An ecological momentary assessment study investigating the function of hoarding

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Abstract

This study examined the function of hoarding behaviors and the relations between hoarding and a series of cognitive and affective processes in the moment using ecological momentary assessment. A matched-groups design was used to compare college students with higher hoarding symptoms (n = 31) and matched controls (n = 29). The two groups did not differ in what function they reported acquiring served, and positive automatic reinforcement was the most commonly reported function in both groups. Engaging in hoarding-relevant behaviors did not predict change in positive or negative affect when controlling for previous affect. Emotional reactivity and experiential avoidance in the moment were both elevated in the higher hoarding group compared to controls, while momentary mindfulness and negative affect differentiation were lower. Overall, these findings support the importance of emotion regulation processes in hoarding. They also suggest individuals may not be successfully regulating affect in the moment with hoarding behaviors, despite efforts to do so. It may be useful to evaluate processes such as striving for positive affect in hoarding disorder in the future.

Keywords: experience sampling; acquisition; mindfulness; acceptance; mixed-effects location scale models

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Hoarding disorder has an estimated prevalence of at least 1.5% (Nordsletten et al., 2013) and is linked to high functional impairment (Drury, Ajmi, Fernández De La Cruz, Nordsletten, & Mataix-Cols, 2014). Understanding the function of problem behaviors in HD (e.g., acquiring and saving) can help guide behavioral interventions. A functional approach involves clarifying the context in which a behavior occurs (e.g., its antecedents and consequences) in order to intervene on modifiable aspects of the context.

One functional model is the cognitive-behavioral model of hoarding, which suggests that hoarding symptoms (acquisition, saving, and clutter) are maintained by both approaching positive emotions (e.g., urges to acquire, attachment to belongings) and avoidance of distress linked to discarding, and that information processing deficits and beliefs about belongings contribute to these functional processes (Grisham & Barlow, 2005). This model suggests hoarding serves both positive automatic (e.g., increasing excitement or comfort) and negative automatic (e.g., avoidance of anxiety or sadness) functions.

Several studies have provided initial support for the hypothesized avoidance function of hoarding (Ayers, Castriotta, Dozier, Espejo, & Porter, 2014; Wheaton, Abramowitz, Franklin, Berman, & Fabricant, 2011; Wheaton, Fabricant, Berman, & Abramowitz, 2013). One study has found acquiring is linked to both urges and distress, providing some support for both positive automatic and negative automatic functions being relevant (Raines, Allan, Oglesby, Short, & Schmidt, 2015). The cognitive-behavioral model of hoarding could potentially be improved by clarifying whether this hypothesized positive and negative automatic reinforcement occurs during typical acquiring and/or discarding experiences, and testing alternative possible functions for hoarding. For example, it may be useful to consider if a problem behavior serves positive

social (e.g., gaining attention or praise from others) or negative social (e.g., avoiding attention or demands from others) functions (Nock & Prinstein, 2004).

In addition to information processing deficits and beliefs about belongings, emotion regulation processes have been hypothesized to contribute to hoarding. Survey research supports a potential role for lack of emotional clarity (Fernández de la Cruz et al., 2013), heightened experiential avoidance (the tendency to attempt to avoid unwanted thoughts and feelings; Ayers et al., 2014; Wheaton et al., 2011, 2013), and low mindfulness in hoarding (Ong, Krafft, Levin, & Twohig, 2018). In addition, experimental and survey research shows hoarding may be linked to heightened negative emotional reactivity (Hall, Tolin, Frost, & Steketee, 2013; Shaw, Timpano, Steketee, Tolin, & Frost, 2015; Timpano, Shaw, Cougle, & Fitch, 2014).

Processes such as emotional reactivity, experiential avoidance, mindfulness, and emotion differentiation are particularly important to research from a functional perspective because they are modifiable processes that may alter the functions of hoarding. For example, heightened negative emotional reactivity could serve as an establishing operation for escape and avoidance. Persistent experiential avoidance may undermine opportunities for new learning by narrowing behavior (e.g., not only avoiding discarding itself, but also avoiding worries about discarding). Low mindfulness may contribute to the persistence of approach and avoidance behaviors even when they no longer produce their intended consequences (e.g., acquiring an item does not lead to anticipated comfort or excitement), because individuals may fail to notice and learn from their ongoing emotional experience. A lack of emotion differentiation may result in decreased opportunities for alternative coping behaviors (e.g., Barrett, Gross, Christensen, & Benvenuto, 2001) that could interrupt patterns of approach and avoidance in hoarding.

Most studies cited thus far rely heavily on global self-report, which is subject to memory and recall bias (Shiffman, Stone, & Hufford, 2008) and fails to capture the context of behavior as it occurs. Using more immediate and ecologically valid forms of assessment—such as ecological momentary assessment (EMA)—may enhance the accuracy of data collected and help identify functional relationships as they occur (e.g., Kashdan & Farmer, 2014).

