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To cite this article: Reha Tuncer, Anastasia Sergeeva, Kerstin Bongard-Blanchy, Verena Distler, Sophie Doublet & Vincent Koenig (25 Sep 2023): Running out of time(rs): effects of scarcity cues on perceived task load, perceived benevolence and user experience on e-commerce sites, Behaviour & Information Technology, DOI: [10.1080/0144929X.2023.2242966](https://doi.org/10.1080/0144929X.2023.2242966)

To link to this article: <https://doi.org/10.1080/0144929X.2023.2242966>



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Running out of time(rs): effects of scarcity cues on perceived task load, perceived benevolence and user experience on e-commerce sites

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ABSTRACT

Online vendors often deploy limited-time and limited-quantity cues on their e-commerce sites to influence consumers purchase decisions. Although these scarcity cues can reflect genuine restrictions in the availability of goods, they are increasingly considered as ill-intentioned nudges or 'dark patterns' due to their omnipresence and success in persuading consumers. In an online experiment ($N=202$), we examined the effects of limited-time and limited-quantity cues on perceived task load, perceived benevolence, and user experience. Results suggest that participants associated scarcity cues with a lack of benevolence from online vendors. E-commerce site design without scarcity cues provided participants with a superior hedonic and pragmatic user experience. In the case of limited-time scarcity cues, participants reported frustration-related negative emotions. We discuss the implications of these findings from the perspectives of dark pattern researchers, designers, and online vendors.

ARTICLE HISTORY

Received 26 October 2022
Accepted 16 July 2023

KEYWORDS

scarcity cues; dark patterns; user experience; benevolence; countdown timers; task load

1. Introduction



Defined as promotional messages highlighting restricted availability of an advertised product (Gierl, Plantsch, and Schweidler 2008), scarcity cues are a common sight in online retail. A large number of marketing studies show that scarcity cues can boost buying intentions (Aggarwal, Jun, and Huh 2011; Song, Choi, and Moon 2021; Wang et al. 2021; Wu et al. 2012) and the perceived value of products (Lynn 1991; Shuey 2014). However, their use also has its downsides. Scarcity cues can lead to brand switching (Biraglia, Usrey, and Ulqinaku 2021), raising customers' aggression levels (Kristofferson et al. 2017) and trigger impulsive buying behavior (Moser, Schoenebeck, and Resnick 2019; Sin et al. 2022). Scarcity cues are nevertheless considered among the most effective sales promotions for both established online vendors (Browne and Jones 2017) and growth-hackers (Bohnsack and Liesner 2019) despite their nefarious effects on customers.


In a typical e-commerce site, scarcity cues can take the form of sales banners, sales promotion labels (e.g. 'last chance offers'), sales counts, or countdown timers attached to one or a group of items. There are two distinct types of scarcity cues: limited-time and limited-quantity

cues (Aggarwal, Jun, and Huh 2011; Cialdini 2009; Friedrich and Figl 2018; Jang et al. 2015). While the former indicates that the product or service is only available for a certain time, the latter indicates that the offer is only available for a predefined quantity. Although both types of scarcity cues are omnipresent across the most visited e-commerce sites (Moser, Schoenebeck, and Resnick 2019), customers often lack the ability to check whether an offer represents genuine scarcity or is merely employed as a commercial trick (Mathur et al. 2019).

1.1. Relationship to dark patterns, nudging and user welfare

Scarcity cues give online vendors the ability to control the setting in which market transactions occur (e.g. format of information, presentation of choices), and can therefore heavily influence or determine the outcome of customer decisions (Competition & Markets Authority 2022; European Consumer Organization 2022; Hanson and Kysar 1999). Researchers in the HCI community consider scarcity cues as instances of 'dark patterns' (Mathur et al. 2019),¹ user interfaces whose designers knowingly manipulate users into taking

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 Supplemental data for this article can be accessed online at <https://doi.org/10.1080/0144929X.2023.2242966>.

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certain actions through ill-intentioned nudges (Luguri and Strahilevitz 2021). Designers of dark patterns leverage the existing body of knowledge in behavioral research and use it against boundedly rational customers in order to get their way (Bösch et al. 2016; Gray et al. 2018). Specifically, how scarcity cues nudge users by evoking feelings of fear, loss, and uncertainty is already well-documented (Caraban et al. 2019).

The nudge theory suggests knowledge about systematic biases in decision-making can be leveraged to support people in making better decisions for themselves (Thaler and Sunstein 2009). Much of the existing literature is dedicated to improving decision-making in the context of government-supported nudges (see Mertens et al. (2022) for a review). More recently, however, discussions also extended to private sector interventions. This branch of the literature addresses the implications of changing behavior for ‘better’ decisions from the firm’s point of view (Beggs 2016; Mills 2020). When firms nudge, there should be a distinction between whether the firm or the recipient of the nudge benefits from it. In other words, nudges can become problematic if the objective of the intervention is to maximise the benefit received by the firm instead of the decision-maker.

The characterization of nudges in terms of the beneficiary (i.e. firms or users) is close to the discussion around dark patterns and persuasive technologies in HCI which revolves around the well-being of users, or user welfare. User welfare is defined as the individual benefits derived from the consumption of a good or service, characterised by the individual’s own assessment of their satisfaction (Khemani and Shapiro 1993). A dark pattern that goes against the users best interests, harms the user, or creates a negative experience for users, affects some aspect of user welfare (Mathur, Kshirsagar, and Mayer 2021). Past work suggests dark patterns can result in the loss of time and money, cause cognitive burden, and even lead to erosion of trust in markets (Competition & Markets Authority 2022; European Consumer Organization 2022; Mathur, Kshirsagar, and Mayer 2021). However, it is less known how users would react when aware of such adverse nudging: People can reject an effort to steer their behavior simply because it is an effort to steer behavior, and nudges might prove ineffective if people are angry or resentful that they have been subjected to it (Sunstein 2017).

The success and pervasiveness of scarcity cues make them appropriate for scrutiny from a user welfare perspective. There is a lack of empirical studies that examine how scarcity cues impact user perceptions and emotions that go beyond the market transaction and touch upon consumers’ well-being. The study presented

here aims to close this gap. We investigated the effects of scarcity cues in an online experiment where participants browsed and executed a set of shopping tasks on one of three different versions of a specifically developed e-commerce site. The sites only differed in the addition of limited-quantity and limited-time cues. Following the shopping tasks, we included surveys to examine participants’ perceptions and feeling about scarcity cues. Specifically, we were interested in (i) how scarcity cues affected the perceived task load during shopping and whether they caused frustration-related negative emotions; (ii) how participants perceived the intentions of online vendors who use scarcity cues; and (iii) how scarcity cues impacted participant evaluations of the hedonic and pragmatic dimensions of the e-commerce sites’ user experience. To our knowledge, we provide the first empirical study to demonstrate how scarcity cues can negatively impact the online shopping experience.

