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Pavlovian-to-instrumental transfer effect after devaluation as indicator of habitual behavior together with stress responsivity predicts daily use of buying-shopping platforms☆

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ABSTRACT

Background and aims: Stress responsivity and habitual behaviors are related to problematic online buying-shopping (BSh) according to the Interaction of Person-Affect-Cognition-Execution (I-PACE) model. This study aimed to investigate if symptoms of problematic online BSh, an experimental indicator of habitual behavior and the interaction of potentially habitual behavior and stress responsivity predict everyday use of buying-shopping platforms.

Participants: The study comprised participants with risky (n = 27) and non-problematic (n = 28) online BSh.

Design and measurements: A Pavlovian-to-instrumental transfer paradigm with devaluation (PIT-dev) was administered. Changes of cortisol stress level after an acute stressor were measured. A subsequent end-of day ambulatory assessment captured use time of buying-shopping platforms for 14 days. Multilevel analyses with collapsed groups were computed.

Findings: Symptoms of problematic online BSh were related with higher everyday use of shopping platforms. The PIT-dev effect solely was not associated with use time of buying-shopping platforms but interacted with cortisol stress responsivity on use time. If stress responsivity was low, PIT-dev effect negatively influenced use time. If stress responsivity was high, PIT-dev effect showed positive associations with use time. The latter effect was more pronounced in persons with more problematic BSh.

Conclusions: The findings indicate an interplay between stress responsivity and habitual behaviors on everyday use of buying-shopping platforms, aligning with the I-PACE model. Future research should investigate long-term longitudinal effects of habit formation in the development of problematic online BSh. Clinical implications include building and implementing functional habits for stressful events to counteract shopping-specific habits facilitated by stress.

1. Introduction

Habit formation and seemingly habitual behaviors may be related to the development and maintenance of both substance use disorders and behavioral addictions as it is postulated in current theoretical models such as the Interaction of Person-Affect-Cognition-Execution (I-PACE) model and in dual-process models/theories that consider a shift from actions to habits to compulsions a central process in the course of

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addictions (Brand et al., 2019, 2025; Everitt & Robbins, 2005, 2016). Empirical studies in the field of behavioral addictions have provided mixed evidence regarding seemingly habitual behavior (e.g., van Timmeren et al., 2023; Wyckmans et al., 2019, 2022; Zhou et al., 2021) and the strict concept of habits as "goal-free" has been questioned (e.g., Hogarth, 2020). Further psychological processes involved in substance-related and non-substance related addictive disorders are conditioning processes (e.g., Heinz et al., 2019). Pavlovian and instrumental conditioning can be intertwined (Heinz et al., 2019), for example if conditioned cues influence instrumental behavior, a phenomenon called Pavlovian-to-instrumental transfer (PIT). PIT paradigms usually involve a transfer phase in which the effect of Pavlovian conditioning on instrumental behavior is investigated (Garbusow et al., 2022). If PIT paradigms are complemented by a devaluation procedure before or in the transfer phase, seemingly habitual behavior can be dissociated from goal-directed behavior as the latter is sensitive to a reduction or elimination of rewards (Hogarth, 2020). This devaluation procedure was employed in the study by Thomas et al. (2025) in which the majority of the participants gained awareness of the experimental contingencies (i. e., that a certain previously neutral stimulus is repeatedly associated with gaming and another one with shopping) in the Pavlovian training phase. Also, the employed devaluation reduced overall instrumental responding for shopping-specific rewards in the transfer phase. Both findings indicated that the PIT paradigm with devaluation showed validity and that participants reacted as expected. Also, modulation effects of acute stress response on the impact of problematic online buying-shopping (BSh) severity on shopping PIT effects after the devaluation (i.e., habitual behavior) were found. In an exploratory analysis, seemingly habitual behavior occurred particularly in participants with more problematic online BSh that showed high stress responsivity to an acute stressor (i.e. Trier Social Stress Test, TSST, Kirschbaum et al., 1993). Embedding these findings into the I-PACE model for behavioral addictions, high stress responsivity represents not only a vulnerability factor but might also function as an acute trigger that can contribute to habit formation and seemingly habitual behaviors. This mechanism can lead to "specific addictive behaviors" (Brand et al., 2019, p. 3), in this context for instance problematic online BSh. However, these conclusions refer to dimensional analyses reported in Thomas et al. (2025) and partly contradict the analyses carried out with stress induction as a factor (TSST vs. placebo condition). There was no main effect of stress condition on the shopping-specific response choice in the transfer part of the PIT paradigm. Thus, there is a need for further investigations of the potential interplay of shopping-specific seemingly habitual behavior and stress responsivity within the addiction framework. Besides, if habitual behaviors measured by PIT effects after devaluation in the laboratory study also have implications for use patterns in daily life (e. g., measured by subsequent ambulatory assessment (ambA)), remains a question for further research. The analyses referred to in Thomas et al. (2025) are restricted to laboratory-based cross-sectional data so that habitual behaviors could not be related to daily use of online shopping in a naturalistic setting. Generally, experimental data on habitual behavior (e.g., using the PIT paradigm) in (behavioral) addictions have been rarely combined with data from another measurement point longitudinally which has been recently criticized by Hogarth (2024). Xu et al. (2024) conducted a study in which specific monetary PIT effects were positively correlated with self-reported weekly gaming hours at a four-month follow-up in persons with internet gaming disorder, but not in persons with recreational gaming. In addition, Steins-Loeber et al. (2025) recently reported that a 'Shopping'-PIT-effect (indicating cue-triggered responding for a non-devalued general online-related reward which may be considered a monetary reward), in interaction with baseline symptom severity significantly predicted higher gaming disorder symptoms at the six-month follow-up assessment. Further support for the predictive validity of monetary PIT effects comes from substance use disorders in which monetary PIT effects in participants with alcohol use disorders have been linked to risk of relapse (Chen, Schlagenhauf, et al., 2023). Also, neural correlates of the PIT-paradigm have been associated with the risk of relapse in persons with alcohol use disorders in two studies (Chen, Schlagenhauf, et al., 2023; Sekutowicz et al., 2019). To the best of our knowledge, no study in the field of compulsive buying-shopping disorder (CBSD)/problematic online BSh has used shopping PIT effects to predict everyday use of shopping platforms.