In addition, EMA research allows an investigation not just of overall levels of processes like emotional reactivity and mindfulness, but also of their variability. Variability in behavior is increasingly conceptualized as an important process to investigate in psychology. From an evolutionary perspective, variations in behavior allow for a process of natural selection by consequences (Wilson, Hayes, Biglan, & Embry, 2014). For example, variation in mindfulness creates opportunities to learn when present-moment, nonjudgmental awareness is helpful (e.g., when experiencing self-critical thoughts), and when it is not (e.g., when planning for the future).

This study used EMA to examine these functions and processes in naturalistic contexts in a matched-control design comparing college students with elevated hoarding symptoms to those with below-average hoarding symptoms. The overarching aim was to evaluate the function of hoarding behaviors as they occurred and how affective and cognitive processes (emotional reactivity, experiential avoidance, mindfulness, and emotion differentiation) that could contribute to these functions may differ among those with higher hoarding symptoms. We hypothesized that compared to the low hoarding group: 1) the higher hoarding group would report acquiring more often for positive automatic and negative automatic functions, 2) hoarding-relevant behaviors (acquiring, discarding, working with items, and looking for items to acquire) would result in greater change in affect in the higher hoarding group, 3) the higher hoarding group would report higher and less variable emotional reactivity and experiential avoidance, 4) the higher hoarding

group would report lower and less variable mindfulness, and 5) the higher hoarding group would report lower emotion differentiation.

Methods

This study utilized EMA in an analogue group comparison design. A group of participants with elevated hoarding symptoms was compared to a group of matched controls using self-report data collected up to four times each day over one week through a mobile app, hosted on the secure LifeData mobile app platform. This approach allowed for a direct comparison between the responses of the higher hoarding group and controls.

Participants

This study used a convenience sample of 60 undergraduate students at a large public university in the Mountain West. Participants were recruited through flyers, class announcements, an undergraduate research participation platform, and contact after participation in a previous survey study. General inclusion criteria were: 1) being 18 years of age or older and 2) being a student at the authors' institution. Participants in the higher hoarding group were included based on having a score of 34 or higher on the Saving Inventory-Revised (SI-R; Frost, Steketee, & Grisham, 2004). The cutoff of 34 on the SI-R for the nonclinical hoarding group has been used in a previous study (Timpano & Schmidt, 2013) and ensured participants were more than 1 SD above average based on previous research at the same university (Ong et al., 2018). Participants in the low hoarding (control) group had a score of 21 or lower on the SI-R and were matched on age and gender to a participant in the higher hoarding group. The cutoff for the low hoarding group of 21 or lower is similar to the typical mean in other undergraduate samples (e.g., Timpano, Buckner, Richey, Murphy, & Schmidt, 2009; Wheaton et al., 2011) and thus helped to ensure a substantial difference between the two groups. Due to insufficient availability of exactly

age-matched controls, some individuals were invited to participate in the low hoarding group who were not exactly matched on age to a participant in the higher hoarding group.

Sixty-two individuals met initial inclusion criteria. One was removed from the higher hoarding group for completing the screening procedure twice with markedly different responses, and another participant was removed from the low hoarding group for failing to complete the minimum of five EMA questionnaires. This resulted in a final sample of 31 individuals in the higher hoarding symptoms group and 29 individuals in the low hoarding symptoms group. Both groups were young, predominantly female, and mostly non-Hispanic and White, with a median household income in the $40,000-$59,999 bracket (see Table 1 for details).

Procedures

Participants attended an initial in-person meeting at which they completed a baseline survey and received training on how to use and respond to the app. The researchers provided at least one email reminder to reply to the app, and an additional email reminder approximately every 2 days if a participant had not responded to any EMA surveys in that time. The mobile app prompted the participants to respond to a brief survey consisting of the EMA measures four times per day over a period of seven days. Participants had a 15-minute time window in which to respond as self-report data change qualitatively after 15 minutes (Delespaul, 1995).

The prompts were administered at random during four specified time intervals evenly distributed throughout the day: 10:00 AM to 1:00 PM, 1:00 PM to 4:00 PM, 4:00 PM to 7:00 PM, and 7:00 PM to 10:00 PM. Participants received research credit and a gift card worth up to $15 for their participation (specifically, they were provided $3 for the initial meeting, $0.25 per EMA survey completed, and $5 for completing a brief posttreatment survey).

Baseline measures

Hoarding symptoms. Hoarding symptoms were assessed with the Saving Inventory-Revised (Frost et al., 2004), a 23-item measure of overall hoarding severity. This measure has been demonstrated to have good reliability and validity (Frost et al., 2004).

Depression. Depression was assessed with the 34-item version of the Counseling Center Assessment of Psychological Symptoms (CCAPS-34; Locke et al., 2012). Six items assessing depression on a scale from 0 to 4 are averaged to generate a depression score. The CCAPS has good reliability and validity in student samples (Locke et al., 2012).

EMA measures

Hoarding behaviors. Hoarding behaviors were assessed with four yes/no questions, on acquiring ("Have you bought or otherwise acquired any new belongings since the last prompt? 'Belongings' refers to items that you plan to save and that are not necessities."), discarding ("Have you thrown out or gotten rid of any belongings since the last prompt? 'Belonging' refers to items that you were saving that are not necessities."), working with items ("Have you looked through, sorted, or organized your belongings since the last prompt?") and looking for items to acquire ("Have you looked for items you might buy or acquire since the last prompt? This refers to objects that you would plan to keep around, that are not necessities.") If participants reported any of these behaviors, they were further asked how long ago the behavior occurred.