This study makes the following contributions on the effects of scarcity cues on user welfare:

- Limited-time cues cause negative emotions during users’ online shopping experience.
- Limited-time or limited-quantity cues do not significantly affect perceived task load while shopping online, subjective estimates of time spent on task, and feelings of being time pressured.
- Users associate limited-time and limited-quantity cues with opportunistic behavior by online vendors.
- The implications of these findings are discussed from the perspectives of dark pattern researchers, designers, and online vendors.

The remainder of the article is organised as follows: In Section 2, we introduce the theoretical background and hypotheses. The proposed research model can be found in Figure 1. In Section 3 we present the design of the experiment; Section 4 is concerned with the empirical results (see Table 4 for a summary); Section 5 discusses the implications of our results and Section 6 concludes.

2. Theoretical background and hypotheses

2.1. Scarcity cues and perceived task load

Studies have shown that companies often use ill-intentioned dark nudges in their designs to control user behavior and increase their profits (Hornuf and Mangold 2022). One commonly used technique involves directing users’ visual attention to specific areas of the screen. Attention refers to the processes

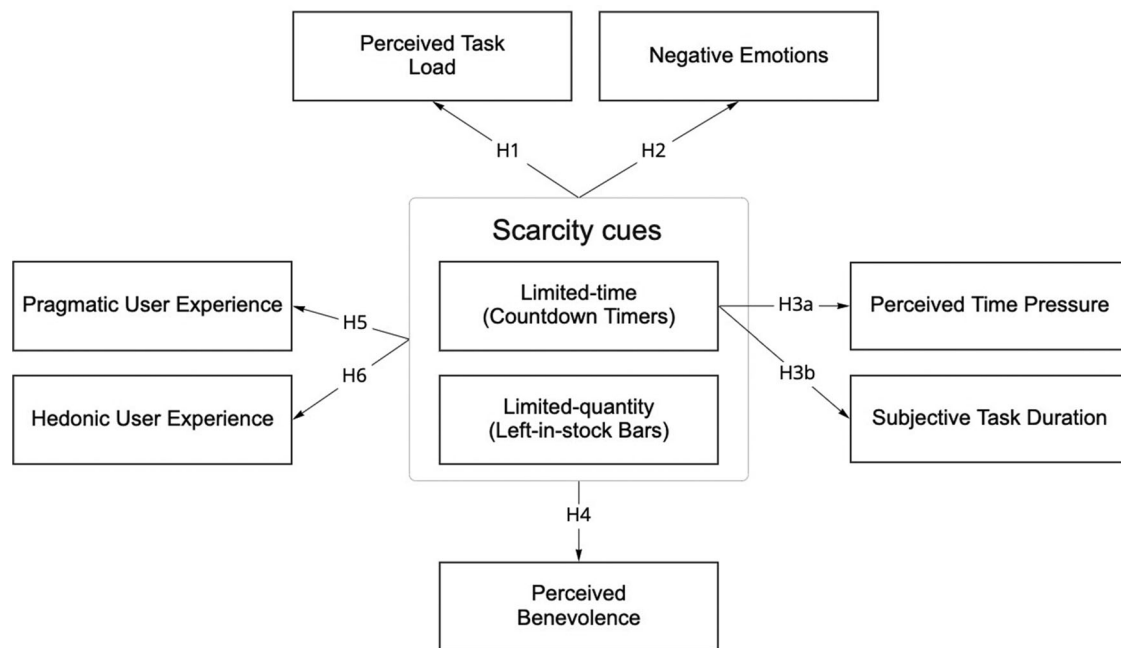


Figure 1. Research model.

that enable individuals to select and focus on particular inputs while suppressing irrelevant or distracting stimuli (Stevens and Bavelier 2012). By using salient stimuli to manipulate users' attention, companies can influence users to perceive certain screen options as unequal and nudge their decisions in the desired direction (Helmers, Krishnan, and Patnam 2019; van der Lans, Pieters, and Wedel 2021).

However, past work has shown those visually salient elements such as animated advertisements, banners, and pop-ups can lead to increased annoyance and frustration (Goldstein et al. 2014; Todri, Ghose, and Singh 2020; Yoo and Kim 2005). These studies have further shown that visually salient elements can increase the time users spend completing experimental tasks, degrading task performance. A possible explanation is that users are not able to ignore these elements because they are simply too conspicuous (Hong, Thong, and Tam 2007). Previous work debated which salient stimuli users can ignore without there being deleterious effects on their task performance (Burke et al. 2005; Simola et al. 2011). Yet, the effects of visually salient animated and static scarcity cues on task load remain unknown. To address this research gap, we examine whether scarcity cues alter participants' perceived task load. Previous studies have also suggested that urgency-based nudges in e-commerce site design can trigger negative emotions, particularly when the need for urgency in completing a transaction is not adequately justified by the seller (Costello, Yun, and Lee 2022). Based on this, we also assess whether participants report feeling

frustration-related negative emotions when scarcity cues are present.

Hypothesis 1 Participants perceive a greater task load on an e-commerce site with (a) limited-time cues, (b) limited-quantity cues, when compared to a site without scarcity cues.

Hypothesis 2 Participants report stronger negative emotions while performing shopping tasks an e-commerce site with (a) limited-time cues, (b) limited-quantity cues, when compared to a site without scarcity cues.

2.2. Limited-time cues, time pressure, and subjective task duration

Previous studies of digital nudges have shown that loss aversion cognitive bias can be exploited by inducing a sense of quickly losing a valuable opportunity (Mirsch, Lehrer, and Jung 2018). This nudges customers towards making a purchase decision without giving it proper consideration (Lee et al. 2015; Li et al. 2021; Schins 2014; Sugden, Wang, and Zizzo 2019). Whether such rapid decisions also alter the user's perception of time is an open question. Often conceptualised as a stressor (Widmer et al. 2012), time pressure can lead to time distortion effects, such as a feeling of elongated time (Hancock and Weaver 2005). Despite the body of research dedicated to subjective time perception in the context of e-commerce (Baraković and Skorin-Kapov 2017; Branaghan and Sanchez 2008; Lee, Chen, and Ilie 2012),

past work has only addressed how to shorten perceptions of time spent waiting (e.g. loading screens) when users have a passive role. The effects of limited-time cues while users actively interact with on-site elements remain unknown. To address this research gap, we examine whether limited-time cues alter the perceived time pressure while participants are performing shopping tasks. We also assess whether participants report spending more time on the tasks when limited-time cues are present.

Hypothesis 3a Limited-time cues are perceived as elements that create time pressure.

Hypothesis 3b Limited-time cues increase the perceived time spent on e-commerce shopping tasks.

2.3. Scarcity cues and perceptions of benevolence

Trust in an online vendor is a multidimensional concept that encompasses trust in the vendor's competence, honesty/integrity, and benevolence (Chen and Dhillon 2003; Oliveira et al. 2017; Seckler et al. 2015). Studies have shown that a web design inspiring customer trust is a core characteristic of successful e-commerce practises (Auinger, Wetzlinger, and Schwarz 2016; Peiris, Kulkarni, and de Silva Mawatha 2015). However, there has been limited research on the impact of scarcity-based nudges on customer trust. To our knowledge, the only preliminary study conducted on this topic found that scarcity-based nudges had no significant effect on customer trust in an online grocery store (Katner and Jianu 2019).

