural avoidance, distress aversion, procrastination, repression/denial, and distress endurance. A subsequent MANCOVA was run to control for the effects of DASS-21 subscale scores. The overall MANCOVA was also significant, $F(8,64) = 2.09$, $p = .050$, $\eta_p^2 = 0.21$. Planned contrasts demonstrated that groups remained significantly different on emotional intolerance during the neutral condition, and MEAQ distress aversion, procrastination, and repression/denial (see Table 15).

Hypothesis 2 stated that negative mood intensity would be a significant predictor of situational avoidance. Negative mood intensity scores following each mood induction were centred prior to running regression analyses. These regressions were run twice to examine effects with and without controlling for the variance accounted for by DASS-21 and SSQ scores. Negative mood intensity did not emerge as a significant predictor of situational avoidance for either mood induction condition in either group.

Hypothesis 3 stated that experiential avoidance would mediate the relationships between negative mood intensity and (a) excessive acquisition and (b) difficulty discarding. First, a series of correlation analyses were run to explore the relationships between experiential avoidance, negative affect, and acquisition and discarding patterns. These were assessed for the negative mood condition only, as experiential avoidance was significantly higher during the negative

Table 14. Correlations between hoarding symptoms and emotional reactivity.

	Hoarding Group					Nonhoarding Group				
MEAQ	CIR	SI-R Discarding	SI-R Acquiring	SI-R Clutter	SI-R Total	CIR	SI-R Discarding	SI-R Acquiring	SI-R Clutter	SI-R Total
Behavioural avoidance	-.18 (-.28)	.14 (.23)	.14 (.13)	.08 (-.02)	.15 (.12)	.10 (.05)	.35* (.32)	.44** (.40*)	.31 (.21)	.40* (.34*)
Distress aversion	-.14 (-.17)	.20 (.32)	.20 (.21)	.08 (.01)	.19 (.20)	.34* (.39*)	.43** (.43**)	.44** (.44**)	.33* (.38*)	.45** (.46**)
Procrastination	-.14 (-.26)	.14 (.09)	.16 (-.01)	.27 (.11)	.25 (.09)	.19 (.20)	.42** (.40*)	.46** (.41*)	.31 (.25)	.44** (.39*)
Distraction/suppression	-.24 (-.26)	-.16 (-.02)	-.11 (-.01)	-.06 (-.03)	-.13 (-.02)	.13 (.14)	.35* (.34*)	.37* (.36*)	.24 (.25)	.36* (.35*)
Repression/denial	.04 (-.01)	.07 (.07)	.26 (.22)	.01 (-.19)	.13 (.01)	.02 (.06)	.37* (.32)	.20 (.12)	.19 (.16)	.29 (.24)
Distress endurance	-.10 (-.05)	-.29 (.01)	-.29 (-.01)	-.27 (-.01)	-.36* (-.06)	.19 (.21)	.14 (.15)	.01 (.03)	-.11 (.14)	.11 (.13)
Total	-.13 (-.23)	.16 (.20)	.23 (.16)	.14 (-.03)	.22 (.12)	.18 (.21)	.49** (.47**)	.51** (.46**)	.35 (.32)	.50** (.47**)

Note. MEAQ = *Multidimensional Experiential Avoidance Questionnaire*; CIR = *Clutter Image Rating*; SI-R = *Saving Inventory-Revised*. Values in parentheses represent correlation coefficients when controlling for the effects of depression, anxiety, and stress scores from the *Depression Anxiety Stress Scales – 21 item version.*

* $p < .05$, ** $p < .01$

Table 15. Planned contrasts to detect group differences in experiential avoidance.

	Hoarding Group *M (SD)*	Nonhoarding Group *M (SD)*	Contrast Estimate	Standard Error	Significance	95% CI Lower Bound	95% CI Upper Bound
Emotional Intolerance							
Neutral induction	7.03 (3.84)	5.02 (1.78)	-2.00 (-1.68)	0.68 (0.83)	.004 (.046)	-3.35 (-3.33)	-0.66 (-0.03)
Negative induction	11.83 (5.17)	9.58 (4.83)	-2.26 (-1.26)	1.15 (1.39)	.053 (.370)	-4.54 (-4.04)	0.03 (1.52)
MEAQ							
Behavioural avoidance	42.86 (11.22)	34.80 (8.51)	-8.06 (-5.32)	2.27 (2.69)	.001 (.052)	-12.59 (-10.69)	-3.54 (0.05)
Distress aversion	53.79 (11.55)	43.03 (11.87)	-10.77 (-9.41)	2.69 (3.20)	< .001 (.004)	-16.13 (-15.78)	-5.41 (-3.03)
Procrastination	29.02 (8.20)	19.97 (5.65)	-9.05 (-4.94)	1.60 (1.69)	< .001 (.005)	-12.24 (-8.32)	-5.86 (-1.56)
Distraction/suppression	28.26 (8.22)	26.82 (6.37)	-1.43 (-2.83)	1.68 (2.00)	.397 (.161)	-4.77 (-6.82)	1.91 (1.15)
Repression/denial	38.80 (11.19)	29.27 (10.14)	-9.53 (-5.52)	2.45 (2.70)	< .001 (.045)	-14.40 (-10.91)	-4.65 (-0.13)
Distress endurance	45.00 (8.60)	51.98 (6.50)	6.98 (1.44)	1.74 (1.85)	< .001 (.438)	3.52 (-2.25)	10.44 (5.13)

Note. MEAQ = *Multidimensional Experiential Avoidance Questionnaire*. Values in parentheses are controlling for the effects of depression, anxiety, and stress scores from the *Depression Anxiety Stress Scales – 21 item version.*

mood induction than the neutral mood induction for both the hoarding, $t(35) = -4.67$, $p < .001$, Cohen's $d = -1.05$, and nonhoarding group $t(39) = -6.68$, $p < .001$, Cohen's $d = -1.25$. Experiential avoidance during the negative mood induction was positively correlated with time spent acquiring for the nonhoarding group only ($r = .38$, $p = .021$). Considering trait experiential avoidance, MEAQ distress endurance was positively correlated with acquisition rate for the nonhoarding group only ($r = .33$, $p = .046$), whereas MEAQ procrastination was negatively correlated with acquisition rate for the hoarding group only ($r = -.35$, $p = .040$). There were no significant correlations between negative affect intensity and time spent acquiring, number of objects acquired, or acquisition rate for either group. As such, no further analyses were conducted to assess the predicted mediation model for excessive acquisition.

Correlations were also run to examine the relationships between experiential avoidance, negative affect, and discarding patterns. State experiential avoidance during the negative mood induction was not significantly correlated with any discarding patterns for either group. For the nonhoarding group, MEAQ distraction/suppression was negatively correlated with only phase 2 discarding rate ($r = -.33$, p = .046), whereas distraction/suppression was negatively correlated with phase 1 discarding rate ($r = -.37$, $p = .031$), phase 2 discarding rate ($r = -.46$, $p = .005$), and overall discarding rate ($r = -.62$, $p < .001$) for the hoarding group. MEAQ procrastination was also correlated with discarding rates in both phase 1 ($r = .34$, $p = .046$) and phase 2 ($r = -.51$, $p = .002$) for the hoarding group. In addition, MEAQ behavioural avoidance ($r = -.40$, $p = .017$) and MEAQ total score ($r = -.46$, $p = .006$) were negatively correlated with phase 2 discarding rate. Finally, distress aversion was positively correlated with the total number of objects remaining following both discarding phases for the hoarding group only ($r = .35$, $p = .040$).