Function of acquisition. If participants indicated that they had acquired something, they were also prompted with a follow-up question asking about the intended function of the behavior ("Indicate why you bought/acquired the item(s)"). Participants could select multiple responses, with one response each indicating automatic positive reinforcement ("Made me feel good"), automatic negative reinforcement ("Distract myself from thought/feeling"), social positive reinforcement ("To get attention or to get a reaction from someone"), and social negative

reinforcement ("To escape from a task/people"), or another function/reason ("Other"). These items were based on the items used in Nock, Prinstein, and Sterba (2009) which were derived from the Functional Assessment of Self Mutilation (FASM) measure (Lloyd, Kelley, & Hope, 1997). However, items were adapted for clarity and relevance (specifically, by replacing "Feel something" with "Made me feel good," "Rid of thought/feeling" with "Distract myself from thought/feeling," "To communicate" with "To get attention or get a reaction from someone," and "Escape task/people" with "To escape from a task/people.")

Recent stressors. Recent stressors were assessed with a novel item, "Have you experienced any stressful events since the last prompt? There are many types of stressful events. Examples include hurrying to meet a deadline, having an argument, being sick, etc." The response options were yes/no.

Positive and negative affect. Participants were asked to rate their affect "right now" on a 5-point scale from 1 (very slightly or not at all) to 5 (extremely). This measure included four items assessing positive affect (*content, relaxed, enthusiastic,* and *joyful*) and four items assessing negative affect (*anxious, angry, sad,* and *sluggish*). These items were developed by Kashdan and Farmer (2014) to assess positive and negative affect in accordance with the circumplex model of emotion (Barrett, 1998). For this study, "anxious/nervous" was changed to "anxious" for simplicity of response.

Experiential avoidance. Experiential avoidance was measured using three items developed by Udachina, Varese, Myin-Germeys, and Bentall (2014) to assess state experiential avoidance. The items are "Since the last prompt my emotions have got in the way of things which I wanted to do," "Since the last prompt I've tried to block negative thoughts out of my mind," and "Since the last prompt I've tried to avoid painful memories." Each item is scored

from 1 (“not at all”) to 7 (“very much”) and a total score is calculated by taking the mean of each response. These items were found to have good internal consistency in Udachina et al. (2014) and were also used as an EMA measure in Varese, Udachina, Myin-Germeys, Oorschot, and Bentall (2011). In the present sample these items had adequate internal consistency ($\alpha = 0.79$).

State mindfulness. State mindfulness was measured using the state version of the MAAS (Brown & Ryan, 2003). This measure consists of five items rated on a 7-point scale. The anchors are typically 0 (“not at all”) to 6 (“very much;” Brown & Ryan, 2003) but were altered for the present study to 1 to 7 to match the measure of experiential avoidance. The instructions were also slightly revised to better fit the present study, and stated for each item, “Please indicate the degree to which you were having this experience when you received the notification.” All items are reverse scored and a total score is calculated by averaging the responses. This version of the MAAS has good reliability and has adequate evidence for validity (Brown & Ryan, 2003). The state MAAS had good internal consistency in this sample ($\alpha = 0.88$).

Analysis Plan

Self-reported function of acquisition. Generalized linear mixed-effects models with a logit link function were used to test whether group (higher hoarding or low hoarding) significantly predicted the likelihood of endorsing different functions of acquisition across the study period. Age was included as a covariate. We modeled random intercepts for participants in order to account for the nested nature of the data (e.g., many observations for each participant).

In addition, the relative frequency of self-reported functions was compared using paired-sign tests. First, proportions were computed for each participant indicating how often a given function was endorsed relative to total acquiring events. Then paired-sign tests were conducted to determine if any proportions for specific functions were significantly larger than others,

indicating whether any intended functions were endorsed more often compared to other possible intended functions. Paired-sign tests were used due to the non-normal and non-symmetrical distribution of the differences between proportions.

Changes in affect following hoarding-relevant behaviors. A series of mixed-effects models (with a random intercept for participant) tested whether the occurrence of a hoarding-relevant behavior (acquiring, discarding, working with items, and looking for items) was associated with affect when controlling for previous affect. These models predicted either positive or negative affect, with the first step adding main effects for previous affect, group, age, and whether or not the behavior occurred, followed by an interaction term (Group x Behavior) to allow for modeling differential effects in the higher hoarding group and low hoarding group. These models were designed to test whether or not engaging in a hoarding-relevant behavior leads to a significant change in either positive or negative affect, and whether the impact of these behaviors on affect was different in the higher hoarding group and the low hoarding group.

For all mixed-effects models including location-scale models described below, likelihood ratio tests comparing nested models were used to confirm that models with statistically significant fixed effects, or models with random slopes added, improved upon simpler models (i.e., adding these parameters resulted in a model that better fit the data). If additional effects did not improve model fit, they were omitted. Only parameter estimates from the final models are reported. All models were examined to confirm they met the assumptions of homoscedasticity and normal distribution of residuals.

