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Research article

Can a virtual environment enhance understanding of hoarding deficits? A pilot investigation

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ABSTRACT

This pilot study tested the utility of a virtual environment for assessing cognitive deficits characteristic of hoarding. A sample representing a broad spectrum of hoarding traits ($N = 20$) was assessed using self-report measures of information processing skills and emotional experience, and placed in a virtually simulated house that contained cluttered spaces and clean spaces. Information-processing significantly differed between high-hoarding and low-hoarding groups, with the high-hoarding group showing increased proneness to emotional attachment and information processing difficulties in the cluttered environment. The high-hoarding group also showed differences in behaviour and appraisal of the simulated environment. The findings suggested that virtual reality is accessible to participants and elicits real-time emotions and behavioural parameters which can assist our understanding of hoarding behaviour. Virtual reality may contribute to hoarding therapy in future, as it allows participants to visualise a different perspective of their condition and could contribute to their knowledge about the severity of their behaviour.

1. Introduction

Hoarding disorder is a chronic progressive mental health problem characterised by accumulation of objects, cluttered living spaces, and pronounced difficulty discarding possessions (American Psychiatric Association, 2013; Williams and Viscusi, 2016). Motivation to hoard has been linked to: (i) fear associated with discarding items, due to the belief that they may be needed in the future (Frost et al., 2018); (ii) exaggerated sentimental value on each item; (iii) sharing strong emotional attachments with possessional to compensate for unmet social bonds (Yap et al., 2020; Yap and Grisham, 2019); (iv) difficulties in decision-making (Tolin et al., 2012), categorisation and organisation; and (v) being driven by maladaptive beliefs on the responsibility of possessions (Steketee et al., 2003; Williams and Viscusi, 2016). Concern about failing to remember which items one has already accumulated, and a need for control over one's environment have also been cited as contributors to hoarding disorder (Kyrios et al., 2018), with other motivations for hoarding include information value, emotional reasons, aversion to waste, and aesthetic reasons (Frost et al., 2015). As well as distress and compromised use of living spaces (American Psychiatric Association, 2013), outcomes of hoarding include increased fire risk, risk of falls, and disease, infection, and parasite risk due to squalor (Williams and Viscusi, 2016).

2. Emotional processes

Emotional processes are central to understanding onset and maintenance of hoarding (Shaw et al., 2015). The cognitive-behavioural model of hoarding disorder posits an important role for emotional responses such as fear and strong attachment (Tolin et al., 2018). Hoarding disorder is strongly correlated with the experience of negative feelings, with most clients presenting with high levels of anxiety and sadness when they are in the act of trying to organise their items, or in the process of deciding whether to discard their items (Tolin et al., 2018). These negative emotions are also linked to early life experiences such as trauma, or social factors such as detachment from family and friends (Grisham and Barlow, 2005; Hartl et al., 2005). Tolin, Meunier, Frost, and Steketee (2010) found that 75% of females in a sample of individuals with hoarding difficulties had a history in interpersonal violence, in comparison to the 32% of adult females in the general population.

Hoarding is also associated with social anxiety, with individuals with hoarding difficulties experiencing social inactivity and social withdrawal due to marriage issues, family conflict, and feelings of shame due to their hoarding tendencies (Frost et al., 2000; Grisham and Barlow, 2005; Steketee et al., 2000). Yap et al. (2020) suggested that individuals with hoarding disorder accumulate items to compensate for unmet social

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connections, to feel a sense of comfort and security, and to reduce feelings of loneliness. Therefore, one explanation of the negative emotions involved with hoarding, such as fear and sadness, is that they arise when strong emotional connections formed with the possessions are threatened, as losing these objects may result in a feeling that one is losing their comfort and security (see also Steketee and Frost, 2003). Although it is known that individuals with hoarding disorder experience negative emotions when in the act of categorising or deciding to discard their possessions, relatively little is known about their affective responses to stimuli that is non-personal to them. Research on emotional reactivity to non-personal items has the potential to provide further information about the link between negative emotion and material possessions for individuals vulnerable to hoarding difficulties.