Ecological momentary assessments (EMA) and ambA represent an important source of information that is close to naturalistic, daily behavior and that is considered more ecologically valid than questionnaire-based or laboratory data (Ebner-Priemer & Trull, 2009). EMA and ambA have been applied to various mental disorders (e.g., Knorr et al., 2025; Serre et al., 2015; Walz et al., 2014; Wenze & Miller, 2010). Two EMA studies examined relations between daily stress and compulsive buying episodes in clinical samples with CBSD (A. Müller et al., 2012; Silbermann et al., 2008). While one study reported more daily stress on days with compulsive buying events compared to days without compulsive buying events (Silbermann et al., 2008), the other study did not observe between-day differences and also no changes in daily stress prior to/after compulsive buying episodes in the within-day analyses (Müller et al., 2012). None of these studies have however investigated the impact of laboratory-based predictors such as salivary cortisol stress reactivity and measures of habitual behavior on daily use time of shopping platforms. Therefore, we utilized data from participants of the Thomas et al. (2025) study who had undergone the TSST and a Pavlovian-to-instrumental transfer paradigm with devaluation (PIT-dev) in the laboratory and related these data to the results from a subsequent ambA. The present study intends to link symptom severity of problematic online buying/shopping (assessed using a standardized questionnaire), shopping-specific PIT effects and stress responsiveness (i.e. changes in salivary cortisol) with everyday use time of online shopping platforms (assessed with ambA). Thus, this investigation will extend the data reported in Thomas et al. (2025) by examining if the interaction of stress responsiveness and shopping-specific seemingly habitual behaviors has an effect on everyday usage of shopping platforms. We will examine the following hypotheses:

H1. Symptom severity of problematic online BSh reported in the laboratory study predicts the use time of online shopping platforms as measured by subsequent ambA.

H2. Shopping-specific PIT effect after devaluation as indicator of habitual behavior derived from the laboratory study predicts the use time of online shopping platforms as measured by subsequent ambA.

H3. The interaction of cortisol stress response and shopping-specific PIT effect after devaluation as indicator of habitual behavior derived from the laboratory study predicts the use time of online shopping platforms as measured by subsequent ambA.

2. Methods

2.1. Participants

Participants assessed were part of the FOR2974 cohort (Brand et al., 2021). The present sample represents a subgroup of the Thomas et al. (2025) study, which contains only those persons who had undergone the TSST, took part in the subsequent 14-day ambA and filled out 7 or more days of the ambA. Also, cortisol stress response should not exceed $\Delta = 10$ nmol/L as typical cortisol stress reactions should fall within this range (Liu et al., 2017). The sample comprised 27 participants with risky online buying-shopping behavior and 28 participants with non-problematic buying-shopping behavior (as assessed by diagnostic interview).

Participants were recruited at two sites (Hannover Medical School, Germany and University of Bamberg, Germany). Approval for the study was given by the local ethics committees (Hanover: 9025_BO_K_2020; 17.04.2020; Bamberg: 2019–12/33; 18.12.2019). Written informed consent was obtained by all participants. Inclusion criteria were an age between 18 and 65 years and native or comparable German language skills. Participants were excluded if any illness or medication taken was supposed to have an impact on the hypothalamic-pituitary-adrenal axis, or if there were learning or developmental disorders or severe mental disorders. Severe mental disorders referred to schizophrenia, psychosis, mania/bipolar disorder, alcohol use disorders (dependence syndrome, F10.2) or substance use disorders (dependence syndrome, F1X.2), except for tobacco, and acute suicidal ideation/suicidality. Comorbidities were assessed via reviewing participants' medical history and prior mental health consultations.

2.2. Material and procedure

2.2.1. Pavlovian-to-instrumental transfer paradigm with devaluation

A PIT paradigm with three phases was conducted (see Fig. 1): First, a Pavlovian conditioning phase took place in which formerly neutral stimuli were paired with either a gaming or a shopping image. In the second phase, an instrumental training phase was performed in which participants were intermittently rewarded for instrumental responses to earn gaming- and shopping-related rewards. Pressing the "S" key yielded a shopping-related reward, whereas pressing the "G" key yielded a gaming-related reward. In the third phase, the transfer phase, either the conditioned gaming stimulus, the conditioned shopping stimulus or a neutral stimulus was shown prior to again rewarding button presses as before. In a devaluation after half of the blocks, participants were told that more shopping-related instrumental behavior would not yield further shopping rewards. The specific PIT effect for shopping captures in how far the presence of a conditioned shopping stimulus increased instrumental shopping-specific responding compared to a neutral stimulus (shopping-specific button presses after $CS_{shopping}$ - shopping-specific button presses after neutral stimulus). For this analysis, only the shopping-specific PIT effect after the devaluation was considered. The transfer phase was carried out under conditions of extinction.