Mixed-effects location-scale models. Analyses of group differences on experiential avoidance, mindfulness, and emotional reactivity employed mixed-effects location scale analyses, an extension of mixed-effects regression models that use log-linear submodels to

model, and account for the influence of covariates on, between-subjects and within-subjects variance (Hedeker, Mermelstein, & Demirtas, 2008). In intensive longitudinal data, respondents can vary in terms of their individual mean (i.e., "location" or intercept), and also their within-individual variability (i.e., "scale") around their mean. In all models below, the intercept and variability of dependent variables were allowed to correlate. Importantly, these models allow for the inclusion of subject-level and within-subject (time-varying) independent variables to predict not only between-subject but also within-subject variance. In this case, subject-level covariates were hoarding group (low or higher) and age. An additional random term models between-individual differences in within-person variability that are not accounted for by the covariates. The MIXWILD program (Hedeker & Dunton, 2018) was used to compute these analyses.

The experiential avoidance, mindfulness, and emotional reactivity models were developed using a stepwise approach. A null model was generated employing a random intercept to account for the multilevel nature of the data (time points within persons). Next, group was tested as a subject-level covariate predicting the level of the dependent variable to determine if the higher hoarding group had higher experiential avoidance, lower mindfulness, and/or higher negative affect. At this step, age was included as a covariate, and stressor was included as a covariate for the emotional reactivity model only. Then an effect was added for group predicting the within-subject variance in the dependent variable, to determine if the higher hoarding group was more rigid (i.e., less variable) on the outcome. Parameter estimates for the impact of predictors on within-subject variance (τ) are in the natural log scale. In the emotional reactivity model only, subsequent steps added the interaction of stressor and group as a predictor of the level of negative affect, followed by the interaction of stressor and group as a predictor of within-subject variance in negative affect. Random slopes were also tested at the participant level

for each model to determine whether or not there was a significant amount of variation over time for different individuals. Adding random slopes allows models to account for individual differences in the slope of the dependent variables over time due to study reactivity or other unmeasured individual-level variables. In all mixed-effects models, time was calculated as the number of days since beginning the EMA period of the study.

Emotion differentiation. Emotion differentiation was estimated by calculating the two-way random intraclass correlations (ICCs) with absolute agreement between positive/negative affect descriptors across assessment points for each participant, consistent with previous studies in this area (e.g., Kashdan & Farmer, 2014; Tugade & Barrett, 2005). This method results in a single, between-subjects variable representing the degree to which individuals are, on average, differentiating between specific emotions over a given time period. Higher ICCs indicate that an individual is engaging in less differentiation of specific emotions (i.e., they are more often reporting the same levels of different specific emotions such as sadness and anxiety). Two emotion differentiation models were built, with positive and negative affect differentiation as the dependent variables. Simple linear regression was then used to test whether the higher hoarding group differentiated less between specific emotions (positive or negative) compared to controls. A similar approach has been used in previous studies (e.g., Kashdan & Farmer, 2014).

Results

Missing data

Participants were excluded from further analysis if they failed to complete a minimum of five EMA questionnaires (n = 1) consistent with standard practice of dropping participants with very low response rates in EMA studies (e.g. Bylsma, Taylor-Clift, & Rottenberg, 2011; Kashdan & Farmer, 2014). Compliance with the EMA procedure did not differ significantly

between groups. Those in the low hoarding (control) group completed a total of 568 questionnaires (69.96% of the questionnaires administered to them, and an average of 19.59 per participant), while those in the high hoarding group completed a total of 547 (63.04% of the questionnaires administered to them, and an average of 17.65 per participant). The total overall rate of missing questionnaires was 33.63%. Missing data were handled using maximum likelihood estimation. Generalized linear mixed-effects models were used to test whether baseline variables (group, hoarding severity, depression, age, or gender) significantly predicted missingness on any momentary variables (positive affect items, negative affect items, experiential avoidance, or mindfulness). No baseline variables significantly predicted missing data (ps > 0.05), supporting the assumption of data missing at random, which can be modeled appropriately with maximum likelihood estimation (Enders, 2001). Rates of hoarding-relevant behaviors were relatively low in each group (see Table 1), perhaps due to the brief timeframe.

Preliminary analyses

The low hoarding and higher hoarding groups were compared on baseline variables with *t*-tests and χ^2 tests to determine if there were differences on any theoretically relevant variables. The higher hoarding group had significantly higher scores for hoarding symptoms (t (47.30) = 18.96, Cohen's d = 4.81, p < .001), as well as depression (measured with the CCAPS-34; Locke et al., 2012; t (49.84) = 3.35, d = 0.85, p = 0.002), and was significantly older (t (41.95) = 2.41, d = 0.61, p = 0.02). The two groups did not differ significantly on other baseline variables. Age was included as a covariate in all subsequent analyses in which group was a predictor. Depression was not included as a covariate in all analyses as it is very frequently comorbid with hoarding, to the extent that it is unclear if we would accurately capture the effects of overall hoarding severity after controlling for depression. However, models with depression covaried

were also tested, and compared to results for models without depression in order to confirm that group differences were not solely attributable to depression.