There was only one significant correlation between negative affect and discarding

patterns. Specifically, there was a negative correlation between negative affect and phase 2 discarding rate for the hoarding group (r = -.38, p = .025), indicating that higher negative affect was associated with fewer objects discarded per second during the second discarding phase only. Regressions were run to determine whether negative affect was a significant predictor of phase 2 discarding rate using the centred predictor variable, either with or without controlling for DASS-21 and SSQ scores. Negative affect intensity did significantly predict phase 2 discarding rate in the negative mood condition and the hoarding group only, $t(33)$ = -2.35, p = .025, B = -0.01, SE = 0.01, β = -0.38. This effect was nonsignificant when controlling for the effects of DASS-21 and SSQ scores, $t(29)$ = -1.58, p = .126, B = -0.01, SE = 0.01, β = -0.31. The effect was also not replicated in the neutral condition. State experiential avoidance showed no significant correlations with discarding behaviour in the hoarding group. As such, the mediation analysis was not completed.

Hypothesis 4 posited that a significant interaction between emotional reactivity and fear of decision making would predict difficulty discarding. First, a series of correlation analyses was run to assess whether there was a relationship between each of these three variables. See Table 16 for a summary of the correlations between emotional reactivity and fear of decision making in each group. Regression analysis results indicated that emotional reactivity, fear of decision making, and their interaction were not significant predictors for any hoarding symptom severity measures in the hoarding group. A different pattern of results was found in the nonhoarding group, such that emotional reactivity and its interaction with fear of decision making predicted CIR scores, SI-R difficulty discarding, acquiring, and total scores (see Table 17). Emotional reactivity was the only predictor of SI-R clutter in the nonhoarding group.

With respect to in-session difficulty discarding, fear of decision making was significantly

Table 16. Correlations between fear of decision-making and emotional reactivity.

Measures	Hoarding Group (n = 36)	Nonhoarding Group (n = 40)
PANAS		
PA: Reactivity to negative mood induction	.09	.33*
NA: Reactivity to negative mood induction	-.09	.17
PA: Reactivity to imagined discarding	-.28	.24
NA: Reactivity to imagined discarding	.34*	-.17
ERS		
Sensitivity	.57***	.52**
Arousal	.52**	.38*
Persistence	.67***	.52**
Total	.60***	.50**

Note. PANAS = *Positive and Negative Affect Schedule*; PA = *Positive Affect subscale*; NA = *Negative Affect subscale*; ERS = *Emotion Reactivity Scale*. Fear of decision-making assessed with the *Frost Indecisiveness Scale*.

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 17. Interactions between emotional reactivity and fear of decision making in predicting hoarding symptoms.

DV	Predictors	B (SE)	β	t	df	R	ΔR^2
Hoarding Group							
CIR	ERS	-0.01 (.01)	-.24	-1.15	32	.32	.10
	FIS	-0.01 (.02)	-.14	-0.63			
	ERSxFIS	0.01 (.01)	-.10	-0.51			
SI-R Discarding	ERS	-0.01 (.03)	-.01	-0.04	32	.27	.07
	FIS	0.07 (.06)	.31	1.33			
	ERSxFIS	0.01 (.01)	.16	0.85			
SI-R Acquiring	ERS	0.01 (.04)	.01	0.01	32	.19	.03
	FIS	0.03 (.07)	.11	0.45			
	ERSxFIS	-0.01 (.01)	-.11	-0.56			
SI-R Clutter	ERS	-0.01 (.05)	-.04	-0.18	32	.26	.07
	FIS	0.11 (.08)	.31	1.32			
	ERSxFIS	0.01 (.01)	.18	0.91			
SI-R Total	ERS	-0.01 (.09)	-.02	-0.11	32	.26	.07
	FIS	0.22 (.16)	.31	1.32			
	ERSxFIS	0.01 (.01)	.10	0.52			
Nonhoarding Group							
CIR	ERS	0.01 (.01)	.40	2.13***	36	.41	.17
	FIS	-0.01 (.01)	-.16	-0.87			
	ERSxFIS	-0.01 (.01)	-.37	-2.28*			
SI-R Discarding	ERS	0.14 (.04)	.60	3.42**	36	.27	.27**
	FIS	-0.08 (.07)	-.22	-1.30			
	ERSxFIS	-0.01 (.01)	-.39	-2.55*			
SI-R Acquiring	ERS	0.08 (.03)	.51	2.89**	36	.50	.25*
	FIS	-0.03 (.05)	-.12	-0.69			
	ERSxFIS	-0.01 (.01)	-.41	-2.62*			
SI-R Clutter	ERS	0.08 (.04)	.43	2.24*	36	.39	.15
	FIS	-0.05 (.06)	-.16	-0.86			
	ERSxFIS	-0.01 (.01)	-.29	-1.78			
SI-R Total	ERS	0.30 (.09)	.58	3.31**	36	.53	.28**
	FIS	-0.17 (.15)	-.19	-1.13			
	ERSxFIS	-0.02 (.01)	-.40	-2.66*			

Note. CIR = *Clutter Image Rating*; SI-R = *Saving Inventory-Revised*; ERS = *Emotion Reactivity Scale*; FIS = *Frost Indecisiveness Scale*.

* $p < .05$, ** $p < .01$, *** $p < .001$

correlated with only two discarding variables and in the hoarding group only. These included the average phase 2 discarding rate (r = -.45, p = .006) and the overall average discarding rate (r = -.41, p = .014). Similar regression analyses were run to identify significant predictors of VR discarding variables. The overall regressions were not significant in predicting time spent discarding overall, or time spent discarding, number of objects discarded, or proportion of originally acquired objects remaining following both discarding phases in the negative mood induction. Despite the nonsignificant regression, emotional reactivity did appear as a significant predictor of total number of objects discarded for the nonhoarding group only, $t(31) = 2.44$, p = .020, $B = 0.04$, $SE = 0.04$, $\beta = 0.19$.

Hypothesis 5 posited that a significant interaction between emotional reactivity and memory confidence would predict excessive acquisition. Regression analysis results indicated that emotional reactivity, memory confidence, and their interaction were not significant predictors for any hoarding symptom severity measures in the hoarding group. In the nonhoarding group, memory confidence was a significant predictor of SI-R difficulty discarding, and its interaction with emotional reactivity was a significant predictor of CIR scores (see Table 18). Similar regression analyses were run to identify predictors of VR acquisition. No significant predictors were found for mean number of objects acquired across both phases, or time spent acquiring, number of objects acquired, or rate of acquisition following the negative mood induction.

Discussion

The purpose of Study 2 was to examine the role of emotional experiences in hoarding symptoms in a more ecologically valid manner than had previously been reported. An

Table 18. Interactions between emotional reactivity and memory confidence in predicting hoarding symptoms.