At the same time, past work has shown that the use of manipulative design elements may disrupt trust and lead to negative evaluations of the site (Mavlanova, Benbunan-Fich, and Lang 2016; Voigt, Schlögl, and Groth 2021). The negative outcomes from exposure to these design elements result when users recognise them (Luguri and Strahilevitz 2021), which seems to be the case for scarcity cues. Indeed, according to Bongard-Blanchy et al. (2021), users are well aware of these cues' potentially manipulative impact on their decisions. Still, it remains unclear which dimensions of customer trust are relevant in the context of scarcity cues. As a first step to disentangle the relationship between dark patterns and customer trust, we concentrate on benevolence, which captures users' perception of the vendor as an active relational partner with proper objectives (Koschate-Fischer and Gartner 2015). Specifically, we define benevolence as the belief that the vendor is interested in the customer's well-being and has no intention of engaging in opportunistic behavior but rather seeks a

mutually beneficial relationship (Doney and Cannon 1997; Flavián, Guinalú, and Gurrea 2006; Larzelere and Huston 1980). The effects of scarcity cues on benevolence remain unknown. To address this research gap, we examine whether scarcity cues alter the perceived benevolence of an e-commerce site.

Hypothesis 4 The perceived benevolence of an e-commerce site will be negatively impacted by (a) limited-time cues, (b) limited-quantity cues, when compared to a site without scarcity cues.

2.4. Scarcity cues and user experience

Hassenzahl (2003) describes user experience as a reflection of pragmatic and hedonic design attributes. Pragmatic qualities incorporate usability and utility. Hedonic qualities refer to experience dimensions with no obvious relation -or at least a second-order relation- to task-related goals such as originality, innovativeness, and so forth (Hassenzahl 2001). Previous studies in the e-commerce domain have shown that user experience designers have extensive knowledge of how to use nudges in their designs to achieve company objectives (Duanea 2021). Mejtoft et al. (2019) conducted a preliminary user study that found a link between the effectiveness of digital nudges and the dimensions of user experience. The study argued that achieving good user experience may be a prerequisite for the success of nudging interventions. Further, Bergman (2021) found that exposure to certain dark patterns in e-commerce worsened the overall user experience. Despite not including scarcity cues or distinguishing between the hedonic and pragmatic dimensions of user experience, the study provided the first empirical evidence of the relationship between adverse digital nudging and user experience. A later experimental study by Calawen (2022) included limited-quantity cues, such as low stock messages, combined with other manipulative elements, but found no significant differences in either dimension of user experience. The impact of both types of scarcity cues on user experience is still unknown. To address this research gap, we examine (i) whether scarcity cues result in lower scores for the pragmatic user experience as they introduce additional stimuli unrelated to the user's main task, and (ii) whether scarcity cues result in higher scores for the hedonic user experience as they render websites visually more diverse and lively.

Hypothesis 5 The pragmatic user experience on an e-commerce site is worsened by (a) limited-time cues, (b) limited-quantity cues, when compared to a site without scarcity cues.

Hypothesis 6 The hedonic user experience on an e-commerce site is improved by (a) limited-time cues, (b) limited-quantity cues, when compared to a site without scarcity cues.

3. Method

3.1. Sample

We recruited participants via the crowdsourcing platform Prolific,² as it provides access to a large English-speaking population and is GDPR-compliant. The sample size was calculated using the G*Power software³ (estimated effect size $f=0.22$ based on the results of an annoyance scale and trust scales in a similar study by Voigt, Schlögl, and Groth (2021) with an estimated power of 0.8). Our criterion for participation was fluency in English and age 18 or above. Since gender is known to impact the way people interact with e-commerce sites (Lin et al. 2019), we opted for a balanced gender distribution on Prolific. Potential participants then received a link to the study's LimeSurvey⁴ page.

We collected 202 full responses after removing participants who failed attention checks or provided insufficient answers. In total, 104 identified as women, 94 as men and 4 as non-binary. 158 participants had at least some college education, 44 participants had a high-school diploma or lower. 102 participants were 18 to 24 years old, 73 participants were 25 to 34 years old, and 27 participants were older than 35. The study took about 22 minutes to complete, and participants received 7.45 per hour in compensation. Ethical approval for the experiment was received from the university ethics review panel (removed for anonymous review).

3.2. Procedure

At the beginning of the survey, participants provided informed consent based on a detailed information sheet. Then, standard demographic information (gender, age, and education level) was collected. On the next page, participants received the instructions for the shopping task. The instructions contained a list of shopping requirements to perform on a specifically developed e-commerce site (see Subsection 3.3 for details). After the instructions, participants were randomly assigned to one of three experimental conditions (between-subjects design), and were provided with the URL for a version of the e-commerce site. Two versions of the e-commerce site contained either limited-time or limited-quantity cues on the homepage and the product pages. The third (control) version was without scarcity cues (see Subsection 3.4 for details). After completing

the shopping task, participants returned to the survey to answer attention check questions about the items they had picked. Then, participants went through a series of questionnaires on their perceived task load, the site's benevolence towards users, and their user experience (see Subsection 3.6 for details). Finally, an open feedback question allowed participants to express their opinions about the study and the e-commerce site.

3.3. Shopping task design

Participants were presented with descriptions of three personas with specific traits and preferences. We organised a workshop with user experience researchers ($N=10$) to create the personas within the university's HCI research group and obtained 16 personas.⁵ We then selected three contrasting personas which lead to non-overlapping sets of clothing, requiring participants to go through the site several times to complete the shopping task. The descriptions of personas did not point to any particular shopping products on the site. For each persona, we asked participants to choose two suitable items from our site, meaning one participant had to choose six items in total (see Appendix for details on the instructions). The reasons for using personas in the shopping task were (i) providing participants with context, (ii) reducing participants' bias toward certain products, (iii) enabling the use of all possibilities offered by the site (e.g. size and color selection).