Given that looking for items to acquire and working with items were the most common behaviors reported, their pairwise correlations with other relevant behaviors were calculated. In the higher hoarding group, looking was correlated with acquiring ($r = 0.49$, $p < 0.01$) and working ($r = 0.44$, $p < 0.05$), but not discarding ($p > 0.05$), and working was further correlated with discarding ($r = 0.56$, $p < 0.01$) but not acquiring ($p > 0.05$). In the low hoarding group, looking was not significantly associated with any other behavior, but working was correlated with both acquiring ($r = 0.52$, $p < 0.01$) and discarding ($r = 0.63$, $p < 0.001$). No other pairwise correlations were significant.

What are the self-reported functions of acquiring in each group?

Group was not a statistically significant predictor of endorsing any specific function (all ps > 0.05), so we cannot conclude that there are differences between groups in the function acquiring serves. The effect of group remained nonsignificant in each model after controlling for baseline depression (ps > 0.05).

In the higher hoarding group, a positive automatic function was endorsed in 56% of acquiring events (compared to 43% in the low hoarding group), a negative automatic function was endorsed in 21% of acquiring events (compared to 5% in the low hoarding group), a positive social function was endorsed in 15% of acquiring events (compared to 11% in the low hoarding group), a negative social function was endorsed in 16% of acquiring events (compared to 6% in the low hoarding group), and another unspecified reason for acquiring was reported in 44% of acquiring events (compared to 55% in the low hoarding group).

In the higher hoarding group, paired sign tests indicated the proportion of acquiring events with a positive automatic function was significantly larger than the proportion of acquiring events with a negative automatic function ($p = 0.002$, Cohen's $d = 0.71$), positive social function ($p = 0.004$, $d = 0.80$), or negative social function ($p = 0.001$, $d = 0.84$). There were no other significant differences between any proportions. This pattern of results was replicated in the low hoarding group: the proportion of acquiring events with a positive automatic function was significantly larger than the proportion of events with a negative automatic function ($p = 0.04$, $d = 0.73$), positive social function ($p = 0.03$, $d = 0.68$), or negative social function ($p = 0.04$, $d = 0.62$). In the low hoarding group, there were also no other significant differences between any proportions. It was not possible to control for depression or age in these analyses as paired sign tests do not allow for covariates.

Does affect change following a hoarding-relevant behavior, and does this vary by group?

The occurrence of hoarding-relevant behaviors did not predict subsequent positive or negative affect when controlling for affect at the previous time point in any of the models. In other words, whether or not participants engaged in these hoarding-relevant behaviors did not appear to influence subsequent affect. There were also no significant interactions between group and behavior, indicating that engaging in hoarding-relevant behaviors did not have a significantly different impact on positive or negative affect in the higher hoarding group compared to the low hoarding group. None of these results differed (i.e., no significant effects of group or a group-by-time interaction were found) when controlling for baseline depression.

Does the higher hoarding group have higher or less variable emotional reactivity?

The interaction between group and stressor ($b = 0.19$, SE = 0.07, $p < 0.01$) was significant in predicting the level of negative affect (see Table 2). Specifically, those in the

higher hoarding group had greater increases in negative affect compared to those in the low hoarding group after stressful events (see Figure 1 for a model plot), indicating greater negative emotional reactivity. There were also significant main effects of group (b = 0.33, SE = 0.08, p < 0.001) and stressor (b = 0.40, SE = 0.03, p < 0.001) on level of negative affect. Age was included in the model but was not a significant predictor (b = 0.02, SE = 0.01, p = 0.11). Group significantly predicted within-subject variance (τ = 0.40, SE = 0.18, p < 0.05) in the log-linear submodel, such that variance was higher in the higher hoarding group. The interaction of group and stressor did not significantly predict within-subject variance (p > 0.05) therefore that effect was not retained in the final model. Finally, adding random slopes in negative affect for each participant over time significantly improved model fit (χ^2 (1) = 9.12, p < 0.01). That is, slopes (i.e., change over time) for negative affect were allowed to vary by participant, and adding this effect significantly improved the model. The effects of group and the interaction of group and stressor remained significant (ps < 0.05) after adding depression as a predictor of negative affect.

Does the higher hoarding group report higher or less variable levels of experiential avoidance?

Group significantly predicted experiential avoidance (b = 0.88, SE = 0.30, p = 0.003) while age (b = -0.04, SE = 0.04, p = 0.20) did not (see Table 2). Experiential avoidance was higher among those in the higher hoarding group. Group also significantly predicted within-subject variance in momentary experiential avoidance in the log-linear submodel (τ = 0.97, SE = 0.26, p < 0.001). This means that within-subject variance in momentary experiential avoidance was significantly higher in the higher hoarding group compared to the low hoarding group, contradicting the study hypothesis that the higher hoarding group would have less variability in experiential avoidance. Random slopes for time also improved model fit (χ^2(1) = 17.02, p <

0.001) and were therefore retained. The effect of group remained significant ($p < 0.05$) after including depression as a covariate.

Does the higher hoarding group report lower or less variable levels of state mindfulness?