DV	Predictors	B (SE)	β	t	df	R	ΔR^2
Hoarding Group							
CIR	ERS	-0.01 (.01)	-.22	-1.01	32	.32	.10
	MCCS	-0.01 (.01)	-.12	-0.57			
	ERSxMCCS	0.01 (.01)	.03	0.17			
SI-R Discarding	ERS	0.02 (.03)	.12	0.52	32	.14	.02
	MCCS	0.01 (.03)	.05	0.21			
	ERSxMCCS	0.01 (.01)	.05	0.24			
SI-R Acquiring	ERS	0.01 (.04)	.01	0.06	32	.20	.04
	MCCS	0.01 (.03)	.04	0.19			
	ERSxMCCS	-0.01 (.01)	-.18	-0.96			
SI-R Clutter	ERS	-0.01 (.05)	-.03	-0.15	32	.25	.06
	MCCS	0.05 (.04)	.28	1.27			
	ERSxMCCS	0.01 (.01)	.12	0.64			
SI-R Total	ERS	0.01 (.09)	.03	0.12	32	.19	.04
	MCCS	0.06 (.08)	.18	0.80			
	ERSxMCCS	0.01 (.01)	.01	0.02			
Nonhoarding Group							
CIR	ERS	0.01 (.01)	.22	1.10	36	.40	.16
	MCCS	-0.01 (.01)	-.02	-0.09			
	ERSxMCCS	-0.01 (.01)	-.34	-2.20*			
SI-R Discarding	ERS	0.03 (.04)	.12	0.61	36	.51	.26*
	MCCS	0.10 (.05)	.39	2.03*			
	ERSxMCCS	-0.01 (.01)	-.19	-1.31			
SI-R Acquiring	ERS	0.02 (.03)	.15	0.71	36	.42	.17
	MCCS	0.05 (.04)	.28	1.42			
	ERSxMCCS	-0.01 (.01)	-.13	-0.87			
SI-R Clutter	ERS	0.03 (.04)	.15	0.72	36	.41	.16
	MCCS	0.04 (.05)	.18	0.87			
	ERSxMCCS	-0.01 (.01)	-.28	-1.85			
SI-R Total	ERS	0.08 (.10)	.15	0.77	36	.49	.24*
	MCCS	0.19 (.12)	.32	1.66			
	ERSxMCCS	-0.01 (.01)	-.23	-1.57			

Note. CIR = *Clutter Image Rating*; SI-R = *Saving Inventory-Revised*; ERS = *Emotion Reactivity Scale*; MCCS = *Memory and Cognitive Confidence Scale*.

* $p < .05$

anthropomorphizing script was developed for this study to address concerns that participants may not have felt a strong attachment to novel virtual objects. Pilot testing demonstrated that the script, which was developed to elicit a sense of agent knowledge (e.g., "Some have even said that [selected object] seems to have a mind of its own."), effectance motivation (e.g., "In the future, this [object] hopes to end up in a happy home with somebody who will look out for its well-being."), and sociality motivation (e.g., "It is looking forward to one day being surrounded by people who will be caring and thoughtful owners."). Pilot testing demonstrated that the script was efficacious at increasing attachment to novel objects, even in a population that is not prone to developing unusually strong object attachment. Anecdotally, there were a number of participants who asked follow-up questions after hearing the anthropomorphizing script, specifically wondering if each object in the virtual store had a unique story, and how the researcher had learned this information about the selected object. Many participants, particularly in the hoarding group, verbally reported feeling badly for their selected object following the script. They often demonstrated a reluctance to even imagining discarding the object in part due to its sad history. Taken together, the pilot testing and anecdotal feedback from participants indicate that this manipulation was effective at inducing attachment in the study population, perhaps particularly in the hoarding sample. However, the use of this script may also present a limitation, such that naturalistic attachment processes may have been either interrupted or enhanced. Future studies should test whether such a manipulation is necessary for participants to feel a sense of attachment to virtual objects.

Preliminary analyses showed the same pattern of results as in Study 1 with respect to VR-related measures. Specifically, there were no group differences on sense of presence or realism, but the hoarding group did exhibit significantly greater simulator sickness symptoms. The mood

induction was effective at eliciting an increase in negative affect. Both the negative and neutral mood induction videos led to a decrease in positive affect; this decrease was larger for the negative mood induction. There was also an increase in SCR during the negative mood induction only. Interestingly, HR actually decreased from baseline in both mood inductions. Taken together, it appears that the mood induction was effective.

Preliminary analyses also examined group differences on general acquisition and discarding patterns. The hoarding group acquired significantly more objects and spent more time acquiring than the nonhoarding group, which is unsurprising and supported by previous research showing that individuals with more severe hoarding symptoms also tend to be high acquirers (Preston et al., 2009). The hoarding group also spent significantly longer making discarding decisions and discarded significantly more objects than the nonhoarding group, presumably because they had more objects available to discard. Similarly, the hoarding group had a higher number of objects remaining following each discarding task compared to the nonhoarding group. The hoarding group also reported significantly higher object attachment to their selected virtual objects than the nonhoarding group with a large effect size (although this effect size is small to medium when accounting for general distress), which makes sense given the important role of attachment to objects in the maintenance of hoarding symptoms (Frost & Hartl, 1996; Nedelisky & Steele, 2009; Steketee et al., 2003), at times for the purpose of soothing intense emotions (Phung et al., 2015). This finding is consistent with the cognitive-behavioural conceptualization of hoarding disorder and emphasizes the speed and intensity at which individuals with hoarding problems develop strong emotional attachments, even to objects they have not touched.

Perhaps some of the most interesting findings in this set of preliminary analyses are in the different pattern of results for acquisition and discarding rates between groups, which remained

consistent even when controlling for the variance accounted for by general distress. The hoarding group acquired significantly more objects per second, showing a faster acquisition rate, than the nonhoarding group. There were no differences in discarding rates between groups. There was also no difference between the groups with respect to the proportion of the originally acquired objects that remained following both discarding tasks. Information regarding acquiring and discarding rates has not yet been reported in the hoarding literature, and provides important information about these differences in people with hoarding problems. Additionally, the hoarding group discarded significantly fewer objects than the nonhoarding group following the negative mood induction with a medium to large effect size. This finding is consistent with previous research, which has demonstrated less discarding in the context of sad mood for individuals with hoarding problems (Norberg et al., 2015). This pattern of results is illustrative of important group differences in acquisition and discarding patterns. Given that the hoarding group discarded objects at the same rate as the nonhoarding group, one could argue that if the acquisition rate was slowed, then fewer objects would be acquired, leading to a decrease in difficulties associated with discarding and clutter. It also suggests that excessive acquisition may be equally, if not more, important to include as a core feature of hoarding despite its absence from the diagnostic criteria. Furthermore, these findings suggest that negative affect may play a stronger role in reluctance to discard than it does in object acquisition.

Hypothesis 1 stated that emotional intensity, emotional reactivity, and experiential avoidance would be positively related to hoarding. Contrary to this hypothesis, there were no group differences with respect to state emotional intensity during the negative mood induction. There were also no overall differences across groups on either trait or state emotional reactivity when controlling for general distress. However, group comparisons and a priori planned

contrasts did show that the hoarding group had a higher increase in negative affect following the imagined discarding task than did the nonhoarding group. The hoarding group also reported higher scores on the persistence subscale of the ERS than the nonhoarding group. Shaw, Timpano et al. (2015) similarly reported a positive relationship between hoarding symptom severity and intense emotional reactions to imagined discarding. There were, however, overall group differences on state and trait experiential avoidance. Specifically, even when controlling for the effects of general distress, the hoarding group reported higher experiential avoidance during the neutral (but not negative) mood induction, distress aversion (i.e., a core component of experiential avoidance), procrastination, and repression/denial with a large effect size. These findings also support previous research, which has found elevated experiential avoidance in the context of hoarding (Wheaton et al., 2011). There are at least two possible explanations for why the hoarding group showed higher experiential avoidance during the neutral mood condition only. First, it is possible that the neutral induction was relatively more distressing for the hoarding group as this consisted of instructional videos on home improvement projects. This may have triggered discomfort regarding the state of participant's own homes. It is also possible that this finding indicates that hoarding participants are less tolerant of emotions such as boredom than their nonhoarding counterparts. This pattern of finding also suggests that emotional intensity, reactivity, and experiential avoidance may be particularly elevated in hoarding-related contexts (e.g., imagined discarding). This may also explain the lack of significant findings with respect to experiential avoidance reported by Wheaton et al. (2013) and Fernández de la Cruz et al. (2013). As difficult emotions tend to last longer and feel more aversive for individuals with hoarding problems, it naturally follows that this group would be more likely to procrastinate and attempt to turn off uncomfortable internal experiences. The

interesting finding that the hoarding group, but not the nonhoarding group, acquired significantly fewer objects with a medium effect size during Lab Visit 2 also points to this theory. Participants likely anticipated that they would be required to discard their selected objects again, which may have led participants in the hoarding group to avoid acquiring objects that they would have to later discard and the painful emotions that may be associated with parting with treasured objects.