2.2.2. Stress measures

Participants underwent a modified version of the Trier Social Stress Test (TSST; Kirschbaum et al., 1993) between the Pavlovian and instrumental phase of the PIT. The TSST was conducted between 12 pm and 3 pm to control for circadian effects of cortisol. Saliva samples were collected at four different measurement points, two before and two after the stress induction (−30 min, −5 min, +25 min and +35 min relative to the stress onset, for details see Fig. 1). Handling of saliva samples was in accordance with usual procedures (stored between −15 °C and −20 °C) and was detailed in Thomas et al. (2025). Analysis of the samples took place at the biochemical lab of the departments of cognitive psychology and genetic psychology at Ruhr University Bochum, inter- and intra-assay coefficients of variance: <5% (Thomas et al., 2025). The cortisol response to the TSST was computed as a peak-to-baseline difference value between the fourth (i.e. in the last part of the PIT paradigm) and

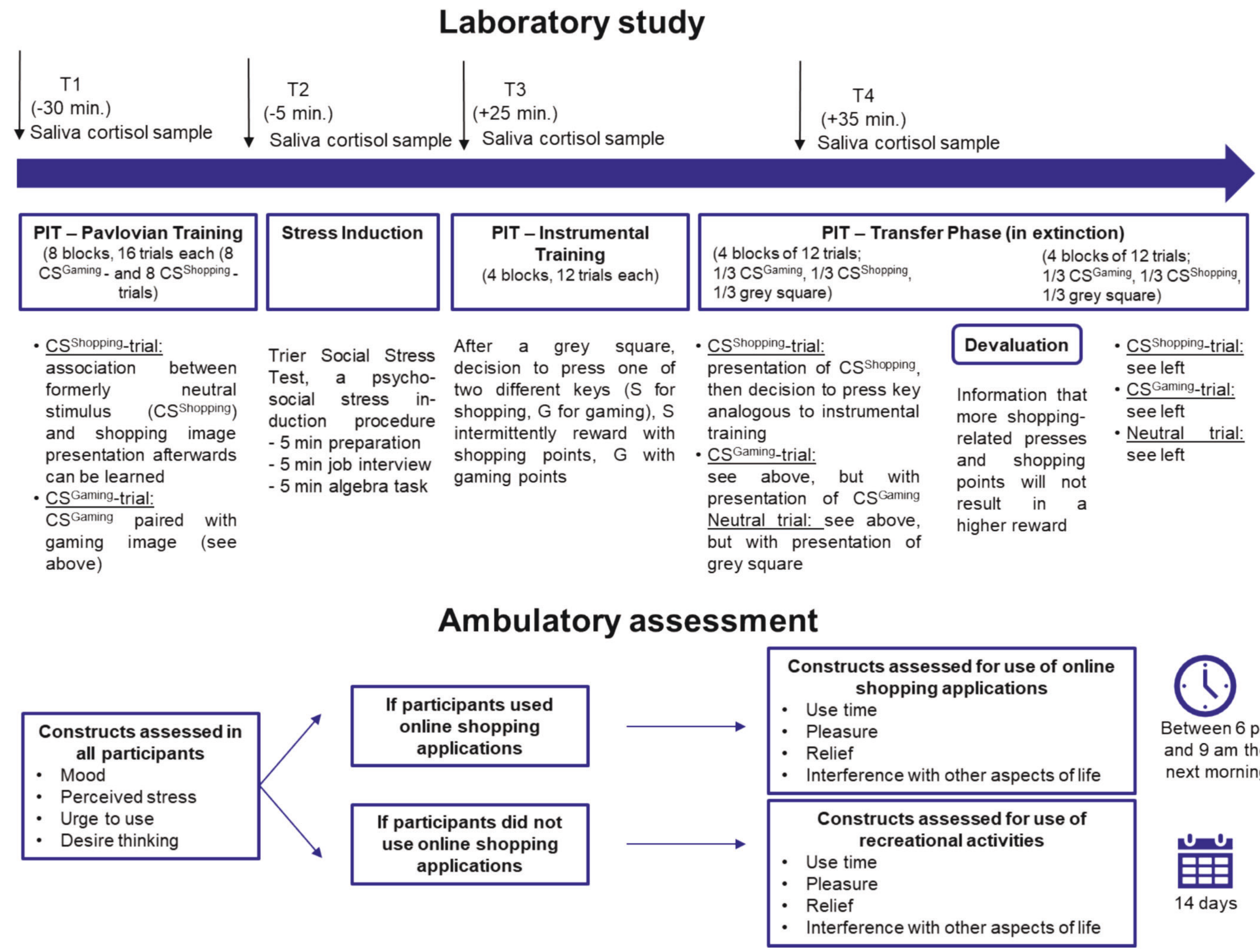

Fig. 1. Illustration of the laboratory study (Pavlovian-to-instrumental transfer paradigm with focus on transfer phase) and the subsequent ambulatory assessment. *Notes.* The time points of the stress measures refer to stress onset. CS = conditioned stimulus; PIT = Pavlovian-to-instrumental transfer.

the second measurement point (i.e. shortly before the stress induction).

2.2.3. Questionnaires and further variables

Severity of problematic online BSh was assessed with the *Assessment of Criteria for Specific Internet-use Disorders* (ACSID-11; Müller et al., 2022), α = 0.92. The ACSID-11 is based on the ICD-11 criteria for gaming disorder, adapted for online CBSD.