Group was a significant predictor of mindfulness (b = -1.11, SE = 0.20, $p < 0.001$) while age (b = 0.05, SE = 0.03, p = 0.08) was not (see Table 2). State mindfulness was significantly lower in the higher hoarding group. Group also significantly predicted within-subject variance in state mindfulness (τ = 0.83, SE = 0.29, p = 0.004) in the log-linear submodel. This means that within-subject variance in state mindfulness was significantly higher in the higher hoarding group compared to the low hoarding group, contradicting the study hypothesis that the higher hoarding group would have less variability in state mindfulness. Once again, random slopes for time were added and improved model fit ($\chi^2(1) = 7.77$, p = 0.005) and were therefore retained. The effect of group remained significant after controlling for depression ($p < 0.05$).

Does the higher hoarding group have lower emotion differentiation?

The average ICC for negative affect was M = 0.37 (SD = 0.04) in the higher hoarding symptom group and M = 0.24 (SD = 0.04) in the low hoarding group. The two groups were very similar in their ICCs for positive affect (M = 0.79, SD = 0.03 in the higher hoarding group compared to M = 0.78, SD = 0.02 in the low hoarding group).

Group significantly predicted the negative affect ICCs (b = 0.14, SE = 0.06, p = 0.02), and age was not a significant predictor (b = 0.001, SE = 0.007, p = 0.90). This means that those in the higher hoarding group differentiated less between specific negative emotions relative to the low hoarding group. After inspecting residuals, one outlier was removed from the linear regression model predicting positive affect. Neither group (b = 0.05, SE = 0.03, p = 0.14) nor age (b = -0.003, SE = 0.004, p = 0.55) significantly predicted positive affect ICCs. After controlling

for baseline depression, group still significantly predicted the ICC for negative emotion differentiation ($p < 0.05$), but not positive emotion differentiation ($p > 0.05$).

Discussion

Although acquiring and discarding have been hypothesized to serve positive automatic and negative automatic functions, there is limited research on the function of hoarding behavior at the time it occurs. This study used ecological momentary assessment to investigate the function of hoarding behaviors in context and to evaluate if emotional reactivity and emotional regulation processes (experiential avoidance, mindfulness, and emotion differentiation) in daily life are linked to hoarding. Overall, results suggest that acquiring may be done as an attempt to increase positive affect, but that it is possible affect may not change significantly following acquiring or discarding. This study further found that emotional reactivity, experiential avoidance, mindfulness, and negative emotion differentiation in daily life are linked to hoarding.

In contrast to study hypotheses, the higher hoarding group did not endorse any particular function of acquiring at significantly different rates compared to the low hoarding group. However, the number of acquiring events was low ($n = 78$ out of 1115 total EMA responses) so power was limited to test questions specific to acquiring events. Within both groups, a positive automatic function was endorsed significantly more often than any of the other specific functions (negative automatic, positive social, and negative social). This suggests the possibility that acquisition in hoarding may be driven by seeking to achieve positive internal states. While a large body of research exists on how people who hoard experience and respond to negative affect (e.g., Shaw et al., 2015; Timpano, Keough, Traeger, & Schmidt, 2011; Wheaton et al., 2013), there is relatively little research on the potential role of positive affect in hoarding. One factor analytic study supported a distinct role for positive emotions in acquiring (Raines et al., 2015),

and high rates of comorbidity between hoarding and impulse control disorders also suggest that urges to seek stimulation or comfort by acquiring or saving may be an important process (Frost, Meagher, & Riskind, 2001; Samuels et al., 2008). The results of this study are distinct from previous research (e.g., Raines et al., 2015) in suggesting a particularly important role of positive emotions in acquiring. However, acquiring events were relatively low, with participants reporting a higher rate of looking for items to acquire. Given that looking for items to acquire was correlated with, and more common than actual acquisition, it would be useful in future research to examine if looking for items is also done with the aim of increasing positive affect.

Surprisingly, neither positive or negative affect changed following engaging in a hoarding-related behavior (acquiring, discarding, looking for items to acquire, or working with items) in either group. This was also in contrast to study hypotheses, which predicted greater impact of hoarding behaviors on affect in the higher hoarding group. Power was limited for these models as acquiring and discarding were endorsed relatively infrequently. If these findings were replicated with sufficient power, it would suggest that hoarding behaviors are not maintained primarily through real changes in affect and that the actual impact of acquisition on affect may be different from its intended function. That is, individuals may acquire in order to achieve greater positive affect but possibly find that this does not actually occur.

Such a discrepancy could theoretically be due to inattention (not noticing actual consequences of behavior). This study did not have the precision to determine if inattention is related to such a discrepancy, but future research should explore this possibility. If this is the case, teaching mindfulness could help people who hoard to better observe their actual experience (i.e., acquiring is ineffective at increasing positive affect). Another possibility is that people who hoard have different attitudes toward positive affect. Attitudes toward positive affect have

recently come to be understood as an important contextual variable in psychopathology. For example, highly valuing happiness is associated with decreased well-being (Tamir & Ford, 2012). Determining if those who hoard tend to overvalue or ineffectively strive towards positive affect could help explain why certain people are more vulnerable to these urge-related aspects of hoarding. An alternative explanation is that acquiring does lead to an increase in positive affect, but only intermittently. Behaviors that are intermittently reinforced are particularly resistant to change (see Pittenger, 2002 for a review). Thus, a pattern of intermittent reinforcement of acquiring in hoarding could also explain the lack of observed impact on positive affect and why this behavior is difficult to stop.