Hypothesis 2 stated that negative mood intensity would predict situational avoidance in the VR shopping task. This hypothesis was not supported, which suggests that situational avoidance (i.e., presence of excessive clutter) is likely maintained by a different mechanism and not simply by negative mood intensity. Other possible mechanisms may include object attachment (Norberg et al., 2015), desire to use objects to soothe emotions (Phung et al., 2015), or poor memory confidence (Hallion et al., 2015).

Hypothesis 3 stated that experiential avoidance would mediate the relationships between negative mood intensity and acquisition/discarding patterns. Although experiential avoidance was significantly correlated with certain acquisition indicators, there were no significant correlations between negative affect and acquisition. As such, the mediation model was not assessed further. Similarly to hypothesis 2, these findings suggest that there are other factors implicated in excessive acquisition that are more important than simply negative affect. For example, correlations showed that greater procrastination levels were associated with slower acquisition rates for the hoarding group. Rather than acquiring to cope with current negative emotions, it is possible that excessive acquisition occurs to prevent the occurrence of future negative emotions. This hypothesis would be consistent with the emotional processing model (Foa & Kozak, 1986; Foa et al., 2006), as individuals with hoarding problems are unlikely to approach situations that they fear may trigger uncomfortable emotions, such as leaving an object

behind during a virtual shopping trip. A similar pattern of results emerged for discarding patterns. Greater experiential avoidance was related with slower discarding rates in both groups, but particularly in the hoarding group. Higher distress aversion was also associated with a higher number of remaining objects following both discarding phases for the hoarding group. The one significant relationship between negative affect and discarding patterns became nonsignificant when controlling for the effects of general distress and simulator sickness. These findings point to the same conclusion, such that experiential avoidance is likely more important in predicting discarding patterns than is current negative affect intensity. These findings provide important information regarding potential treatment targets. Emotional exposure may be required to reduce the effects of experiential avoidance and to increase capacity for resisting acquiring and saving urges.

Hypothesis 4 stated that an interaction between emotional reactivity and fear of decision making would predict difficulty discarding. Fear of decision making was strongly positively correlated with trait emotional reactivity. It was also positively correlated with an increase in negative affect following imagined discarding in the hoarding group, and with increase in positive affect following the negative mood induction in the nonhoarding group. This interaction did not significantly predict any hoarding symptom severity measures in the hoarding group. It was a significant predictor of SI-R difficulty discarding, as well as excessive acquisition and overall hoarding symptom severity for the nonhoarding group. Furthermore, this interaction was not a significant predictor of VR discarding for either group. A similar pattern was found for hypothesis 5, which predicted that an interaction between emotional reactivity and low memory confidence would predict excessive acquisition. This interaction was not a significant predictor of any hoarding symptom severity measures in either group. These results are in contrast to the

findings reported by Shaw, Timpano et al. (2015). These mixed findings that occur in the literature highlight the importance of improving existing methodologies for testing the relationships between these complex constructs.

Study 3: Differential Experiences of Clutter

Study 3 explored questions related to physiological and subjective responses to clutter. The purpose of this study was to investigate the effects of exposure to a cluttered versus a cleared space on individuals who hoard versus those who do not. According to a literature search, it appears that no previous work has investigated this question. This is problematic as there is an inherent assumption in CBT for hoarding that less cluttered living spaces are more desirable to cluttered ones for individuals who hoard. As such, this goal may be in conflict with patients' own personal preferences and intrinsic aesthetic values if it is the case that individuals who hoard actually feel more comfortable in more cluttered homes. Clutter does not decrease significantly following even successful treatment of hoarding (Tolin et al., 2015), which lends evidence to suggest that motivation to reduce clutter may be low. The present study explored whether individuals with hoarding disorder have less discomfort in physically enclosed spaces relative to nonhoarding counterparts. One way of examining this is by examining the subjective and physiological experiences of being in a virtually cluttered environment and to investigate the presence of claustrophobic symptoms.

Claustrophobia is one of the most commonly reported specific phobias (Curtis, Magee, Eatin, Wittchen, & Kessler, 1998). Whereas claustrophobia is colloquially understood as a fear of enclosed spaces, research has shown that it is more appropriate to consider the feared outcomes of being in an enclosed space as the true underlying fears (Rachman, 1990). For individuals with claustrophobia, these feared outcomes are largely accepted to be the fear of suffocation and/or the fear of physical restriction (Rachman & Taylor, 1993). Although no studies have examined comorbidity between claustrophobia and hoarding disorder, one might expect that the two disorders would not commonly co-occur. Whereas individuals with

claustrophobia are typically fearful of physically restrictive spaces, the hallmark feature of hoarding disorder is the presence of excessive clutter to the point that living spaces are no longer usable. Indeed, one of the risks of unmanaged hoarding problems is that of physical restriction in case of emergency such as fire. Clutter is often so severe that it can be difficult to access an exit in a timely manner and it can be difficult or unsafe for emergency personnel to enter and attempt to navigate through the home (Barksdale, Berry, Leon, & Madron, 2006).

One construct that may be helpful in distinguishing between these differential experiences of physically restrictive environments (i.e., claustrophobia and living in extreme clutter) is *defensive peripersonal space* (DPPS). DPPS is considered the amount of personal space, or the safety zone surrounding one's body, that individuals require to maintain comfort and a sense of personal safety. Sambo and Iannetti (2013) conducted a study wherein 15 participants were instructed to place their own hand at varying degrees of proximity to their own face (e.g., resting their hand at an arm's length away in the ultra-far condition, and holding their hand approximately 4 cm away from their face in the ultra-near condition). *Hand-blink reflex* (HBR), or the magnitude of the blink reflex when presented with hand stimuli, was recorded and analyzed using electromyography. Sambo and Iannetti found that across participants, there was an abrupt point at which HBR magnitude increased significantly, indicating a boundary of sorts that triggers the startle response when crossed. They also found that there were individual differences in DPPS size. For example, for six participants this boundary fell somewhere between 4 cm and 20 cm from the face, whereas for eight other participants this boundary fell between 20 cm and 40 cm, with HBR magnitude increasing gradually with nearer positions. For one participant, the boundary appeared between 20 cm and 40 cm, but there was no increase in HBR magnitude once that boundary was crossed. These findings indicate that there is indeed a

sharp boundary that demarcates DPPS and that there are individual differences in where this boundary lays. Although Sambo and Iannetti reported no relationship between DPPS size and claustrophobic fears, they did find that higher trait anxiety reliably predicted a larger DPPS size.