3. Information-processing deficits and current treatment

Frost and Hartl (1996) demonstrated that individuals with hoarding difficulties exhibit impairments in decision-making, memory, and attention. Patients with hoarding disorder experience visual processing deficits in object recall, attention, decision-making, and categorisation, as well as diminished confidence about performance at certain cognitive tasks (Hartl et al., 2004; Tolin et al., 2011; Woody, Kellman-McFarlane and Welsted, 2014). Individuals with hoarding disorder tend to present with poor insight and struggle to perceive dangers in their environment (Grisham and Barlow, 2005). Grisham, Brown, Liverant, and Campbell-Sills (2005) suggested that this may be explained by the belief that their hoarding behaviour is non-problematic, a phenomenon potentially contributing to high relapse rates post-treatment (Saxena and Maidment, 2004).

Hoarding has proven difficult to treat, even using current best-practice psychotherapeutic interventions (Steketee and Frost, 2003). Studies focusing on cognitive-behavioural therapy (CBT) for hoarding show that although CBT was effective on a short-term basis, follow-up sessions presented high-relapse rates and ongoing anxiety (Ayers, Bratiotis, Saxena, & Wetherell, 2012; Ayers, Wetherell, Golshan, & Saxena, 2011; Frost & Steketee, 2014). Meta-analyses conducted on the use of CBT to treat hoarding disorder have shown mixed results, with an approximately 1-in-3 chance of clinical significant improvement (Bodryzlova, Audet, Bergeron and O'Connor, 2018). Therefore, there is continuing room for improvement in interventions for hoarding disorder (Tolin et al., 2015; Tolin et al., 2019). Exploring virtual reality (VR) is one avenue by which to pursue this.

4. Virtual reality

VR incorporates real-time computer visuals, audio and other sensory input mechanisms to place the user inside a computer-generated environment that they can safely interact with in a controlled setting (Kim et al., 2009). This is facilitated via a head-mounted device that displays three-dimensional scenes, motion tracking sensors, and other sensations that allow for real-time presence. VR has been used in exposure therapy and has been effective in treating many psychiatric disorders such as panic disorder (Botella et al., 2007), specific phobias, social-anxiety disorder, post-traumatic stress disorder, generalised anxiety disorder, OCD, schizophrenia, eating pathology, and autism (Maples-Keller et al., 2017).

St-Pierre-Delorme and O'Connor (2016) investigated whether virtual technology is effective in the treatment of compulsive hoarding. Their experimental group that was exposed to a cluttered virtual environment, consisting of personal objects, whilst their control group was exposed to a cluttered virtual environment consisting of non-personal objects. Improvement was observed in hoarding symptoms such as responsibility, emotional attachment, and memory deficits. Additionally, scores from the Savings Inventory-Revised (SI-R; a self-reported measure that assesses the severity of hoarding symptoms) declined, demonstrating significant improvements in hoarding behaviour. Applications of VR to hoarding have more recently been explored by Chasson et al. (2020) as well as McCabe-Bennett, Lachman, Girard, and Antony (2020). These authors simulated a representation of participant's houses without the presence of clutter in order to assess their motivation to change hoarding behaviours, with an indication that individuals with hoarding disorder may be more willing to seek treatment post VR exposure to a clean version of their home environment.

VR offers a high safety standard when contrast with in vivo exposure, as the software/hardware can be switched off immediately if the participant begins to feel distressed with the process (Kim et al., 2009). More importantly, VR technology primarily aims to focus on the visual sensory system, therefore it can be effective with understanding the complexities involved with hoarding behaviour, as the level of clutter in the living spaces is a visual outcome of symptoms (St-Pierre-Delorme & O'Connor, 2016).

5. The present study

Initial exploration of the use of VR to treat hoarding disorder has focused predominantly on efficacy, and no study to date has examined how information processing difficulties may be mapped within a VR environment. As information processing is a critical factor that underlies hoarding disorder, and VR is predominantly a visually rich experience, investigating cognitive processing in VR will potentially allow greater insight into hoarding. The objectives of this pilot study pilot were to explore differences in emotional processes (comfort, overwhelmingness, familiarity) and information-processing (categorisation and decision-making) between individuals with high hoarding behaviour and low-to-absent hoarding behaviour using VR. Two hypotheses were formulated: (1) individuals with high hoarding behaviour will present more information processing difficulties than individuals with low hoarding behaviour, in a virtual environment; and (2) in comparison to low hoarding behaviour, those with high hoarding would experience less discomfort in the cluttered spaces, and conversely more discomfort in the clean spaces.