2.2.4. Clinical interview

Group allocation was based on the *Assessment of internet and computer game addiction, Structured clinical interview on Internet-use disorders [Strukturiertes klinisches Interview zu Internetbezogenen Störungen]* (AICA-SCI:IBS; Müller & Wöfling, 2018). Participants that fulfilled 0–1 DSM-5 criteria for gaming disorder, adapted for online CBSD, were allocated to the control group. Participants that fulfilled 2–4 criteria were allocated to the risky online shopping group. For most statistical analyses, groups were collapsed. After the clinical interview, an extensive test battery was administered which is part of a multi-center addiction research unit (FOR2974) on affective and cognitive mechanisms of specific Internet-use disorders funded by German research foundation (Deutsche Forschungsgemeinschaft) (Brand et al., 2021).

2.2.5. Ambulatory assessment

The ambA was performed as an end-of-day assessment to which participants were invited via an automatic e-mail. The email was sent on 14 consecutive days at 6 pm, starting the day after the laboratory session. Participants could access the ambA webpage until 9 am on the next day (see Fig. 1). Afterwards, it was not possible to fill out that day of the ambA anymore. Participants were included if they filled out more than half of the 14 days to capture enough variance for the detection of intra-individual associations. An initial question was if participants had used online shopping platforms on the day of interest (dichotomous option: yes/no). If participants answered 'yes', additional questions e.g., concerning use time (minutes per day) of shopping platforms on each of the 14 days, which is the focus of the present study, followed. If not, participants were asked to answer the same questions regarding another leisure activity to avoid biased responding. For sample description, use time was merged over the 14 days by creating both a sum of use time and a mean use time.

2.3. Statistical analysis

Data regarding the sample description were computed with IBM SPSS version 29/in R. Multi-level analyses were conducted with use time of online shopping platforms derived from the ambA as criterion. Note that indicating no usage of buying-shopping platforms was coded as use time = 0 and these days were included in the analyses. Predictors were severity of problematic online BSh, shopping-specific PIT-dev effect, cortisol stress response and PIT-dev effect*stress response interaction. The first model contained symptom severity only, the second model contained the PIT-dev effect only and the third model contained PIT-dev effect and stress response as well as their interaction. On an exploratory basis, a model containing all possible two-way interactions and the three-way interaction between severity of problematic online BSh, cortisol stress response and PIT-dev effect was analyzed to investigate the effect of symptom severity on the interaction of PIT-dev effect and cortisol stress response on use time. All analyses were repeated with a dichotomous criterion indicating if shopping platforms were used or not (yes/no) on the day of interest. Predictors were centralized by their grand mean as all predictors were level-2 predictors (Enders & Tofighi, 2007). Multi-level analyses were computed in R using e.g., lmerTest and lme4 (Bates et al., 2015; Kuznetsova et al., 2017; R Core Team, 2024).

For visualization purposes, stress responsivity was categorized as either below average ($M - 1$ SD), average and above average ($M + 1$ SD) or as low (≤ median) or high (> median). Symptom severity of problematic BSh was also categorized as high (> median) and low (≤ median) for visualization.

2.4. Power analysis

The sample size was based on an a priori power analysis conducted for the study published by Thomas et al. (2025).

2.5. Transparency and openness

The overall study with main research questions (not including the research question of this work) was preregistered on Open Science Framework in October 2021 (https://osf.io/f27qw/overview). Details regarding the ambulatory assessment are provided in the preregistration of the FOR2974 model testing subproject (https://osf.io/6x93n/overview).

3. Results

3.1. Sample description

In total, 55 individuals that completed an average of 13.31/14 days (SD = 1.12) of the ambA were included. Participants were predominantly female (80.0%), of younger age ($M = 26.24$, $SD = 9.91$ years) and mostly (university) students (72.2%). Participants with risky use showed higher severity of online BSh as measured by the number of criteria fulfilled in the AICA-SKI IBS, $|t|(37.38) = 11.50$, $p < .001$, $d = 3.12$, and as measured by ACSID-11, $|t|(51.08) = 3.16$, $p = .003$, $d = 0.85$. They reported more days on which shopping platforms were used and a higher use time (mean use time and sum of use time) of shopping platforms (see Table 1). For the following results, groups were merged to run continuous analyses. Participants from both groups together used shopping platforms on average on 2.95 days ($SD = 2.64$) and spent 10.96 min/day ($SD_{between} = 11.54$, $SD_{within} = 25.87$) with shopping platforms during the 14 ambA days. The likelihood to use shopping platforms was 0.22 (SD = 0.20).

3.2. Severity of online BSh and everyday use of shopping platforms

First, a model for use time as criterion with severity of online BSh as predictor was computed. As hypothesized, severity of online BSh was significantly and positively associated with use time of shopping platforms (see Table 2). Severity of online BSh emerged as important related factor of use time of shopping platforms as it accounted for 14% of the variance of the person-specific intercepts (there are no level 1 predictors, thus person-specific intercepts refers to within-person means) compared to a null model (i.e., pseudo R^2).

3.3. PIT effect after devaluation and everyday use of shopping platforms

Second, the PIT-dev effect as indicator of habitual behavior served as predictor for use time as criterion. Contrary to the hypothesis, the PIT-dev effect was not significantly related with use time (see Table 2). In this model, the PIT-dev effect accounted for only 4% of the variance of the person-specific intercepts (there are no level 1 predictors, thus person-specific intercepts refers to within-person means) compared to a null model (i.e., pseudo R^2).