Another study used a different measure of DPPS, termed *near space size* (Lourenco, Longo, & Pathman, 2011). Near space size was determined by identifying the point at which one's perception shifts from peripersonal to extrapersonal space. This can be measured by identifying the point at which individuals' visual perception shifts from left to right bias. Jewell and McCourt (2000) reviewed this literature on pseudoneglect, or the tendency to shift from identifying the midpoint of a horizontal line as slightly more leftward in near space to slightly more rightward in far space. The point at which this shift occurs can be used as a proxy for near space size. In their study, Lourenco et al. found that both claustrophobic fears and arm length were independent predictors of near space size. They were not correlated with each other, but both added significant variance to the prediction of near space size. Specifically, individuals with higher levels of claustrophobic fear and with longer arm length demonstrated a larger near space size.

Arm length and claustrophobic fears are thought to relate to near space size based on two distinct functions. First, arm length is considered to be important in guiding visuomotor action (Farnè, Iriki, & Làdavas, 2005), whereas claustrophobic fears may be more representative of the need to protect the body's surface (e.g., Graziano & Cooke, 2006). With respect to arm length, near space size has been shown to be malleable depending on the arm's functioning. For example, near space size increases when one uses tools to accommodate the inclusion of extra space required for the hand tool (e.g., Longo & Lourenco, 2006). Similarly, near space size shrinks when the arm is restricted using wrist weights (Lourenco & Longo, 2009). As the amount

of effort required to navigate the arm through space increased, near space size decreased.

This malleability of near space size may be relevant to hoarding, in that individuals who live with chronic clutter may have experienced a shrinking effect of near space size given that their movement has likely been restricted and become more effortful over time. By extension, it is possible that as near space size decreases (i.e., individuals requiring less space around their body in order to feel at ease), so would claustrophobic fears. Although results are mixed with respect to the relationship between near space size and claustrophobic symptoms, this is an avenue worth pursuing as it has yet to be investigated in the context of hoarding. Investigating differences in baseline clutter preferences has similarly been neglected. The purpose of this study was to gain a preliminary understanding of whether there are group differences in subjective and physiological responses to cluttered spaces, and whether claustrophobic fears are experienced to a lesser degree for people who hoard, perhaps as related to increased exposure to cluttered spaces and decreased near space size.

Hypothesis and Exploratory Questions

Hypothesis 1: Near space size is malleable depending on environmental factors. As near space size is likely smaller for those living in severely cluttered environments, meaning a smaller personal safety zone may be required for optimal comfort, it was predicted that claustrophobic fears would be negatively associated with hoarding symptom severity.

Exploratory Question 1: Will participants who live in more cluttered homes demonstrate preference for greater amounts of virtual clutter than participants who live in less cluttered homes?

Exploratory Question 2: Will participants who live in more cluttered homes demonstrate

attenuated discomfort in increasingly cluttered virtual environments?

Method

Participants

The same participants that were described in Study 1 and 2 were used in Study 3.

Measures

Clutter preferences. Following the VR procedure described below, participants were asked to indicate which room they preferred the most. Scores ranged from 1-9, with higher scores indicating preference for more cluttered rooms. Preferred rooms ranged from 1-5 for the hoarding group, and 1-3 for the nonhoarding group.

Subjective reports of discomfort were collected using the *Subjective Units of Distress Scale* (SUDS; Wolpe & Lazarus, 1966). Participants were asked to report their subjective feelings of distress using a scale of 0-100, 0 being no distress and 100 being extreme distress, upon viewing each room described below. SUDS ratings were originally found to be positively correlated with physiological measures of distress, including HR and skin temperature (Thyer, Papsdorf, Davis, & Vallecorsa, 1984). However, the concordance between self-reported distress ratings and psychophysiological indicators of distress has also been reported as not being significantly correlated with one another (e.g., Alpers & Sell, 2008). SUDS ratings ranged from 0-100 for both groups.

Claustrophobic fear. The *Claustrophobia Questionnaire* (CLQ; Radomsky, Rachman, Thordarson, McIsaac, & Teachman, 2001) was used to measure claustrophobic fears. This is a 26-item measure in which items are rated on a 5-point Likert scale. The CLQ consists of two subscales: *suffocation* (SS) and *restriction* (RS). Participants were asked to answer how anxious they would feel in a variety of enclosed spaces, with answers ranging from 0 (“Not at all

anxious") to 4 ("Extremely anxious"). The CLQ has been found to be reliable in distinguishing between claustrophobic and nonclaustrophobic participants. This scale and its subscales have demonstrated high internal consistency, with Cronbach's α ranging from .85 to .96, as well as high test-retest reliability. The CLQ has also shown strong predictive validity for physical and cognitive fear responses in enclosed spaces. In the present study, the hoarding group's SS scores ranged from 0-43 (α = .91), RS scores ranged from 0-45 (α = .95), and total scores ranged from 2-85 (α = .95). For the nonhoarding group, SS scores ranged from 0-24 (α = .84), RS scores ranged from 0-42 (α = .93), and total scores ranged from 0-64 (α = .94).

Apparatus

VR. Participants wore the same HMD described in Study 1 to view a series of 360° photographed environments of an uncluttered living room that became progressively more cluttered over the course of nine images to mimic the CIR format. White room noise was overlaid to increase realism.

Psychophysiological measures. HR and SCR were measured using the same procedures described in Study 2, and were used as indicators of physiological reactivity throughout the procedure.

Procedure

This study occurred during Lab Visit 1 immediately following the RCFT. Participants completed the CIR during the online screening and the CLQ during the filler tasks for the memory tests described in Study 1. The Biopac equipment was attached and participants put on the HMD. They were verbally instructed on how to report their discomfort using SUDS ratings. A baseline SUDS rating was obtained after having spent approximately 5 minutes acclimating to the VR while viewing a distinct virtual room in a home. Once participants expressed comfort

with the VR equipment and the SUDS rating scale, they then viewed each of the nine VR living room environments described above in 20 second intervals. After 20 seconds and prior to viewing the next virtual room, participants were asked for their current SUDS rating. They were then given the option to review the sequence of cluttered rooms and were asked to indicate which room they preferred the most. Upon completion of this task, participants completed the VR measures (i.e., PQ, SSQ, *VR Realism*).

Results

Pilot Testing

The VR procedure was pilot-tested using four individuals without hoarding problems to assess an appropriate duration for exposure to each virtual room. Qualitative feedback indicated that 20 seconds was the optimal duration to ensure that it was possible to feel fully immersed and view all aspects of each room.

Preliminary Analyses

There were no group differences on sense of presence or VR realism; however, as in Studies 1 and 2, participants in the hoarding group experienced significantly greater simulator sickness than those in the nonhoarding group (see Table 3). After removing two outliers from the hoarding group and one outlier from the nonhoarding group, there were no significant differences between groups on baseline SUDS ratings, $t(71) = 0.19$, $p = .85$. There were also no group differences on baseline HR $t(62) = -0.92$, $p = .36$, or SCR, $t(60) = 1.66$, $p = .10$.

Primary Analyses

Hypothesis 1 stated that participants in the hoarding group would show lower mean claustrophobic fear compared to the nonhoarding group. There were no significant correlations between hoarding symptom scores and CLQ scores. An independent samples *t*-test was used to

compare group differences on CLQ total scores. This test indicated that the hoarding group (M = 43.65, SD = 23.30) scored significantly higher than did the nonhoarding group (M = 23.15, SD = 16.65) on overall claustrophobia symptoms, $t(58.42) = -4.28$, $p < .001$, Cohen's $d = -1.01$. A MANCOVA was then conducted to assess for group differences on each subscale controlling for the effects of DASS-21 scores. The MANCOVA demonstrated an overall difference between groups, $F(2,68) = 3.45$, $p = .037$, $\eta_p^2 = 0.09$. Contrary to this hypothesis, planned contrasts demonstrated that the hoarding group scored significantly higher on all CLQ subscales compared to the nonhoarding group (see Table 19).