6. Method

6.1. Participants

The sample comprised 20 adults (15 female and 5 male) aged between 21 and 63 ($M = 26.5$, $SD = 11.7$). Of these, 85% were single, 10% were married, and 5% were either separated or divorced. Additionally, 55% were employed, 5% were unemployed, 30% were students, and 10% were retired. Of the 20 participants, 55% identified themselves as Caucasian and 45% identified as Asian.

6.2. Materials

Participants completed a brief demographic survey along with the following questionnaires.

6.2.1. Hoarding behaviour

The Savings Inventory-Revised (SI-R; Frost et al., 2004) is a 23-item questionnaire used to measure hoarding behaviour as three associated subscales: (i) excessive acquisition; (ii) difficulty discarding possessions; and (iii) clutter. Questions are answered on a 5-point Likert scale, with options ranging from 0 (None) to 4 (Almost All/Complete). Participants are required to respond to the questions in correspondence to their experience during the past week. The SI-R demonstrates good internal consistency for the total score ($\alpha = .94$) and all subscales (Difficulty Discarding: Cronbach's $\alpha = .93$; Clutter: Cronbach's $\alpha = .88$, Acquisition: Cronbach's $\alpha = .80$), and presents good test-retest reliability (Frost et al., 2004). The internal consistency of the scale was appropriate when assessed with the current sample (Cronbach's $\alpha = .90$).

Figure 1. Clean environment representation in SketchUp.

6.2.2. Emotional experience

Emotional experience is one of the central outcome measures in the present study. It was measured via a written hand-out created on Microsoft Excel by the student researcher. The variable consists of items that focus on participants' level of comfort, familiarity and overwhelmingness in the virtual environment. Questions involved are: "Are you overwhelmed in this room?", "How comfortable do you feel in this room?", and "How familiar are you with this room?". Questions are answered on a 4-point Likert scale, with options ranging from 0 (Not at all) to 3 (Very much). This model of scoring was adapted from the SI-R as items aimed to gauge hoarding-related behaviors in the VR environment. Reliability was acceptable when assessed for the high hoarding group (Cronbach's $\alpha = .83$).

6.2.3. Information-processing difficulties

Information-processing was measured on the same written hand-out measuring emotional experience. Measurement comprised four items focusing on categorisation skills and logical decision-making. Categorisation was measured using a dichotomous yes-or-no question ("Do you believe that most of the items in this room could have been organized into specific categories). One out of the three items relating to decision-making ("Would you choose to discard items for the safety of this room or keep all or most of the items due to sentimental value?") was also measured using a dichotomous question, in which participants answered either "keep items" or "discard items". The other two items relating to decision-making ("If this was a part of your own living space, would you buy/collect more things to fill up the space?" and "If this was a part of your own living space, would you discard most of the items?") were answered on a 4-point Likert scale, with options ranging from 0 (Not probable) to 3 (Very probable).

All items used to assess emotional experience and information processing difficulties were developed based on the item content of the Savings Cognitions Inventory – Revised (Steketee et al., 2003). However, these were adapted to accommodate responses specific to a VR environment scenario.

6.2.4. Virtual reality equipment/session location

The VR headset (Oculus Rift CV1), motion controllers, and optical tracking sensors used in the study were developed and manufactured by Oculus VR (Oculus VR, LLC. Menlo Park, California, USA). The session was located at RMIT University city campus, in the psychology laboratory. The laboratory was a private room that consisted of a computer desk, PC, and the VR equipment.

6.2.5. Virtual reality environments

Two environments (practice environment - an animated car park, and experimental environment - an animated house that contained variants of clean spaces and cluttered spaces; see Figures 1 and 2) were designed using the SketchUp software for three-dimensional modelling (Trimble Inc., Sunnyvale, California, U.S.). The two different types of clutter in the virtual house were used to grasp an in-depth understanding of participants emotional and information processes, based on hoarding group (high-hoarding or low-hoarding). Many objects were generated (e.g., CDs, boxes, house plants, etc.) in the cluttered space. Both spaces were identical apart from the clutter in one version of the house. Virtual environments were uploaded onto the Prospect platform (IrisVR Inc., New York City, NY, U.S.), allowing participants to view them using the Oculus VR equipment.