3.4. PIT effect after devaluation, cortisol stress response and everyday use of shopping platforms

Third, two models were computed containing PIT-dev effect and cortisol stress response as predictors and use time as criterion. One model comprised the two main effects only and the other one included the main effects and the PIT-dev effect*stress response interaction effect. Only the interaction between stress response and PIT-dev effect, but not the two main effects showed relations with use time of buying-shopping

Table 1
Mean comparisons of compliance with ambA and use characteristics of buying-shopping platforms.

	Non-problematic use of shopping				Risky use of shopping				Test statistics				
	M	SD_{within}	$SD_{between}$	*ICC*	*M*	SD_{within}	$SD_{between}$	*ICC*	$\|t\|$	df	*p*	*d*	*Pseudo* R^2
Number of days on which the ambA was filled out	13.07	–	1.36	–	13.56	–	0.75	–	1.64	42.40	0.108	0.44	
Number of days on which shopping platforms were used	1.50	–	1.43	–	4.44	–	2.79	–	4.90	38.41	<0.001	1.33	
Mean use time	3.70	12.22	2.94	0.06	18.38	34.46	12.51	0.12	4.73	53.89	<0.001		0.39
Sum of use time	47.93	–	56.94	–	248.70	–	213.23	–	4.73	29.56	<0.001	1.29	

Notes. $N_{L1} = 732$. $N_{L2} = 55$. n_{L1}(risky use) = 366. n_{L2}(risky use) = 27. n_{L1}(non-problematic use) = 366. n_{L2}(non-problematic use) = 28. *ICC* = intra-class coefficient. *M* = mean, *SD* = standard deviation. A multi-level model with group as predictor and use time as criterion was calculated for the *mean use time* variable. df is estimated by Satterthwaite-approximation.

Table 2
Parameter estimates (fixed effects only) for multilevel models with use time of shopping platforms as outcome variable (model 1, 2, 3 and 4).

	Est.	SE	Pseudo std. coeff.	95% CI	$\|t\|$	df	*p*
Model 1							
pseudo R^2: 0.14							
Severity of online BSh	7.35	2.78	0.40	[0.10, 0.70]	2.64	52.66	0.011
Model 2							
pseudo R^2: 0.04							
PIT effect	0.07	0.04	0.27	[−0.04, 0.58]	1.71	53.02	0.093
Model 3a – main effects only							
pseudo R^2: 0.02							
PIT effect	0.07	0.04	0.26	[−0.06, 0.58]	1.61	51.95	0.115
Cortisol stress response	0.35	0.68	0.08	[−0.24, 0.40]	0.51	51.68	0.614
Model 3b – main effects and interaction							
pseudo R^2: 0.22							
PIT effect	0.06	0.04	0.26	[−0.04, 0.55]	1.71	50.93	0.093
Cortisol stress response	−0.16	0.65	−0.04	[−0.34, 0.26]	0.25	50.42	0.805
PIT effect * Cortisol stress response	0.04	0.01	0.21	[0.08, 0.34]	3.12	50.89	0.003
Model 4 – main effects and interactions							
pseudo R^2: 0.50							
Severity of online BSh	4.72	2.66	0.26	[−0.03, 0.54]	1.78	45.76	0.082
PIT effect	0.09	0.03	0.35	[0.08, 0.62]	2.57	46.45	0.014
Cortisol stress response	−0.04	0.65	−0.01	[−0.31, 0.29]	−0.06	45.70	0.957
Severity of online BSh * PIT effect	−0.04	0.06	−0.04	[−0.17, 0.09]	−0.62	45.71	0.535
Severity of online BSh * Cortisol stress response	−0.92	1.07	−0.06	[−0.20, 0.08]	−0.86	44.93	0.393
PIT effect * Cortisol stress response	0.03	0.01	0.15	[0.02, 0.27]	2.31	46.16	0.026
Severity of online BSh * PIT effect * Cortisol stress response	0.08	0.03	0.18	[0.04, 0.32]	2.58	45.41	0.013

Notes. Model 1: $N_{L2} = 55$. $N_{L1} = 732$. Model 2: $N_{L2} = 54$. $N_{L1} = 718$. Model 3: $N_{L2} = 54$. $N_{L1} = 718$. Model 4: $N_{L2} = 54$. $N_{L1} = 718$. Level-2 predictors were grand-mean centered. Est. = Estimate (unstandardized regression coefficient). SE = standard error. Pseudo std. coeff. = Pseudo standardized coefficient. 95% CI = 95% confidence interval for pseudo std. coeff. Pseudo R^2 refers to variance explained by the predictor(s) that could not be explained in a model without a predictor solely containing the intercept (there are no level 1 predictors, thus person-specific intercepts refers to within-person means). df is estimated by Satterthwaite-approximation.

platforms (see Table 2, model 3b). The whole model with interaction explained 22% of the variance of the person-specific intercepts (there are no level 1 predictors, thus person-specific intercepts refers to within-person means) compared to a null model. In participants with average stress response (*M* – 1*SD*), a higher PIT-dev effect was associated with higher use time and a lower PIT-dev effect with lower use time (see Fig. 2b). The positive association between PIT-dev effect and use time even became stronger in participants with above average stress response (*M* + 1*SD*). This association was inverse if participants showed low stress response (*M*) which means that a higher PIT-dev effect was associated with lower use time. As indicated by the Johnson-Neyman plot (see Fig. 2a), the PIT-dev effect was positively and significantly associated with use time for pronounced cortisol responses. It would not be significantly or negatively related with use time if cortisol responses were not pronounced. Deviance tests however indicated that the model with main effects and cortisol stress response*PIT-dev effect interaction (see Table 2, model 3b) was not superior to a model with main effects only (see Table 2, model 3a), $\chi^2(1) = 2.35$, $p = .125$, although deviance and Akaike information criteria favor the model with interaction (Akaike information criteria: 6798.0 for main effects only vs. 6797.7 for model with main effects and interaction).