3.4. E-commerce site design

We designed three versions of a hypothetical retail site for male clothing using a standard e-commerce template⁶ from the WooCommerce framework on WordPress.⁷ The reason for creating a clothing site was to be able to sample as wide as possible, and not rule out people based on demographic criteria such as gender, socioeconomic status, age, and education. By using an already existing and commercially successful template,⁸ we aimed at creating a realistic shopping experience. We then used shopping plugins freely available on WooCommerce with our custom code to implement scarcity cues. Out of the three versions of the site, two included identical static price reduction elements (new price over old one) and shopping labels ('Bestseller', 'Sale', 'Last chance'). These were presented on 20 randomly selected products, held constant across conditions. The difference between the two versions of the site were in the scarcity cues. For the remainder of the article, we refer to the limited-time cues version as the *timer* condition and the to limited-quantity cues version as the *stock* condition. The timer condition had countdown timers

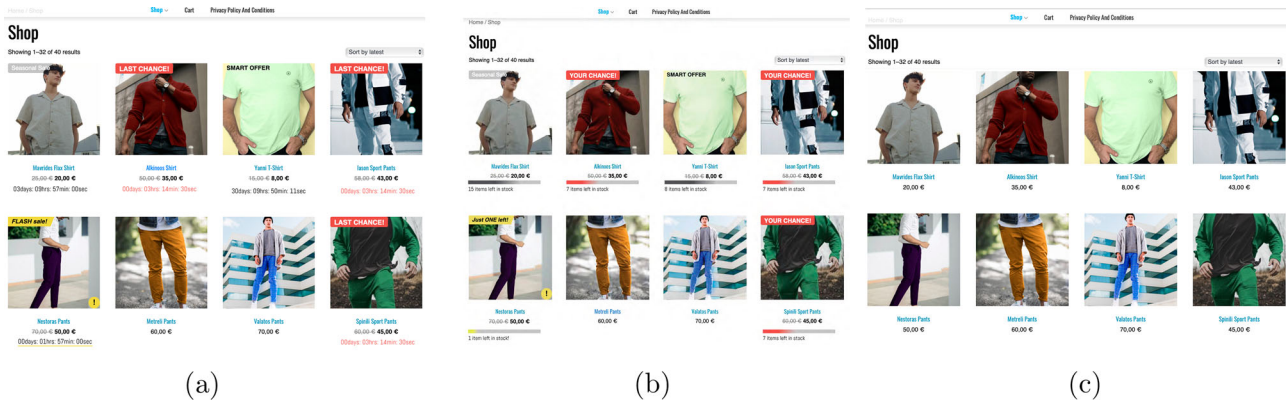


Figure 2. Homepage by treatment condition (a) Timer (b) Stock (c) Control.

whereas the stock condition employed a moving progress bar for items left-in-stock. The third version of the website constituted the control condition and it did not contain any scarcity cues, price reductions or shopping labels. All 3 versions contained 40 product items, divided into four 10-item categories of clothing (shoes, pants, jackets, shirts). The product images were taken from the public domain⁹ and were edited to display a variety of colors and textures. Figure 2 shows the versions of the homepage on which participants landed,¹⁰ and Figure 3 shows product pages for one of the 20 randomly selected items across the three treatment conditions.

3.5. Pretests

The entire study material and procedure was pretested with 4 participants from the university and with 10 Prolific participants to ensure both instructions and questionnaires were understandable. Pretests also showed the average time to complete the shopping task was around 10 minutes. We had designed the shopping task such that participants on the experimental sites would spend at least the same amount of time

customers spend on real e-commerce sites, which is 5 minutes on average.¹¹

3.6. Measures

3.6.1. Task load index.

Task load emerges from the interaction between the requirements of a task, the circumstances under which it is performed, and the skills, behaviors, and perceptions of the user (Hart and Staveland 1988). The NASA Task Load Index (TLX) questionnaire is a well-known tool for investigating subjective task load. The full version of the NASA-TLX consists of a two-step procedure. First, participants weigh the six scales regarding their contribution to task load and then provide numerical subjective ratings on each of the six scales. We opted for using the scales without the weighting procedure (so-called Raw-TLX rating), as it is suitable for quantitative studies where ease of application is a priority (Hart 2006; Mansikka, Virtanen, and Harris 2019). Additionally, we analysed scores for the *frustration* ('How insecure, discouraged, irritated, stressed and annoyed did you feel during the task?') and *temporal* subscales ('How hurried or rushed

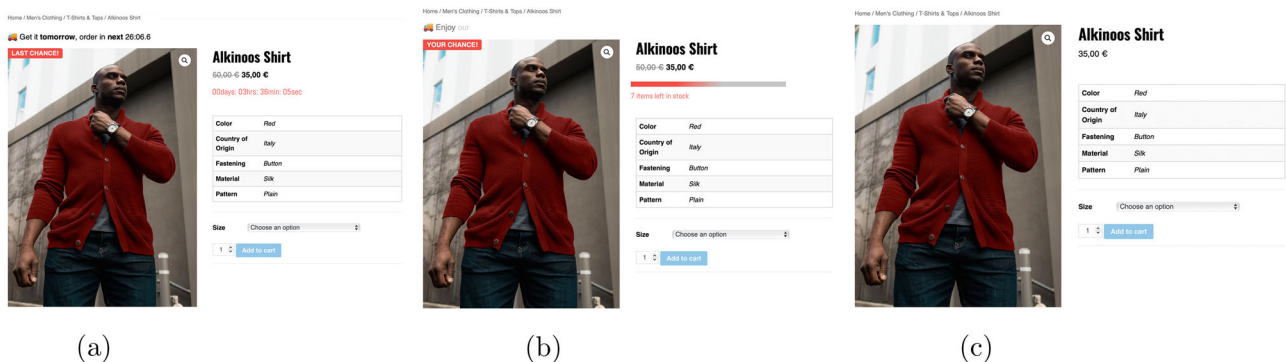


Figure 3. Product page by treatment condition (a) Timer (b) Stock (c) Control.

was the pace of the task?') separately. Despite its name, the frustration scale question allowed us to assess a palette of negative emotions (see Hypothesis 2 and 3a). The NASA-TLX scales were implemented in our questionnaire as 20-point slider scales to ensure their similarity to the offline version. During the pretests, the original version of the 'Performance' scale confused our participants. We therefore decided to invert the slider endpoints (see online supplementary material for details).

3.6.2. Subjective task duration scale.

To capture the effect of countdown timers on the perception of time (see Hypothesis 3b), we introduced an additional scale in which participants reported how long the shopping task felt (from 0 'It was really fast' to 20 'It was really slow'). We chose a 20-point slider to keep the scale coherent with the NASA-TLX questionnaire.

3.6.3. Benevolence.

We assessed the perceived benevolence of the e-commerce site (see Hypothesis 4) with the benevolence subsection (e.g. 'I think that this website is concerned with the present and future interests of its users') of the Website Trust Scale (Doney and Cannon 1997; Flavián, Guinalíu, and Gurrea 2006; Kumar, Scheer, and Steenkamp 1995; Roy, Dewit, and Aubert 2001). A higher score in this scale implies a higher perceived benevolence of the e-commerce site. The benevolence scale is parsimonious and strongly correlates with the honesty/integrity dimension and weakly with usability (Flavián, Guinalíu, and Gurrea 2006). We used a 5-point rather than 7-point Likert scale for this scale. Despite some evidence supporting the use of 7-point Likert scales in remote usability studies (Finstad 2010), other studies show that 5-point scales yield the best results for agree-disagree scales (Lissitz and Green 1975; Revilla, Saris, and Krosnick 2014). There is also evidence that lesser point scales lower the cognitive burden on participants (Nemoto and Beglar 2014; Smith Jr et al. 2003) and their frustration (Babakus and Boller 1992). Further, we used the fully labeled version of the scale, as it provides the best protection against an extreme response style (Weijters, Cabooter, and Schillewaert 2010).