6.3. Procedure

Following ethical approval from the RMIT Human Research Ethics Committee (Project ID: 27-19/22139) advertisements for the study were distributed. Participants were recruited using advertisements posted at RMIT University, online advertisements posted on social media websites, and by promotion in undergraduate psychology lectures. Interested volunteers scheduled a time with the student researcher via email/phone to attend the VR session in the psychology laboratory at RMIT University city campus. Participation in the study was completely voluntary. Individuals under 18 years of age were excluded from the study. DASS scores were not used for analysis. Instead, the total DASS score was used

Figure 2. Cluttered environment representation in SketchUp.

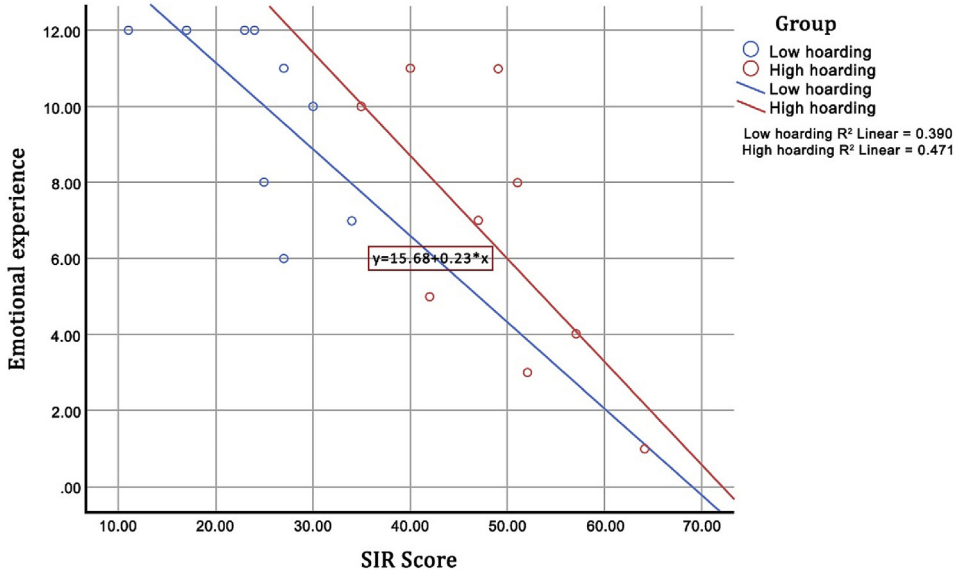

Figure 3. SI-R and emotional experience.

as an indication for the student researcher to advise any participants in the clinical range (as specified in the cut-off criteria) to not proceed with the experiment. This was to ensure minimisation of potential psychological harm.

All participants agreed to continue with the study with the knowledge that they were able to withdraw at any point in time. Sessions were undertaken individually, with only the student researcher and the scheduled participant were present in the laboratory. Participants were provided with an information sheet outlining the study and their ethical rights. Participants that read and provided consent to proceed with the study were then automatically directed to the battery of questionnaires via Qualtrics. These questionnaires took approximately 20 min to complete.

After completing the battery of questionnaires, participants were asked to put on the VR headset to participate in each of the virtual environments. An initial practice environment was implemented to ensure that each participant knew how to manoeuvre around the virtual environment and use the motion controllers effectively. Once comfortable, participants were presented with a virtual house. Participants were asked to manoeuvre around the virtual space for 5 min and were asked to imagine that the house was their own living space. They were then presented with the alternative space and again were asked to navigate it for 5 min. Spaces were randomised between clean versus cluttered across participants. After participants finished the VR session they were asked to remove the headset and completed the self-report assessment of emotional experience and information processing skills.

7. Results

7.1. Data preparation

A median of 29.95 (SD = 14.26) was obtained for total SI-R scores. Participants obtaining a total SI-R score lower than 34 (n = 10; M = 18.10; SD = 6.45) were classified as having low-to-absent hoarding behaviour, whilst participants obtaining a total SI-R score of 34 (n = 10; M = 41.80; SD = 8.70) or higher were classified as having higher hoarding behaviour. Items testing emotional experience in the virtual environment (level of overwhelmingness, comfort, familiarity) were summed to compute a total emotional experience score. Items testing