To further investigate if the interplay between PIT-dev effect and cortisol stress response on daily usage of shopping platforms is related to symptom severity of problematic BSh, we conducted an exploratory analysis. The model containing a symptom severity*PIT-dev*stress response effect three-way interaction as well as the three two-way interactions and the main effects (mentioned above) indicated that the three-way interaction showed significant relatedness with use time of buying-shopping platforms (see Table 2). Visualizations of this interaction (see Fig. 3) suggested that higher shopping-specific PIT-dev effects are associated with higher use time of shopping platforms in persons with high cortisol stress response and that this effect is particularly strong in persons with high symptom severity of problematic BSh. The whole model with interaction explained 50% of the variance of the person-specific intercepts (there are no level 1 predictors, thus person-specific intercepts refers to within-person means) compared to a null model.

In addition, the above-mentioned multilevel analyses were also carried out for the dichotomous usage variable (usage of shopping platforms on day of interest: Yes/no) as criterion. These analyses revealed partly different findings: The symptom severity of problematic BSh was not associated with usage of shopping platforms, although approaching significance. The PIT-dev effect showed no significant association with usage of shopping platforms, but the interaction between

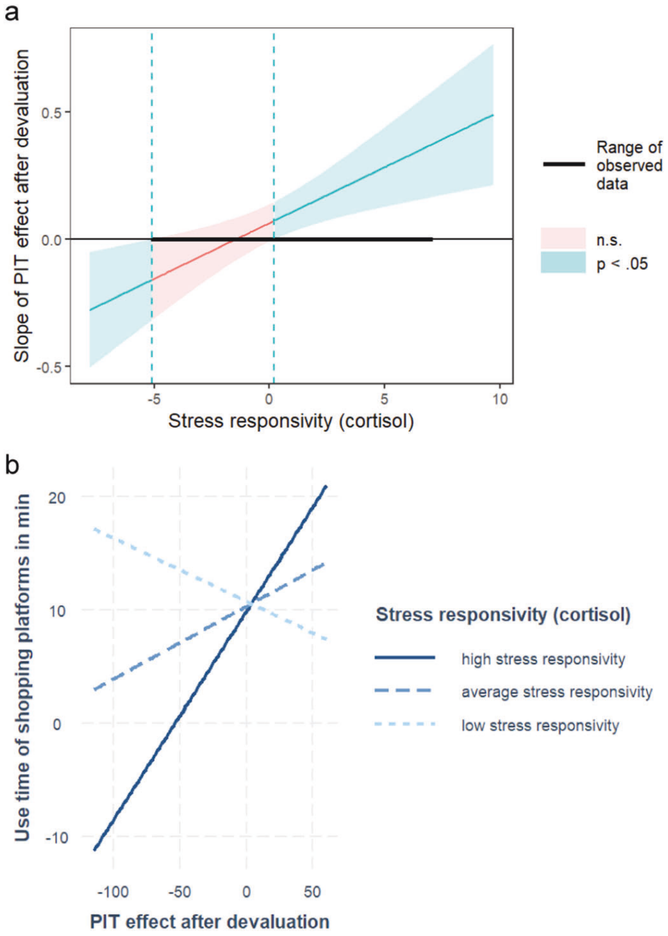

Fig. 2. Illustration of the interaction between PIT after devaluation and cortisol stress response on use time of buying-shopping platforms.
Notes. Panel a shows a Johnson-Newman plot that enables identification of a value range in which a significant moderation of cortisol stress response on the effect of the PIT effect on use time is found. Panel b further portrays the interaction of PIT-dev effect and cortisol stress response by three simple slopes of cortisol stress response, one with a below-mean slope (mean cortisol − 1 standard deviation), one with a mean slope (M) and one with an above-mean slope (M + 1 SD).

the PIT-dev effect and the cortisol stress response was positively related with usage of shopping platforms. The three-way interaction between symptom severity of problematic BSh, the PIT-dev effect and the cortisol stress response failed to show relatedness with the usage of shopping platforms. For details on these analyses, please see supplementary material (Table S1).

4. Discussion

The current study investigated associations of the symptom severity of problematic online BSh, shopping-specific PIT effect after devaluation (as indicator of habitual behavior) and salivary cortisol stress response with daily use time of buying-shopping platforms. Severity of online BSh was related with use time of buying-shopping platforms (H1 fulfilled). PIT-dev effect was not associated with use time of buying-shopping platforms (H2 not fulfilled). The PIT-dev effect by stress response interaction revealed associations with use time of buying-shopping platforms (H3 fulfilled) although this model was not superior to a model with main effects only. Still, the two-way interaction showed significance in the model and the model with the interaction yielded a higher pseudo R^2.