For Exploratory Question 1, there was no correlation between preferred clutter level scores and any hoarding symptom measures for either group. An independent samples t-test was conducted to compare group differences on clutter preference. This analysis detected a significant difference between the groups, such that the hoarding group preferred a more cluttered room (M = 1.89, SD = 1.09) than the nonhoarding group, (M = 1.25, SD = 0.49), $t(47.66) = 3.23$, $p = .002$, Cohen's $d = 0.76$. This difference remained significant with a univariate ANCOVA controlling for DASS-21 subscale scores and SSQ scores, $F(1,70) = 7.92$, $p = .006$, $\eta^2 = 0.11$.

For Exploratory Question 2, it was predicted that individuals in the hoarding group would show attenuated physiological and subjective reactivity to the increasing virtual clutter in comparison to those in the nonhoarding group. A repeated measures mixed analysis of variance (ANOVA) was used to detect main effects of group and clutter level, as well as group by clutter level interactions on SUDS ratings. There was a significant main effect of clutter level, $F(8,64) = 52.03$, $p < .001$, $\eta_p^2 = 0.87$. Tests of within-subjects contrasts demonstrated a significant linear trend to these data, $F(1,71) = 328.88$, $p < .001$, $\eta_p^2 = 0.82$. There was no significant main effect

Table 19. Planned contrasts to detect group differences in claustrophobic fears.

CLQ	Hoarding Group *M (SD)*	Nonhoarding Group *M (SD)*	Contrast Estimate	Standard Error	Significance	95% CI Lower Bound	95% CI Upper Bound
Suffocation	17.13 (1.77)	10.21 (1.60)	-6.92	2.66	.011	-12.23	-1.61
Restriction	23.25 (2.33)	15.71 (2.11)	-7.54	3.50	.035	-14.52	-0.56

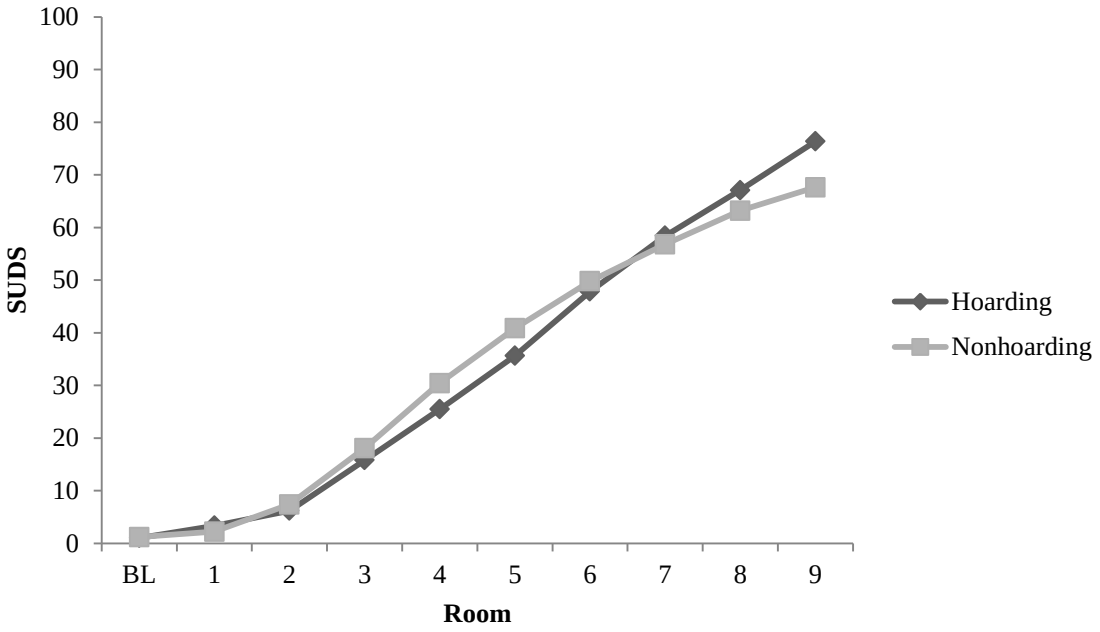
Note. CLQ = *Claustrophobia Questionnaire*.

of group, $F(1, 71) < 0.001$, $p = .996$, $\eta_p^2 < 0.001$. There was also no significant group by clutter level interaction, $F(8,64) = 1.31$, $p = .256$, $\eta_p^2 = 0.14$ (see Figure 3). With respect to HR and skin response, there were no significant main effects of clutter level or group, and no significant group by clutter level interactions.

Discussion

The purpose of Study 3 was to examine differences in experiences of and preferences for clutter. As with Studies 1 and 2, there were no group differences with respect to sense of presence or realism in the VR environment, but the hoarding group did report significantly higher levels of simulator sickness. Interestingly, CLQ scores have been shown to predict distress in enclosed spaces (Radomsky et al., 2001) and the hoarding group scored higher on the CLQ. However, in the present study, simulator sickness was not significantly correlated with either CLQ subscale or the total score for either group. Nonetheless, one possible explanation for the higher levels of simulator sickness in the hoarding group may be that this is actually reflecting difficulty with the physical aspects associated with the HMD. A recent study examining claustrophobic fear in VR may provide insight into this finding (Shiban, Peperkorn, Alpers, Pauli, & Mühlberger, 2016). Participants with high levels of claustrophobia were seated in a chair in a claustrophobic box (i.e., similar to a small closet with a door that opens and closes) wearing a HMD that showed their own perspective within an identical virtual claustrophobic box. In one condition, participants were told that the door on the actual box would remain open, while the door on the VR box appeared to be closed. In another condition, participants were told that the door on the actual box would be closed, while the door on the VR box appeared to be open. In a third condition, they were told that the actual door would be closed, and the VR door also appeared to be closed. Unsurprisingly, participants' anxiety ratings were highest when both

Figure 3. SUDS ratings across time.



Note. SUDS = *Subjective Units of Distress Scale*.

the VR and actual door were closed. However, anxiety was higher when there was perceptual input that the VR door was closed than when participants were informed that the actual door was closed. A similar phenomenon may have occurred in the present study, wherein increasing levels of clutter may have led to increasing claustrophobia-related distress for the hoarding group.

Hypothesis 1 stated that the hoarding group would report lower claustrophobic fears than the nonhoarding group. This hypothesis was not supported. Not only were there no correlations between hoarding symptom severity and claustrophobic fears, but the hoarding group actually reported significantly higher claustrophobic fears than the nonhoarding group with a large effect size overall and on both fears of suffocation and fears of restriction. This finding is very interesting when considering the severely cluttered and crowded environments that this group of participants live in on a daily basis. There are a number of possible interpretations of this finding. First, it is possible that higher general levels of distress may account for increased self-reported claustrophobic fear in the hoarding group. This finding may also highlight the level of distress that individuals living in hoarded environments must face. Their fears of suffocation and restriction are likely frequently triggered simply moving about their homes, and likewise by the increasingly cluttered VR rooms. However, it should be noted that during the screening process, none of the hoarding participants reported symptoms meeting diagnostic criteria for a specific phobia of enclosed spaces. A more likely explanation is that the hoarding group may have been reporting on realistic fears and concerns that they face on a daily basis. It may be the case that these participants were more concerned about things like suffocation and restriction because in reality, they are at a higher risk of encountering these types of problems. Although not measured in this study, this finding may also provide information regarding the lack of relationship between claustrophobic fears and near space size, given that near space size is malleable based

on physical demands (e.g., larger in the context of hand tools; Longo & Lourenco, 2006; smaller in the context of weighted wrists; Lourenco & Longo, 2009), and that near space size is likely smaller for individuals living in severely cluttered environments.