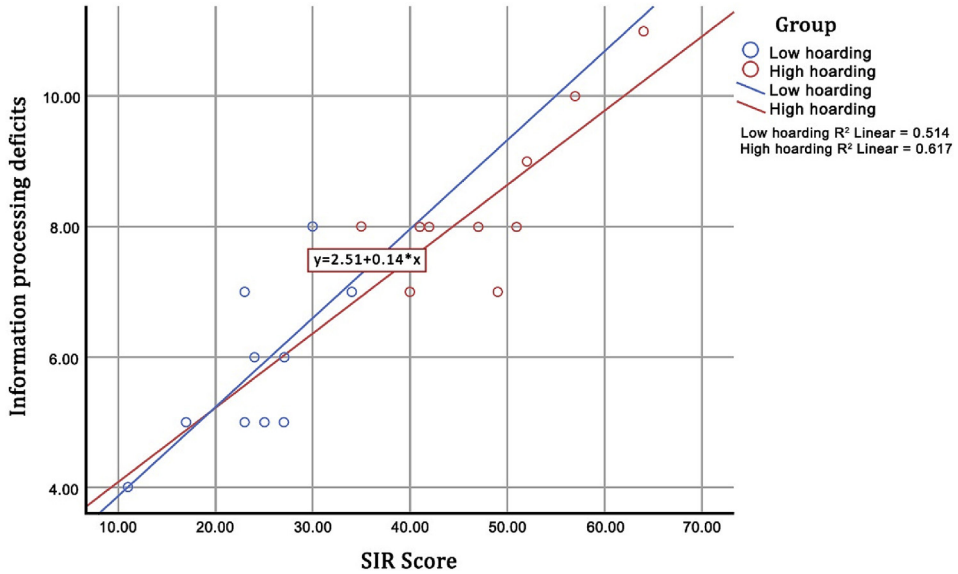

Figure 4. SI-R and information processing deficits.

information-processing (categorisation and decision-making) were summed to compute a total information-processing score.

Inspection of histograms and scatterplots (see Figure 3 & Figure 4 for an example) for the two outcome dimensions, emotional experience, and information-processing difficulties confirmed that distributions were normal. Age was comparable across groups, while gender differed (4 males in the 'low' hoarding group, 1 male in the 'high' hoarding group). No missing data were present.

7.2. Descriptive statistics

Frequencies for individual items within information-processing difficulties and emotional experience are presented in Table 1.

7.3. Correlational analyses

The correlation between total SI-R scores (low hoarding group) and total emotional experience was $r = -.63$ ($n = 10$, $p = .053$). The correlation for total SI-R scores (low hoarding group) and total information-processing difficulties was $r = .72$ ($n = 10$, $p = .020$). The correlation for total SI-R scores (high hoarding group) and total emotional experience was $r = -.69$ ($n = 10$, $p = .028$). The correlation for total SI-R scores (high hoarding group) and total information-processing difficulties was $r = .79$ ($n = 10$, $p = .007$). Correlations between the SI-R subscales and emotional experience and information-processing for low v high hoarding groups are shown in Table 2 and Table 3 respectively.

7.4. Inferential statistics

Analyses were conducted to determine the extent to which low and high hoarding groups differed in information processing and emotional response within a virtual environment. Box's M (6.102) was not significant, indicating homogeneity of covariance across the groups. A significant difference in combined emotion and information-processing was present between those with low hoarding behaviour and high hoarding behaviour, F (2, 17) = 10.30, $p < 0.05$; Wilk's $\Lambda = 0.452$, partial $\eta^2 = 0.548$. Approximately 55% of multivariate variance of overall emotional experience and information processing difficulties in the virtual environment was associated with participants' classified hoarding group.

Follow-up univariate ANOVAs were conducted for each outcome variable. ANOVA indicated a statistically significant overall effect on emotional experience in the virtual environment for participants with different degrees of hoarding behaviour, F (1, 18) = 7.48; $p < 0.05$; partial $\eta^2 = 0.293$, as well as a statistically significant overall effect on overall information processing difficulties in the virtual environment for participants with different degrees of hoarding behaviour, F (1, 18) = 21.73; $p < 0.05$; partial $\eta^2 = 0.547$. The mean score for emotional experience in the low hoarding group ($M = 10.20$, $SD = 2.35$) was significantly higher than for the high hoarding group ($M = 6.60$, $SD = 3.44$), while information processing deficits in the low hoarding group ($M = 5.80$, $SD = 1.23$) were significantly lower than for the high hoarding group ($M = 8.40$, $SD = 1.26$).

Table 1. Frequencies of individual items within information-processing difficulties and emotional experience, based on experience in the virtual house.