In this study, symptom severity of problematic online buying-shopping behavior was related with daily use of shopping platforms which is plausible since problematic (online) buying-shopping behavior is associated with loss of control over buying/shopping potentially manifesting in longer use of shopping platforms. This study did not support the importance of PIT-dev effects after devaluation, the indicator of habitual behavior, as a sole predictor for use time of buying-shopping behavior. The results do not match a part of the body of evidence on substance use disorder (e.g., Chen, Belanger, et al., 2023; Chen, Schlagenhauf, et al., 2023; Sebold et al., 2017; Sekutowicz et al., 2019). Still, PIT-dev effects seem to be significantly associated with daily use of buying-shopping platforms when interacting with salivary cortisol response. The three-way interaction further showed that the interaction between habitual behavior and a high stress response is disorder specific. This means that higher levels of shopping-specific potentially habitual behaviors and high stress responses do particularly seem to be related with high use time in persons with more problematic online buying-shopping behavior. So, shopping-specific potentially habitual behaviors might not per se show relations with daily use time of shopping platforms but rather when present in persons with strong stress reactions and generally problematic levels of online buying-shopping. It is important to note that these observations seem valid for use time of shopping platforms, but not for if or if not shopping platforms were used. Symptom severity does not seem to be strongly related to if or if not shopping platforms were used. The interplay between cortisol stress response and tendency towards seemingly habitual behaviors seems to be associated with an increased likelihood of using shopping platforms although not strongly. Also, this influence of cortisol stress response and

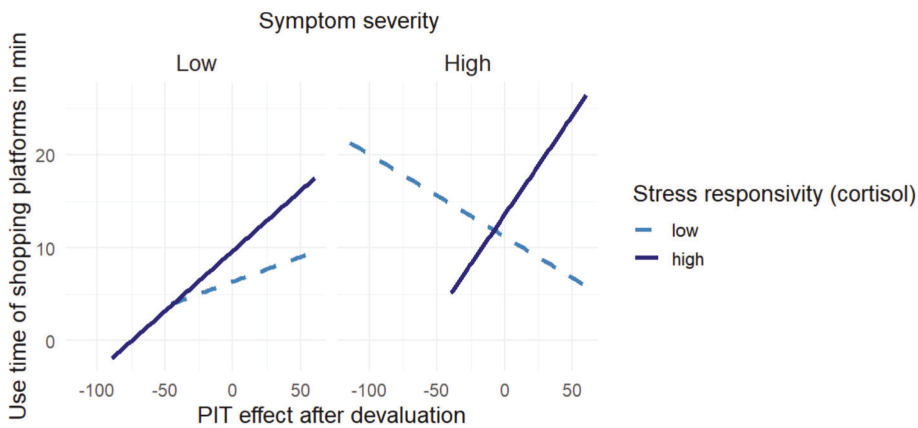

Fig. 3. Illustration of the interaction between PIT after devaluation, cortisol stress response and symptom severity on use time of buying-shopping platforms.
Notes. Panel shows the interaction of PIT-dev effect, symptom severity and cortisol stress response by grouping cortisol response and symptom severity with a median split (low/high symptom severity, low/high cortisol response).

seemingly habitual behavior was not disorder-specific. This means that cortisol stress response and seemingly habitual shopping-specific behavior might not explain if shopping platforms are used or not, but contribute to the explanation of longer use times in persons with higher symptom severity of problematic BSh. While the utilization of online shopping platforms is ubiquitous and not inherently problematic, the extent to which these platforms are employed (i.e., the duration of online shopping) can serve as an indicator of problematic use, characterized by a diminished sense of control over online shopping. Individual stress responses and seemingly habitual behavior might be factors potentially contributing to loss of control over the use of shopping platforms as indicated by longer use time of shopping platforms.

These findings contribute to the framework of addiction theories and potential mechanisms. They elaborate on the validity of PIT effects after devaluation as indicators for habit formation or seemingly habitual behavior that were measured in the laboratory. This is important as there are current scientific controversies on the replicability (Smeets et al., 2023) and scientific importance of habitual behavior in addictions (Hogarth, 2024). While the overall body of research regarding the role of habitual behavior in addictions appears to be less convincing (Hogarth, 2024), our study found that cortisol response to a standardized psychosocial stressor and potentially shopping-specific habitual behavior in interaction predict subsequent everyday use of shopping platforms, particularly in individuals with higher symptom severity of problematic online BSh. Our study thus adds to the scarcity of longitudinal studies on habit formation in addictions. Although this study did not prove that "lower task performance preceded addiction" (Hogarth, 2024, p. 3), it provides important insights into the external validity of the cross-sectional laboratory-based data (Thomas et al., 2025). Most importantly, the outcome suggests that the interaction between psychological processes measured in the laboratory can predict daily usage patterns.

A closer look at how stress reactivity and habitual behavior in a laboratory session contribute to subsequent real-world shopping seems warranted. The response to the acute psychosocial stressor does not only seem to contribute to immediate seemingly habitual behavior as suggested by previous research (Schwabe & Wolf, 2009, 2010; Smeets et al., 2019), it does also seem to have an effect on subsequent daily shopping-specific behavior. This could be explained by the laboratory study mirroring participants' real-life behavior. Those participants who report more problematic internet usage, react to a psychosocial stressor with higher cortisol response and an inclination to more habitual shopping-specific behavior might also do so when being confronted with stressors in their daily life. According to the I-PACE model, stress may function as an internal trigger which might foster shopping-specific habitual behavior and finally lead to problematic usage of shopping platforms (Brand et al., 2019). However, it is important to note that problematic usage of shopping platforms is not always habitual (Brand et al., 2025). It is possible that the usage has been executed goal-directedly but shopping-specific habit formation might have contributed to the occurrence of excessive shopping behavior (Brand et al., 2025). To sum up, the laboratory might capture the relatedness between stress reactivity and habitual behavior that also appears in participants' daily life. The laboratory study might thus be a blueprint of participants' daily life. The results emphasize the importance of the interactions between affective states and potentially habitual behaviors rather than of potentially habitual behaviors alone and are in line with the I-PACE model, but also partly with previous research that reported interactions between acute stress and stress-related vulnerability factors (previous life events and stress reactivity), in this instance on impaired model-based strategies (i.e., habitual behavior; Radenbach et al., 2015).