Individuals in the higher hoarding group experienced a greater increase in negative affect in the context of stress compared to the low hoarding group, indicating heightened emotional reactivity consistent with predictions. Those in the higher hoarding group reported higher levels of experiential avoidance and lower levels of state mindfulness compared to controls, which was also consistent with study hypotheses. These findings support previous research regarding emotional reactivity (Shaw et al., 2015; Timpano, Shaw et al., 2014), experiential avoidance (Ayers et al., 2014; Fernández de la Cruz et al., 2013; Wheaton et al., 2011), and mindfulness (Ong et al., 2018) and extend these findings into a naturalistic setting. However, this study was not designed to evaluate levels of mindfulness or experiential avoidance specifically during hoarding behaviors, and this topic should be explored in future studies. It would be particularly useful to examine whether emotional reactivity, experiential avoidance, and mindfulness predict looking for items to acquire or working with items given the frequency of these behaviors and their correlations with acquiring and discarding respectively in the higher hoarding group.

In contrast to study hypotheses, individuals in the higher hoarding group had more variable experiential avoidance, state mindfulness, and negative affect in the context of stress. However, visual inspection of the raw data suggested that the difference in variability was likely because more individuals in the low hoarding group reported minimal negative affect and experiential avoidance, and the highest possible levels of state mindfulness, leaving little margin in which variability could occur. Although this finding was unexpected, it has clinical implications, as it indicates that those in the higher hoarding group were not equally avoidant, inattentive, or emotionally reactive at all times. Therefore, it may be possible to increase the skills of acceptance and mindful awareness and decrease reactivity by helping individuals who hoard notice when they are less avoidant, reactive, or inattentive, and generalize those skills.

As predicted, there was also a significant difference between the two groups in negative emotion differentiation, which suggests that people who hoard may have a skills deficit in distinguishing specific emotions. Differentiating emotions appears to facilitate effective emotion regulation (Barrett et al., 2001). Future studies should test whether teaching emotion differentiation results in improvements in emotion regulation among those with hoarding problems. However, there was no difference in positive emotion differentiation.

It is possible that emotion regulation difficulties (heightened experiential avoidance, lower mindfulness and emotion differentiation) contribute to both experiencing greater negative affect and putting more effort into achieving positive affect through acquisition or other means. However, it is surprising that no changes in negative affect were observed after hoarding behaviors, as they are theorized to serve a negative automatic reinforcing function (Frost & Hartl, 1996; Steketee & Frost, 2003). It is possible that this null result was related to limited power given the small number of discarding events reported. However, this finding is consistent

with another study that found people who hoard anticipate greater distress than clinical controls when discarding personal belongings, but do not experience increased distress immediately after discarding a personal possession (Frost, Ong, Steketee, & Tolin, 2016). Such findings raise the possibility that avoidance of discarding in HD is due to anticipated distress and inattention to actual experience, rather than discarding causing distress directly.

Experiential avoidance, mindfulness, and emotion differentiation are all processes related to the *context* of thoughts and emotions (e.g., patterns of responding to internal experiences), rather than their *content* (e.g., what the thoughts and emotions are). Contextual approaches to psychopathology focus on changing the impact of difficult thoughts and feelings on behavior, rather than changing those thoughts and feelings directly (Hayes, Villatte, Levin, & Hildebrandt, 2011). Applied to hoarding, a contextual approach would suggest that urges to acquire or distress about discarding are not inherently problematic. Instead, they cause problems when an individual reacts to them automatically, and habitually attempts to avoid unpleasant feelings or strive for pleasant ones. From this broad perspective, these findings are consistent with past research in hoarding that highlights the importance of distress tolerance (Timpano et al., 2009), anxiety sensitivity (Timpano et al., 2009), and metacognitions (Timpano, Rasmussen, Exner, Rief, & Wilhelm, 2014), as these are also processes that describe *how* a person relates to distress, anxiety, and their thoughts. Such findings provide initial support for using contextual cognitive-behavioral interventions such as mindfulness and acceptance-based treatment (Hayes et al., 2011), which address patterns of responding to thoughts and feelings.

A few limitations should be considered. The study used an analogue sample, which means that replication in a clinical population is necessary in order to ensure generalizability. The sample is also largely White, mostly female, and all participants were students, so results

may not generalize to other groups. This study also failed to achieve exactly matched groups due to difficulty finding age-matched controls for all hoarding participants. Age was controlled for statistically in all analyses reported. However, it is possible that the differences in age also resulted in differences in other unmeasured but important variables.