	Responses	Low Hoarding Behaviour *N* (%)	High Hoarding Behaviour *N* (%)
Emotional Experience Items			
1. Are you overwhelmed in this room? (Clean space)	0. Not at All 1. Some Degree 2. Considerable Degree 3. Very Much	0. (10) 90% 1. (10) 10% 2. (10) 0% 3. (10) 0%	0. (10) 70% 1. (10) 10% 2. (10) 10% 3. (10) 10%
2. Are you overwhelmed in this room? (Cluttered space)	0. Not at All 1. Some Degree 2. Considerable Degree 3. Very Much	0. (10) 0% 1. (10) 0% 2. (10) 30% 3. (10) 70%	0. (10) 10% 1. (10) 50% 2. (10) 20% 3. (10) 20%
3. How comfortable do you feel in this room? (Clean space)	0. Not at All 1. Some Degree 2. Considerable Degree 3. Very Much	0. (10) 10% 1. (10) 0% 2. (10) 30% 3. (10) 60%	0. (10) 30% 1. (10) 20% 2. (10) 20% 3. (10) 30%
4. How familiar are you with this room? (Clean space)	0. Not at All 1. Some Degree 2. Considerable Degree 3. Very Much	0. (10) 10% 1. (10) 20% 2. (10) 10% 3. (10) 60%	0. (10) 20% 1. (10) 40% 2. (10) 40% 3. (10) 0%
Information Processing Items			
1. Do you believe that most of the items in this room could have been organised into specific categories? (Cluttered space)	1. Yes 2. No	1. (10) 90% 2. (10) 10%	1. (10) 70% 2. (10) 30%
2. Would you choose to discard items for the safety of this room, or keep all or most of the items due to sentimental value? (Cluttered space)	1. Discard Items 2. Keep Items	1. (10) 100% 2. (10) 0%	1. (10) 50% 2. (10) 50%
3. If this was a part of your own living space, would you buy/collect more things to fill up the space? (Clean space)	0. Not Probable 1. Somewhat Improbable 2. Somewhat Probable 3. Very Probable	0. (10) 20% 1. (10) 30% 2. (10) 40% 3. (10) 10%	0. (10) 0% 1. (10) 30% 2. (10) 30% 3. (10) 40%
4. If this was a part of your own living space, would you discard most of the items? (Cluttered space)	0. Not Probable 1. Somewhat Improbable 2. Somewhat Probable 3. Very Probable	0. (10) 0% 1. (10) 0% 2. (10) 30% 3. (10) 70%	0. (10) 20% 1. (10) 20% 2. (10) 50% 3. (10) 10%

Table 2. Pearson correlations SI-R scores (low hoarding group) ((i) excessive acquisition; (ii) difficulty discarding possessions; and (iii) clutter), and Total Emotional Experience (VR), Total Information Processing Deficits (VR).

	1	2	3	4	5
1. SI-R: Excessive acquisition	1	.161	.027	-.093	.217
2. SI-R: Difficulty discarding	.161	1	.327	0.431	.704*
3. SI-R: Clutter	.027	.327	1	-.734	.508
4. Total Emotional Experience (VR)	-.093	-.431	-.734*	1	-.293
5. Total Information Processing Deficits (VR)	.217	.704*	.508	-0.293	1

* Correlation is significant at the 0.05 level (2-tailed).

Table 3. Pearson correlations SI-R scores (high hoarding group) ((i) excessive acquisition; (ii) difficulty discarding possessions; and (iii) clutter), and Total Emotional Experience (VR), Total Information Processing Deficits (VR).

	1	2	3	4	5
1. SI-R: Excessive acquisition	1	.074	.275	-.245	.358
2. SI-R: Difficulty discarding	.074	1	.731*	-0.416	.481
3. SI-R: Clutter	.275	.731*	1	-.667*	.809**
4. Total Emotional Experience (VR)	-.245	-.416	-.667*	1	-.879**
5. Total Information Processing Deficits (VR)	.358	.481	.809**	-.879**	1

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

8. Discussion

The present results add to a growing body of research investigating deficits characteristic of hoarding behaviour, extending previous literature by incorporating a VR environment to facilitate understanding of emotional experience and information-processing difficulties. Individuals with high hoarding behaviour presented with more information-processing difficulties than individuals with low hoarding behaviour, and in comparison to low hoarding behaviour, those with high hoarding behaviour experienced less discomfort in a cluttered space, supporting hypotheses.