4.1. Strengths, limitations and implications for future research

This study extends the body of existing research on severity of online BSh by combining laboratory outcomes (stress response, PIT-dev effect) with ambulatory assessment findings. This was done in the field of problematic online buying-shopping behavior in which particularly little is known about PIT and habitual behaviors (Thomas et al., 2023).The use of a standardized laboratory stress induction and the measurement of cortisol changes as a biomarker for stress response are advantages of the present study.

A few limitations of the study have to be considered: Information on purchases and expenditure in the 14-day period was not collected. So, potential financial consequences as one important aspect of problematic online shopping (Achtziger et al., 2015; Laskowski et al., 2023; Müller et al., 2021) could not be captured. The use time of shopping platforms was based on self-report. No objective (tracking) data were collected which is recommended for other internet-use disorders (Ryding & Kuss, 2020) as subjective and objective use time can differ (Ellis, 2019). Furthermore, the sample is limited to non-problematic and risky buying-shopping behavior, whereas the consideration of pathological buying-shopping behavior might have resulted in different outcomes. Due to the end-of day assessment there is a risk of bias or time distortions when reporting usage characteristics (Lin et al., 2015). Stress responses might have also been associated with comorbid mental health conditions (e.g., depression or anxiety disorders) beyond risky buying-shopping behavior as only persons with severe mental health conditions were excluded.

Future research might consider the interplay between stress vulnerability, perceived stress during the day as captured by EMA and use time of buying-shopping platforms. Also, habit character and seemingly automatic shopping behavior could be assessed using a longitudinal approach covering a wider time span. PIT effects after devaluation as indicator for habitual behavior and stress responsivity could also be linked with (online) CBSD severity at a follow-up time point e.g., six or twelve months later. Longitudinal assessment of online buying-shopping behavior in real word context should also include objective use time of applications/platforms e.g., by using screen time by application or tracking. Including expenditures and number of purchases into future research might further expand the assessment of buying-shopping behavior in real world. Future studies could also use a more rigorous protocol when it comes to comorbidities to ensure that the stress response and potential alterations can be construed disorder-specific for problematic buying-shopping behavior.

4.2. Potential clinical implications

If proven to be relevant factors in compulsive buying-shopping disorder by further future studies, the interaction between stress responses (including maladaptive stress management) and habitual behavior might be worth integrating into psychotherapy for compulsive buying-shopping disorder. This interaction could be subject of psychoeducation. Therapy could then focus on the detection of stressful situations and its interoception. Afterwards, following pre-defined plans after detection of the stressful event would be important. This requires 'meta-awareness' of the situation (i.e. the patient realizes that this is a stressful situation and that he/she should now counteract the habitual behavior goal-directedly). Metacognitive therapy and detached mindfulness might facilitate entering this 'meta-modus' (e.g., Capobianco & Nordahl, 2023). Working with behavioral plans might comprise formulating old plans (e.g., "When I feel stressed or discomfort, I will shop") and new plans (e.g., "When I feel stressed or discomfort, I will exercise or I will share my feelings with others", cf. implementation intention, Verplanken & Wood, 2006). The new plans should be repeatedly carried out to build a routine and to subsequently override the "bad" habits, cf. habit substitution (Gardner & Lally, 2018). Psychotherapy should also support patients to find a variety of tailored coping strategies and to incorporate them into their plans. This could also be supplemented using interventions beyond those requiring goal-directedness (Breedon et al., 2021). Ecological momentary interventions (e.g., Businelle et al., 2016; Hawker et al., 2021) might further assist patients to remain aware of the intention to stick to their new plan with push-messages containing the new plan and plausible positive consequences when pursuing it. They might also assist in ameliorating patients' perception of stress by asking them periodically about their stress level.

5. Conclusions

The present findings suggest that the interaction of stress responsiveness with seemingly habitual behavior in a laboratory study is (particularly in persons with more problematic online buying-shopping behavior) related to daily use of online shopping platforms. This outcome mirrors the importance of the interplay between specific vulnerability factors/triggers (i.e., stress responsiveness) and habitual behaviors in the development of CBSD and provides support for the assumptions of the I-PACE model.

CRediT authorship contribution statement

Tobias A. Thomas: Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Anna M. Schmid:** Writing – review & editing, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Dominik Vollbracht:** Writing – review & editing, Formal analysis. **Andreas Oelker:** Writing – review & editing, Software, Data curation. **Oliver T. Wolf:** Writing – review & editing, Supervision, Project administration, Funding acquisition. **Matthias Brand:** Writing – review & editing, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization. **Sabine Steins-Loeber:** Writing – review & editing, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization. **Astrid Müller:** Writing – review & editing, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization.

Declaration of Generative AI and AI-assisted technologies in the writing process

The authors declare that they have used ChatGPT (Model: GPT-5 and previous versions, https://chat.openai.com/), developed by OpenAI, for generating parts of the R code. The authors have critically reviewed the content generated by the AI and have adapted it accordingly, if applicable. The authors have not used AI for generating the manuscript.

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Declaration of competing interest

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.actpsy.2026.106453.

Data availability

Data will be made available on request.

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