3.6.4. User experience.

To assess the effects of scarcity cues on the user experience (see Hypothesis 5 and 6), we used the short version of the User Experience Questionnaire (UEQ-S) (Schrepp, Hinderks, and Thomaschewski 2017b). We used the short version in order to shorten the length of our questionnaire. Even though this short instrument

does not cover all scales from the full version of the UEQ (Schrepp, Hinderks, and Thomaschewski 2017a), it does sufficiently capture the pragmatic and hedonic dimensions of user experience.

4. Results

4.1. Data preparation and considerations

Data analysis was performed with SPSS (vers. 28.0.0.0) and Python 3.9.7 (pandas, numpy, scipy, matplotlib, statsmodels, pingouin).¹² We checked the main assumptions regarding the data structure and distribution before the analysis. As we planned to use ANOVA-type inferences for several families of hypotheses, we first verified the normality of the residuals and the homogeneity of the variance. The results showed that the data violated the assumption of residuals' normality, with the exception of the hedonic user experience scale. However, the ANOVA family of tests is robust to the violation of this assumption (Blanca Mena et al. 2017). Our sample did not violate the homogeneity of variance assumption, with the exception of the perceived frustration scale. In this specific case, we used Welch's ANOVA (Krishnamoorthy, Lu, and Mathew 2007). Further, since the presence of outliers in the sample can be considered a risk when using the classical ANOVA model (Osborne and Overbay 2004), we opted for bootstrapped post hoc tests for a better estimation of the confidence intervals (Aguinis, Gottfredson, and Culpepper 2013).

4.1.1. Non response bias

For estimating the effect of nonresponse bias as proposed by Armstrong and Overton (1977), we compared the mean results of our study's variables between the first ($n = 50$) and last ($n = 50$) quarter of the respondents by making multiple t-tests. The tests showed no significant differences in any of the variables. We also compared demographic variables of gender, age, and educational status between the first ($n = 50$) and last ($n = 50$) quarter of the respondents by performing a multiple chi-square test. Results also showed no significant differences between the groups by any of the parameters. The appendix includes the results of both procedures. Therefore we can assume that nonresponse bias probably did not affect the study's results.

4.1.2. Common method variance

Defined as the variance attributed to the measurement method rather than the constructs the measures represent, common method variance is a potential problem that could bias survey outcomes. Such systematic method biases are problematic because they provide

an alternative explanation for the observed relationships between measures of different constructs that is independent of the one hypothesised (Podsakoff et al. 2003). We conducted Harman's single-factor test (Harman and Harman 1976) to address the issue. The non-rotated exploratory factor analysis on the manifest variables generated five latent factors with eigenvalues greater than one. The first factor explained 24.459 percent of the total variance, which was less than the threshold of 50 percent and indicated no common method bias in this study.

4.1.3. Effects of demographic variables

To identify the effects of demographic variables on our variables of interest, we began by cleaning the data to have similarly sized groups of participants.¹³ After cleaning, we ran Chi-Square tests for dependence between age ($p = 0.308$), gender ($p = 0.669$), and education level ($p = 0.312$) across treatments to verify participants were evenly distributed across conditions. We then ran a series of Welch ANOVA's between each demographic variable and outcome variable. Only the perceived benevolence scale and hedonic dimension of user experience scale showed significant differences at 5 percent. For the former, we found that age groups had unequal means ($F = 3.236$, $p = 0.046$). Tukey pairwise comparisons showed that perceived benevolence scores for the age group '35 or more' were significantly higher when compared to the age group '18–24' ($p = 0.026$) and to the age group '25–34' ($p = 0.025$). For the latter, we found that females and males had different means ($F = 6.988$, $p = 0.009$). Tukey pairwise comparison showed that the hedonic dimension of user experience score was significantly higher for the gender group 'female' when compared to the gender group 'male' ($p = 0.01$).¹⁴

4.2. Effects of scarcity cues on the subjective task load (H1)

The one-way ANOVA results for the NASA-TLX sum score showed no statistically significant difference ($F(2, 199) = .916$, $p = .402$) between the conditions (see Table 1 NASASUM for details). The bootstrapped 95% confidence intervals for control and timer conditions included zeros, which point to a lack of differences in means between the two conditions. We did not find evidence to support Hypothesis 1a. There are no statistically significant differences in perceived task load between control and timer conditions. The bootstrapped 95% confidence intervals for control and stock conditions also included zeros and point to a lack of differences in means between the two conditions. We did not find evidence to support Hypothesis 1b. There are no statistically significant differences in perceived task load between control and stock conditions.

4.3. Effects of scarcity cues on frustration-related negative emotions (H2)

The results of the one-way ANOVA for the NASA-TLX frustration scale showed a significant difference ($F(2, 199) = 3.37$, $p = .038$) between the conditions. Post-hoc conservative pairwise comparisons (Tamhane T2) showed that timer condition significantly increased the NASA-TLX frustration scale scores when compared to the control condition (see Table 1 NASAFRUST for details). This finding is also supported by the bootstrapped confidence intervals which do not include zero. Further, in the voluntary feedback section after the experiment, three participants in the timer condition (5%) specifically mentioned the annoyance created by limited-time cues. We find evidence to

Table 1. ANOVA models with bootstrapped post hoc tests for Hypothesis 1 (NASA-TLX sum score; NASASUM), Hypothesis 2 (NASA-TLX frustration; NASAFRUST) and Hypothesis 4 (perceived benevolence; BENSUM).

	N	95% CI	ANOVA $F(2, 199)$	Sig.	Multiple comparisons mean difference Tukey's HSD, Tamhane 2 ^b			Bootstrapped ^a multiple comparisons 95% BCa CI		
					Timer	Stock	Control	Timer	Stock	Control
NASASUM			.916	.402						
Timer	66	36.08, 45.35								
Stock	69	32.33, 41.50					2.60, -10.29	-2.60, 10.29		-2.51, 9.85
Control	67	32.98, 41.20					2.51, -9.85	-6.16, 5.80		6.16, -5.80
NASAFRUST			3.37	.038						
Timer	66	4.84, 7.73				1.53	2.24*		-3.90, 3.51	.550, 3.94
Stock	69	3.38, 6.12			-1.53	.709	-3.51, .390			-9.24, 2.36
Control	67	3.11, 4.98			-2.24*	-7.09	-3.94, -5.50	-2.36, .924		
BENSUM			4.13	.017						
Timer	66	19.11, 21.44				.128	-1.70*		-1.31, 1.53	-3.18, -2.08
Stock	69	19.29, 21.00			-1.28	-1.83*	-1.53, 1.31			-3.08, -5.46
Control	67	21.01, 22.93			1.70*	1.83*	.208, 3.18	.546, 3.08		

Note: * $p < 0.05$.^aUnless stated otherwise, results are always based on 10^4 bias-corrected and accelerated (BCa) bootstrap samples.

^bWe used Tamhane 2 procedure for NASAFRUST scale, because of unequal groups variances.