Consistent with findings of Luchian et al. (2007), the present study found significant differences between those with high hoarding behaviour and low hoarding behaviour in regard to information-processing. Those with high hoarding behaviour presented a greater inability to visually categorise non-personal items in the virtual environment. This finding was consistent with those of Luchian et al. (2007), where a non-clinical high-hoarding group were poor at categorising non-personal items, and further accords with data showing that the ability to group information into similar categories is an area of poor functioning in compulsive hoarding generally (Frost and Hartl, 1996).

Participants with high hoarding behaviour also presented poorer decision-making skills than participants with low hoarding behaviour. Descriptive data showed that 50% of participants in the high hoarding group reported that they would keep items due to sentimental value, rather than discard items for their own safety. In contrast, all individuals classified with low hoarding behaviour prioritised their safety and reported that they would discard items. These findings also suggest that those with high hoarding behaviour may benefit from support with decision-making, and may lack the ability to perceive the advantages associated with discarding items that contain no objective value.

A significant difference was found in emotional experience between individuals with high hoarding behaviour and low hoarding behaviour. In comparison to those with low hoarding tendencies, those with high hoarding tendencies felt less comfortable, more overwhelmed and were less familiar when they walked around the clean spaces of the virtual house. Responses indicate that individuals with high hoarding behaviour felt less overwhelmed in the cluttered spaces within the virtual house. These outcomes were expected and consistent with previous literature on emotions (Steketee and Frost, 2003) indicating that clutter represents a sense of comfort and security. These findings are somewhat consistent with those of St-Pierre-Delorme and O'Connor (2016), who applied virtual reality to assess self-reported hoarding behaviour. In that study, those with hoarding tendencies experienced significantly more anxiety in the virtual environment than the control group. A primary advantage of the present study was that both hoarding groups were exposed to the same environment, and participants were exposed to the same non-personal virtual objects, making comparisons of their emotional experience more standardised, which was a major distinction between the present research and that of St-Pierre-Delorme and O'Connor (2016) study.

Practical implications emerged from the current study that may inform future research and practice. Self-reported hoarding behaviour shared strong correlations with information-processing difficulties and emotional experience within the virtual environment. Given that the information reported from the virtual environment was highly consistent and associated with what participants reported in the SI-R, this suggests that VR can serve as a useful technologically-mediated paradigm to assist our understanding of the cognitive deficits associated with hoarding.

Future research could investigate whether VR may helpfully contribute to provision of therapy for hoarding disorder, as it allows participants to account for a different perspective of their condition and provides a universal platform to examine some of the visual and cognitive cues long implicated in hoarding disorder.

The primary limitation of application of VR to hoarding is currently software availability. Although the present study aimed to obtain a visual understanding of the behavioural complexities involved with hoarding, making the VR environment more interactive, for instance by enabling participants to virtually categorise objects, might have allowed for richer data. Although ownership of VR-enabled devices is becoming more feasible for consumers, the availability of VR equipment limits testing of participants. However, unlike in Chasson et al. (2020) study, participants in the present study were allocated 5 min rather than 10 min to explore each environment. This suggests that shorter periods in VR are efficacious in producing meaningful outcomes for participants and may further lend VR as a suitable brief assessment tool or intervention applied to hoarding disorder.

The lack of a diagnosed clinical sample also limited the present study. Although participants were recruited at random, as the advertisement targeted those who struggling to discard clutter, it was hoped that this study may have captured a portion of the population who symptomatically have difficulties with hoarding behaviours. As a pilot study, the findings indicate that the use of VR environments should be investigated in individuals with a clinical diagnosis of hoarding disorder, paving the way for future work on the use of VR as a potential diagnostic or remediation tool for those with clinical hoarding symptoms.

In conclusion, the present study successfully applied a VR component to understand the differences between individuals with low hoarding behaviour and individuals with high hoarding behaviour, as well as demonstrating consistency between the responses from the virtual environment and self-reported hoarding behaviour, obtained from the SI-R. The VR experience was accessible to participants, and elicited real-time emotional and behavioural response. Further application of VR paradigms will continue to assist understanding of compulsive hoarding.

Declarations

Author contribution statement

Y. N. Somaratne: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

J. Collett: Conceived and designed the experiments; Analyzed and interpreted the data.

A. De Foe: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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