In addition, the EMA measures of daily stressors, affect, experiential avoidance, hoarding symptoms, and function of acquisition lacked thorough validation, so we cannot be certain that they are accurately measuring the desired constructs. However, most of these measures were selected because they have been used successfully in previous studies and measure the intended constructs in a theoretically sound manner. These items also require insight, which can be lacking in hoarding. Replicating these findings with more objective measures would be highly beneficial. In addition, although study compliance was acceptable, there were high rates of missing data, as is typical in studies that use ecologically valid methods (e.g., Courvoisier, Eid, & Lischetzke, 2012; Morren, van Dulmen, Ouwerkerk, & Bensing, 2009). Maximum likelihood estimation was used to account for missing data, and it is able to estimate model parameters well even with large amounts of missing data when the data are missing due to observed variables (Hedeker & Gibbons, 2006). However, if data are missing due to other, unobserved variables, then it is possible that the resulting model parameters are inaccurate (Hedeker & Gibbons, 2006).

Another limitation to the current study is that power was limited to detect changes in affect and intended function linked to hoarding behaviors because relatively low rates of these behaviors occurred during the one-week study period. This study should be replicated with sufficient power in order to conclusively determine whether it is accurate to conclude that acquiring serves the same functions in people who hoard and healthy controls, and that hoarding behaviors do not significantly impact affect. In addition, we did not measure affect immediately

before and after hoarding-relevant behaviors, as questionnaires were initiated at random time-points. This means it is possible that affect changed following hoarding-relevant behaviors, but in a brief timeframe. Future studies of this nature could use a larger or more severe sample, longer time period, or event-contingent responding in order to provide greater power.

Overall, these results provide support for acquisition having an intended positive automatic function and the processes of emotional reactivity, experiential avoidance, mindfulness, and emotion differentiation being relevant to hoarding. As no changes in positive or negative affect following hoarding-relevant behaviors were observed, the results also suggest potential discrepancies between the intended and experienced consequences of hoarding behaviors. Future studies should investigate if there are similarities or discrepancies between the intended function of hoarding-related behaviors and their actual functions in the moment, and if those relationships are impacted by mindfulness or other contextual factors.

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Table 1. *Demographic information*

	Low hoarding group (n = 29)	Higher hoarding group (n = 31)	Difference
Hoarding symptoms			
M (SD)	15.31 (4.42)	46.71 (8.01)	t (47.30) = 18.96, p < .001
Depression			
M (SD)	0.57 (0.56)	1.24 (0.93)	t (49.84) = 3.35, p < 0.01
Age			
M (SD)	20.41 (2.16)	22.74 (4.88)	t (41.95) = 2.41, p < 0.05
Gender			
Female	22 (75.86%)	23 (74.19%)	χ^2 (1) = 0.02, p = 0.88
Male	7 (24.14%)	8 (25.81%)	
Ethnicity			
Hispanic	1 (3.45%)	1 (3.23%)	χ^2 (1) = 0.00, p = 0.96
Non-Hispanic	28 (96.55%)	30 (96.77%)	
Race			
Asian	0	2 (6.45%)	χ^2 (1) = 4.61, p = 0.26
Biracial	0	1 (3.23%)	
White	29 (100%)	27 (87.10%)	
Other	0	1 (3.23%)	
Household income			
Median	$40,000-$59,999	$40,000-$59,999	χ^2 (6) = 4.61, p = 0.59
EMA questionnaires completed			
M (SD)	19.59 (4.98)	17.65 (4.88)	t (57.57) = -1.52, p = 0.13
Acquiring frequency			
M (SD)	0.83 (0.85)	1.74 (1.59)	t (46.41) = 2.80, p < 0.01
Discarding frequency			
M (SD)	0.24 (0.64)	0.84 (1.51)	t (40.90) = 2.02, p < 0.05
Working w/ items frequency			
M (SD)	1.72 (1.33)	3.00 (2.70)	t (44.49) = 2.35, p < 0.05
Looking for items to acquire frequency			
M (SD)	2.10 (1.99)	4.42 (3.70)	t (46.59) = 3.04, p < 0.01

Note: EMA = ecological momentary assessment.

Table 2. Mixed-effects location scale model results

	Experiential avoidance	Mindfulness	Negative affect
Intercept	2.85 (0.78)***	2.96 (0.59)***	1.48 (0.25)***
Age *B*	-0.04 (0.04)	0.05 (0.03)	0.02 (0.01)
Group *B*	0.88 (0.30)**	-1.11 (0.20)***	0.33 (0.08)***
Stressor *B*			0.40 (0.03)***
Group x Stressor *B*			0.19 (0.07)**
Random intercept variance	0.90 (0.19)***	0.62 (0.12)***	0.09 (0.02)***
Random slope variance	0.001 (0.001)	0.001 (0.001)	0.002 (0.001)*
Random intercept-slope covariance	0.02 (0.01)	0.02 (0.01)**	0.001 (0.003)
Log-linear model of WS variance			
Intercept	-0.94 (0.19)***	-1.02 (0.21)***	-1.50 (0.09)***
Group τ	0.97 (0.26)***	0.83 (0.29)**	0.40 (0.18)*

Note. WS = within-subject. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.
Groups are dummy coded such that 0 = Control, 1 = Higher Hoarding group. Group and stressor are mean centered in the Negative Affect model.

Figure 1. *Predicted negative affect based on group and stressor*