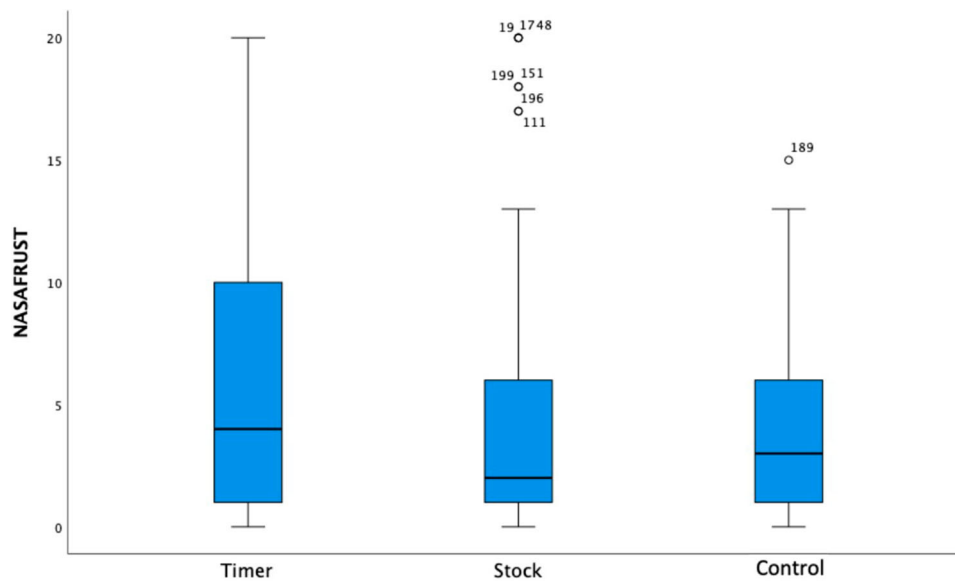


Figure 4. Boxplots for NASA-TLX frustration scale with visible outliers in the stock condition.

support Hypothesis 2a. Limited-time cues increase the frustration-related negative emotions when compared to the control condition. Post-hoc conservative pairwise comparisons (Tamhane T2) were not statistically significant between the stock and control conditions. Bootstrapped confidence intervals for stock and control conditions also included zeros. Nevertheless, the differences in means were in the same direction as with timer condition. We did not find evidence to support Hypothesis 2b. There are no statistically significant differences in frustration-related negative emotions between control and stock conditions.

4.3.1. Outliers in the stock condition

We identified a group of 7 outliers consisting of participants who reported feeling extreme negative emotions in the stock condition (see Figure 4). Further analysis showed no significant differences between the gender and the perceived benevolence scores between these outliers and the rest of the stock condition. In the absence of these outliers, an ANOVA analysis with post hoc comparisons showed significant differences between the stock and timer condition ($F(6.972)$, $p = .005$, $MD = 2.875$). Without these outliers limited-quantity cues caused significantly less frustration-related negative emotions than limited-time cues.

4.3.2. Correlates of the NASA-TLX frustration scale

We ran a regression model (see Table 2) to explore variables that correlate with the NASA-TLX frustration scale. The model with interactions between the three conditions and the NASA-TLX time pressure scale, NASA-TLX mental effort scale, and the benevolence

scale captured approximately 65% of the variance in the NASA frustration scale across treatments.

For the timer and stock conditions, the NASA frustration scale and NASA mental effort scale were positively related: Participants across both conditions who reported stronger negative feelings also reported having spent more mental effort to complete the shopping task.

For the timer condition, we found a statistically significant positive relationship between the NASA frustration scale and the NASA time pressure scale, meaning participants who reported stronger negative feelings also reported feeling more time pressured. Furthermore, we also identified a significant negative relationship between the NASA frustration scale and the benevolence scale, implying that participants who reported

Table 2. Linear regression model for NASA-TLX frustration scale by treatment condition.

	NASA FRUST	
	B	95% Bootstrap CI
Timer:NASAMENT	.430***	.230, .637
Stock:NASAMENT	.567***	.310, .824
Control:NASAMENT	.078	-.112, .261
Timer:NASATEMP	.378***	.121, .626
Stock:NASATEMP	.075	-.222, .371
Control:NASATEMP	.217	-.015, .518
Timer:BENSUM	-.438***	-.659, -.199
Stock:BENSUM	-.333*	-.630, .051 ^a
Control:BENSUM	-.037	-.254, .226
Timer	8.999***	3.341, 14.533
Stock	6.032	-2.157, 12.795
Control	3.011	-2.838, 7.113
Observations	202	
R^2	.67	
Adjusted R^2	.649	

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.^a The lack of support from the bootstrapped confidence intervals for the effect of benevolence in the timer condition should be noted.

stronger negative feelings perceived the site as less benevolent in this condition.

4.4. Effects of limited-time cues on perceived time pressure (H3a) and subjective task duration (H3b)

To investigate the effect of limited-time cues on participants' subjective time estimation and their perception of time pressure, we conducted a one-way MANOVA on the NASA-TLX temporal load subscale and on the subjective task duration scale. The analysis showed no statistically significant differences in subjective task duration and perceived time pressure ($F(4, 198) = 1.113, p = .35$) between the conditions. We did not find evidence to support Hypothesis 3a and 3b. There are no statistically significant differences in perceived time pressure and subjective task duration between the control and timer conditions.

4.5. Effects of scarcity cues on the perceived benevolence of an e-commerce site (H4)

The results of the one-way ANOVA for the benevolence scale showed significant differences ($F(2, 199) = 4.13, p = .017$) between conditions. Post-hoc Tukey pairwise comparisons showed that timer condition significantly lowered the benevolence scores when compared to the control condition (see Table 1 BENSUM for details). Bootstrapped confidence intervals for the timer and control conditions did not include zero, providing further support for differences between the conditions in terms of the perceived benevolence. We find evidence to support Hypothesis 4a. The perceived benevolence of an e-commerce site is negatively impacted by limited-time cues. Post-hoc Tukey pairwise comparisons showed that stock condition also significantly lowered the benevolence scores when compared to the control

Table 4. Summary of results.

Hypothesis (Status)	Construct	Summary
1a (X)	Perceived Task Load	No evidence of effect for limited-time cues
1b (X)		No evidence of effect for limited-quantity cues
2a (✓)	Frustration Related Negative Emotions	Increased by limited-time cues
2b (X)		No evidence of effect for limited-quantity cues
3a (X)	Time Pressure	No evidence of effect for limited-time cues
3b (X)	Subjective Task Duration	No evidence of effect for limited-time cues
4a (✓)	Perceived Benevolence	Decreased by limited-time cues
4b (✓)		Decreased by limited-quantity cues
5a (✓)	Pragmatic User Experience	Decreased by limited-time cues
5b (X)		No evidence of effect for limited-quantity cues
6a (X)	Hedonic User Experience	No evidence of effect for limited-time cues
6b (X)		Decreased by limited-quantity cues

condition. This finding is supported by the bootstrapped confidence intervals which did not include zero. We find evidence to support Hypothesis 4b. The perceived benevolence of an e-commerce site is negatively impacted by limited-quantity cues.