Exploratory question 1 investigated differences in clutter preferences between groups, and found that the hoarding group did indeed prefer a room with slightly more clutter than the nonhoarding group. Although this difference was significantly different with a medium to large effect size, it likely does not represent a clinically significant difference in clutter level preferences (i.e., 1.89 versus 1.25 out of a possible 9). This finding suggests that psychotherapeutic interventions that explicitly state a goal of reducing clutter are likely in line with patients' own goals. It also demonstrates the discrepancy between preferences and actual living conditions, which must contribute to the level of distress and functional impairment reported by individuals with hoarding problems.

Exploratory question 2 investigated possible differences between subjective and physiological responses to increasing clutter levels. Analyses indicated that there were no group differences on psychophysiological reactivity; nor were there group differences on subjective ratings of distress. There was also no main effect of clutter level on either measure of psychophysiological reactivity. In fact, both groups reported a pattern of SUDS ratings that steadily increased at the same rate, and that corresponded with increasing levels of clutter. Similar to the interpretation of the findings from exploratory question 1, these findings suggest that individuals with hoarding problems are equally bothered by the experience of being surrounded by clutter as would someone without a diagnosis of hoarding disorder. The distinction between these groups and their living environments must therefore be explained by

mechanisms other than clutter preferences, some of which have been described in detail in Studies 1-2.

The negative impact of clutter on sense of wellbeing in the home may be important to emphasize in hoarding treatment as a way of bolstering motivation. A recent study of almost 1,500 participants with mild to severe hoarding problems examined the effect of clutter on experiences of a psychological sense of *home* using structural equation modeling (Roster, Ferrari, & Jurkat, 2016). Results indicated that a sense of home was significantly and positively influenced by a sense of feeling attached to the physical place of home, and a sense that possessions represent an extension of the self. A more positive sense of psychological home was a significant predictor of subjective wellbeing. However, the presence of clutter had a negative impact on both sense of home and of subjective wellbeing. These findings, in tandem with the findings reported in Study 3, highlight the importance of improving existing interventions so that they can adequately address reducing clutter as well as improving discarding and acquiring patterns, not only to improve the safety and functionality of risky homes, but also to increase individuals' enjoyment and sense of satisfaction in their homes.

General Discussion

The three studies described earlier contribute to the growing literature on the cognitive and emotional aspects of hoarding disorder by examining its component parts as described by the cognitive-behavioural model of hoarding (Frost & Hartl, 1996; Frost & Steketee, 1998). This goal was accomplished by using novel VR technology in an effort to improve ecological validity in this field, and to provide clarifying information in the context of mixed findings reported in the literature. Ultimately, CBT for hoarding disorder may benefit from the findings of these studies, as the efficacy of such treatments depend upon a clearly defined model that can increase patients' understanding of the disorder, and that will direct therapists to key junctures for empirically-supported interventions.

Some treatment implications have already been discussed (e.g., tailoring attentional training depending on case conceptualization, leveraging intact state memory confidence to improve global memory confidence, collaboratively develop rules for minimum numbers required to create categories, target perfectionism directly, increase emphasis on emotional exposure to reduce effects of experiential avoidance, develop strategies to slow acquisition rate). Based on the complexity of the cognitive-behavioural model of hoarding and the individual differences that were observed in the present series of studies, the most important message is that individualized case conceptualization is likely critical in providing adequate psychological treatment for this disorder. Although many overall trends have been reported and discussed in the literature, individuals who present with this problem have diverse experiences, which likely have led to diverse importance in mechanisms that maintain their problems.

With respect to directions for future research, these studies demonstrate that it is possible to study hoarding disorder using novel technologies such as VR. Using VR allowed us to

investigate questions that otherwise would be nearly impossible to test. For instance, using a VR messy home office for the organizing task stimulus in Study 1 allowed for standardization across participants without placing severe restrictions on the number or type of objects that could be sorted. Similarly, a key finding from Study 2 with respect to acquisition and discarding rates would be much more difficult to ascertain using other methodologies. Lastly, using VR to assess responses to varying levels of clutter again allowed for a high degree of standardization and feasibility. Using VR in Study 3 also bypassed any ethics or safety concerns that would pose problems by having participants spend time in dangerously cluttered spaces, where risk of falls and avalanches would be very high. Anecdotally, participants in both groups tended to be quite excited at the opportunity to use VR. It will be interesting to observe whether this novelty effect will persist over time, as VR becomes more commonplace in both research and entertainment. Some hoarding participants in particular noted that it helped give them a different perspective on their own clutter.

Future studies, using either the same or modified versions of the VR environments described in this dissertation, should investigate whether certain interventions could improve hoarding participants' performance on these tests. For example, future studies should test whether assigning specific rules about minimum numbers of objects per category would improve individuals' with hoarding's tendency toward underinclusivity. With respect to emotional impacts on hoarding behaviour, future studies should investigate whether acquisition in subsequent lab visits would be lower if participants were unaware that they would be required to make discarding decisions. If this effect is only present in the context of anticipated discarding, this would provide further evidence for the hypothesis that reduced acquisition during Lab Visit 2 was a behavioural indicator of experiential avoidance. To further investigate the question about

clutter preferences, future research could continue to use VR to show 360° photographs of participants' own homes with digital manipulation to increase or decrease clutter levels. Perhaps subjective experiences of increasing clutter levels would be different for individuals with hoarding problems when the added element of emotional attachment to objects is included.

There are a number of general limitations that must be considered when interpreting the findings of these studies. First, there was no clinical comparison group, which reduces some degree of confidence that group differences are attributable to hoarding disorder specifically versus the presence of psychopathology more generally. However, the nonhoarding group was permitted to have psychopathology (with the exclusion of hoarding disorder, OCD, and current major depressive episode), as this type of sampling method allows for a comparison group that is more similar to the general population. In addition, variance accounted for by general distress (i.e., depression, anxiety, stress) was controlled for in statistical analyses wherever possible.