4.6. Effects of scarcity cues on the pragmatic (H5) and hedonic (H6) dimensions of user experience

To assess the effects of scarcity cues on the pragmatic and hedonic dimensions of user experience, we analysed the corresponding subscales of the UEQ-Short with a one-way MANOVA. Since our scales violated the multivariate outliers assumption, we used Pillais Trace test statistics. The results in Table 3 show significant differences between the conditions on both pragmatic and hedonic dimensions ($F(4, 198) = 3.1, p = .016$).

Table 3. MANOVA models with bootstrapped post hoc tests for Hypothesis 5.

Multivariate test	$F(4, 198) = 3.100$	$p = .016$	Pillais Trace = 0.60	Partial Eta Squared = 0.3	
Multiple Comparisons		(I) RAND	(J) RAND	Mean Difference (I-J)	Bootstrapped 95% BCa CI
Dependent Variable					
UXPRAG	Tukey HSD	Timer	Stock	-.35	-2.03, 1.33
			Control	-2.05*	-3.75, -.329
		Stock	Timer	.35	-1.33, 2.03
			Control	-1.70	-3.17, -.216
		Control	Timer	2.05*	.329, 3.75
			Stock	1.70	.216, 3.17
UXHED	Tukey HSD	Timer	Stock	1.43	-.290, 3.16
			Control	-.81	-2.58, .905
		Stock	Timer	-1.43	-3.16, .290
			Control	-2.24*	-3.91, -.612
		Control	Timer	.81	-.905, 2.58
			Stock	2.24*	.612, 3.906

Note: * $p < 0.05$.

For the pragmatic dimension of user experience, post hoc analysis showed a significant difference between the timer and control conditions. Bootstrapped confidence intervals for the timer and control conditions did not include zero, providing further support for differences between the two conditions. We find evidence to support Hypothesis 5a. Pragmatic user experience scores are lower when limited-time cues are present. However, post hoc analysis showed no differences between the stock and control conditions.¹⁵ We find no evidence to support Hypothesis 5b. There are no statistically significant differences in pragmatic dimension of user experience between the control and stock conditions.

For the hedonic dimension of user experience, post hoc analysis and bootstrapped confidence intervals showed no differences between the control and timer conditions. We did not find evidence to support Hypothesis 6a. There are no differences in hedonic dimension of user experience between the control and timer conditions. Post hoc analysis showed a significant difference between the control and stock conditions. Participants in the control condition gave a higher score to the hedonic dimension of user experience on average when compared to the stock condition. Bootstrapped confidence intervals also support this finding. This finding goes in the opposite direction to our hypothesis. We did not find evidence to support Hypothesis 6b. However, there is statistically significant evidence on the opposite direction of our hypothesis: Presence of limited-quantity cues significantly lowered the scores on the hedonic user experience dimension.

5. Discussion

5.1. Scarcity cues and task load

In a previous study, Burke et al. (2005) found that only extreme forms of animated visual stimuli (e.g. flashing text banners) increased users' perceived task load. Mainstream animated or static commercials had no significant impact on task performance. Similarly, we found no evidence that scarcity cues increase participants overall task load. Therefore, both types of animated and static scarcity cues also fall under the category of mainstream visual stimuli. Factors such as familiarity with the shopping task and participants' past experience in environments with comparable visual stimuli could explain this result. In other words, it is possible that customers have become so accustomed to scarcity cues that these elements no longer hinder their shopping performance. Considering our design choice of emulating current industry practises in terms of visual stimuli, these findings should remain

valid with respect to real-world applications of scarcity cues. In sum, the impact of scarcity cues on the perceived shopping task load is either much smaller or non-existent. When making decisions with limited consequences, online customers do not experience an increase in cognitive strain when exposed to limited-time and limited-quantity scarcity cues. In online marketplaces, nudges are often used to encourage product purchases or to communicate with customers. However, nudges can also be used for less benevolent purposes than originally intended (Ghose et al. 2023). Our results suggest that scarcity cues are popular nudges partly because companies can use them to sway customers choices without causing an increase in their perceived task load while shopping.

5.2. Limited-time cues and frustration-related negative emotions

In case of limited-time cues, we found that participants experienced stronger negative emotions during the shopping task when compared to the control condition. We did not find this result in the stock condition, even though limited-quantity cues also introduced comparable amounts of visual stimuli, both static and animated. The negative emotions tied to limited-time cues are in line with the empirical research in dark patterns literature (Bergman 2021; Calawen 2022; Luguri and Strahilevitz 2021; Voigt, Schlögl, and Groth 2021). While past work suggested that dark patterns cause negative emotions, the relationship was generally linked to the perceived manipulateness of these design elements. Our findings suggest that designs perceived as equally less benevolent can cause different levels of negative emotions, pointing to the complexity of evaluating dark patterns' impact on customer well-being. Our exploratory findings also showed that reported time pressure highly contributed to the perceived negative emotions in the timer condition. As visual stimuli closely resembled in stock and timer conditions, what makes limited-time cues cause stronger negative emotions seems more related to the time pressure they create than their visual salience. Online vendors leverage a variety of influencing mechanisms in a bid for higher profits, even if it means sacrificing the benefits of buyers (Thaler 2018). We found that one such sacrifice is customers' psychological well-being when faced with countdown timers. Participants in our experiment reported experiencing higher levels of frustration and stress when exposed to limited-time cues compared to limited-quantity cues or no cues at all.

5.3. Limited-time cues, time pressure and subjective time estimation

Furthermore, we find no evidence that limited-time cues affected participants' reported perception of time pressure or their subjective time estimation. This unexpected finding is at odds with our initial hypothesis but is consistent with a recent study about deceptive countdown timers. According to Tiemessen (2022), some participants may deliberately ignore products with limited-time cues. We observed similar behavior during our pretests, where participants avoided products with limited-time cues. Doing so would naturally bypass the time pressure related to these product choices and it would be interesting for future researchers to explore why this may be the case. It is also possible that in the absence of a subjective value attached to a product, the mere presence of limited-time cues is simply not enough to create time pressure. Since in both studies participants had no meaningful cost when losing the opportunity to obtain products, they may not have been very concerned about the limited-time cues. These results make it somewhat challenging to draw comparisons with real-world purchase decisions involving limited-time cues. Future studies with more realistic stakes should put these results under examination.

5.4. Scarcity cues and benevolence

Scarcity cues have previously been described under the umbrella of dark patterns (Mathur et al. 2019). Dark patterns are design elements characterised by a potentially malicious intention that materialises in commercial strategies that deceive (Bösch et al. 2016) or trick users (Gray et al. 2018). We approached user perception of potentially malicious intentions to nudge from the perspective of benevolence, a sub-dimension of customer trust defined as the belief that a vendor does not behave opportunistically and pursues a mutually beneficial relationship (Doney and Cannon 1997; Flavián, Guinalú, and Gurrea 2006; Larzelere and Huston 1980). Our findings suggest that both types of scarcity cues are considered less benevolent when compared to the control condition. Expanding on Bongard-Blanchy et al. (2021), customers are well aware of the potentially malicious intentions of online vendors when (i) the e-commerce site is completely fictional; (ii) scarcity cues on the site do not limit the product selection¹⁶; (iii) and customers face no financial cost attached to selecting one product or the other. The mere sight of scarcity cues is sufficient to harm the trust relationship between the customer and the online vendor, as perceived benevolence constitutes a crucial

part of trust (Flavián, Guinalú, and Gurrea 2006). This result showcases a clear trade-off that comes with the use of scarcity cues.