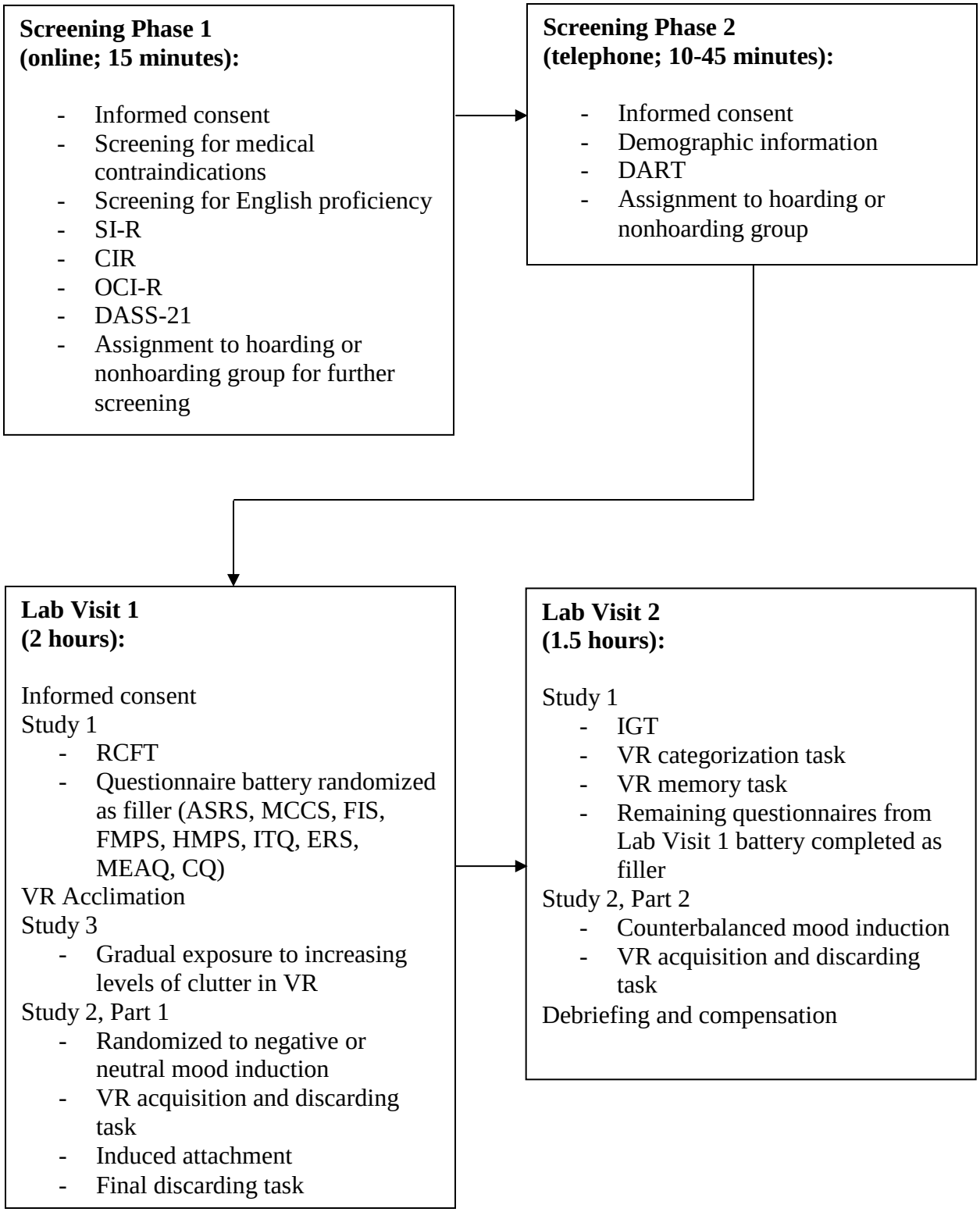
Another limitation is that, due to scheduling and logistical coordination, there was inconsistency in terms of the delay between the online screening, telephone screening, and first lab visit. As such, it is possible that certain measures completed at earlier stages may not have remained consistent throughout the testing period. For instance, it is possible that a participant's DASS-21 depression score could have changed over the course of the few weeks between completing the screening and completing the lab visits, or even that the onset of a major depressive episode could have occurred during that period. Fortunately test-retest reliability was good for the DART, so it is unlikely that this would have posed a significant risk to the validity of the analyses.

There is still a great deal to be learned about hoarding disorder. The present dissertation successfully implemented a novel approach to improve our understanding of the cognitive-

behavioural model of hoarding. It is important to continue considering innovations with respect to future treatment approaches and research approaches, such as the use of VR, to increase our understanding of how this complex problem develops and is maintained.

Appendices

Appendix A: Procedure Flow Chart



Appendix B: Demographics Questionnaire

Gender:

- Female
- Male
- Transgender
- Other (please specify): _____

Age: _____

Relationship Status (please select one):

- Single
- In a steady relationship
- Married
- Cohabiting
- Separated
- Divorced
- Widowed

Ethnicity/Cultural Background:

- Aboriginal (e.g., First Nations, Métis, Inuit)
- Black/Afro-Caribbean/African
- White/European
- Hispanic/Latin American
- Asian (e.g., South Asian, East Asian, Southeast Asian)
- Biracial/multiracial
- Other (specify _____)

Are you enrolled in an educational program?

- Yes
- No

If yes, please select one:

- Community College
- University
- Adult Education/Continuing Education
- Other (specify _____)

Field of Study: _____

Education Level (please select one):

- Did not attend High School
- Some High School
- Completed High School/High School Equivalency (GED)
- Some College/University
- Completed College/University
- Some Graduate/Professional School (e.g., Masters or doctoral program, medicine, law)
- Completed Graduate/Professional School (e.g., Masters or doctoral program, medicine, law)

Employment Status:

- Not Working
- Working Part-Time
- Working Full-Time

If working part-time or full-time, indicate occupation: _____

Annual Family Income (please select one):

- Less than $19,000
- $20,000 - $39,999
- $40,000 - $59,999
- $60,000 - $79,999
- $80,000 - $99,999
- $100,000 - $199,000
- More than $200,000
- Don't know

Number of people supported by the family income (including self): ____

Appendix C: Virtual Reality Memory Test

Immediate and Delayed Free Recall Instructions

A short time ago, I asked you to come up with categories to sort objects in a messy room. I would now like you to tell me every object that you can remember being on the couches. Tell me what object you saw, what it looked like, and where it was. Just tell me about the objects that were on the couches.

Element	Perceptual Details	Spatial Details

Recognition Instructions

Please rate how confident you are that you either did or did not see each object in the virtual room.

1 Sure it was not in the room	2	3	4	5	6 Sure it was in the room

A

B

C

How confident are you that **A** was in the virtual room? 1 2 3 4 5 6

How confident are you that **B** was in the virtual room? 1 2 3 4 5 6

How confident are you that **C** was in the virtual room? 1 2 3 4 5 6

Note. Objects shown in this are samples only, and do not represent the actual virtual objects used in this measure.

Appendix D: VR Realism

Please indicate using the scale below how similar the VR experience was to your everyday experiences in cluttered environments:

0 Very slightly or not at all	1 A little	2 Moderately	3 Quite a bit	4 Extremely

1. The VR environment was similar to real life cluttered environments. 0 1 2 3 4
2. The emotions that I felt were similar to how I would feel in real life. 0 1 2 3 4
3. The thoughts that I had were similar to what I would think in real life. 0 1 2 3 4
4. The actions that I did were similar to what I would do in real life. 0 1 2 3 4

Briefly describe the ways in which the VR experience was similar to your everyday experiences in cluttered environments:

Briefly describe the ways in which the VR experience was different than your everyday experiences in cluttered environments:

How would your experience have been different if the VR environment was filled with your own personal belongings?

Appendix E: Anthropomorphizing Script

"I would like to tell you a little bit more about the object that you chose. This [object] has been described as humorous, quirky, and unique. Some have even said that it seems to have a mind of its own. Other people who have seen this [object] in person have also noticed its warmth and vulnerability. People who have used this [object] in the past have also remarked on its reliability and dependability. It has overcome challenges in the past. It was neglected by its previous owner and eventually lost, before it was found on the side of the road and made its way onto the shelves of this store. In the future, this [object] hopes to end up in a happy home with somebody who will look out for its well-being. Although it has been kept safe at this store, it has been lonely while waiting for its forever home. It is looking forward to one day being surrounded by people who will be caring and thoughtful owners."

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