However, scarcity cues may not be perceived as less trustworthy in all contexts, and we note three cases where our results should not apply. First, we considered a private sector application of scarcity that is different from a public sector one, given its implicit purpose of making profits. Previous studies have demonstrated that the mere context of a marketing proposal raises suspicions about the authenticity of scarcity claims (Sergeeva et al. 2023). When a government institution uses scarcity in a purely informative way, for example, to show how many hospital beds are available at a given nursery or to show the availability of seats in the website of a state-run railway company, the trust relationship between the citizen and the public entity should not be harmed because of the underlying understanding that the presented information has no other purpose than serving the citizen. Second, to convey scarcity in our application, we created a clothing brand whose name and products were unknown to participants prior to the study. Yet, the trust relationship towards a familiar brand is known to be different from an unknown brand (Koschate-Fischer and Gartner 2015) and past interactions with vendors can impact how their scarcity claims are perceived. For example, customers could condemn scarcity cues as less trustworthy when they do not know the vendor and its intentions, whereas they would tolerate similar practices with a vendor that has a favorable reputation. More research on how the actors behind the scarcity impact the perceptions of trust is therefore needed before generalizing our findings. Third, we found that the youngest age group (18–24) in our sample perceived scarcity cues as less trustworthy compared to all older groups. Given that about half of our sample was in this age group, it is possible that the effect of scarcity cues on trustworthiness of an e-commerce site might be smaller for the general population. If the general population perceives scarcity cues as more trustworthy than what was found in our sample, then the tradeoff between scarcity nudges and their cost on individual welfare could be lower. Further research is needed to see if our finding holds true for different demographic groups.¹⁷

5.5. Scarcity cues and user experience

We partially confirmed our hypothesis that scarcity cues would result in a lower pragmatic user experience score. Limited-time cues proved significantly worse than the control condition, and in the case of limited-quantity

cues, the evidence hinted at a smaller effect size in the same direction (see [Table 3 UXPRAG](#)). It implies that sites with scarcity cues potentially have a lower ability to support users' behavioral goals, and are thus perceived as less useful and harder to use (Hassenzahl 2003). Attention-grabbing elements are known to make sites harder to navigate for users (Nielsen 1994), and visually salient scarcity cues in the current study proved to be no exception. We believe this result showcases another deleterious effect on individual welfare that comes with the use of scarcity cues.

In terms of hedonic user experience, we found that limited-quantity cues resulted in the lowest score across all treatments. The differences were, however, only statistically significant between the stock and control conditions. The control condition had the highest hedonic user experience score. We believe that one explanation for this result could be that participants perceived the control condition as an unusually neat e-commerce site, going against the norms in terms of scarcity cues' pervasive use. Another explanation is that the control condition reminded participants of a higher range fashion brand. In stark contrast to wholesale vendors (e.g. Shein, Zalando, Amazon) scarcity cues are generally not sought by higher range vendors because all the goods are rare by definition, and the hedonic potential is paramount in such shopping experiences (Hagtvedt and Patrick 2009).¹⁸ Because our clothing site and the fictional brand associated with it were previously unknown to the participants, it is difficult to weigh which role these factors played without additional measures. In sum, more research on the hedonic user experience is required to understand how it depends on the way the brand is perceived.

5.6. Limitations and further research

In an online experiment, it is methodologically challenging to simulate real-life monetary incentives related to online shopping. Although the financial costs of scarcity cues are part of the welfare costs customers accrue, we did not include them in our study. The effects of financial costs on task performance were also not addressed. For these reasons, the negative emotions we captured were limited in that they did not cover the adverse consequences on customers' financial well-being. Scarcity cues likely generate stronger emotional reactions when customers' wallets are impacted. Nevertheless, our literature review found only a limited amount of incentivized studies where shopping choices were tied to financial consequences. Future research on scarcity cues should

therefore attach financial costs to shopping decisions. Partnerships with online vendors willing to share their data can especially benefit researchers on this matter. To assess the complete picture in terms of how scarcity cues impact individual welfare, future work should complement our findings with the financial costs of scarcity cues to consumers.

Our study also has some implications related to the measurement instruments and methods used. We worked with an aggregate measure of frustration-related negative emotions. It could be promising for future studies to be more specific and investigate whether these emotions reflect frustration, annoyance, stress, or a combination of the three. Although the Task Load Index proved useful for testing our hypotheses, the sensitivity of the measures could be improved by using more precise tools such as the Brief Mood Introspection Scale (Mayer and Gaschke 1988). We suggest further exploring the sub-dimensions of user experience through mixed methods to understand the impact of scarcity cues on hedonic user experience in higher range and mass-market e-commerce sites. Researchers could take advantage of the AttrakDiff User Experience scale (Hassenzahl, Burmester, and Koller 2003), as it includes a dedicated item capturing whether the product in question feels rather 'cheap' or 'premium'. Future researchers can gain a deeper understanding of the emotions triggered by scarcity cues or other dark patterns and how they impact the overall user experience by supporting quantitative measurements with additional interviews.

We did not incorporate any other measurement of customer trust in our study, as we deemed it irrelevant in the context of an artificial e-commerce setting. To our surprise, in the voluntary feedback after the experiment, participants suggested enlarging the product range, including more product sizes, optimizing the search bar, and enhancing the sites in various other ways. It seems participants thought of our sites as preliminary versions of a real e-commerce site. This is likely because genuine online vendors test their sites on the same crowdsourcing platform before their launch. Researching additional dimensions of customer trust seems therefore feasible even in a prototypical setting like ours. For example, the honesty/integrity dimension of customer trust relates to how authentic the online vendor is perceived. This dimension could allow exploring the potential effects of scarcity cues on the authenticity of both the products for sale and the vendor. Researching these additional dimensions could also contribute to a better understanding of the relationship between dark patterns and customer trust, and further contribute to the user welfare evaluation of such design elements.

5.7. Practical implications

In the context of e-commerce digital nudges, the deviation from transparency can result in difficulties for users in identifying whether scarcity cues represent genuine sales promotions or deceptive tactics. According to Lembcke et al. (2019), digital nudges should be designed with ethical values such as freedom of choice, transparency, and goal-oriented justification in mind. Our study is in line with the current research trends on dark patterns or ill-intentioned nudges, which show how deviating from these ethical values can result in nudges that do not function as intended and may even backfire, deteriorating the user experience and raising questions about the motives of the nudge creators (Bongard-Blanchy et al. 2021; Gray et al. 2021). In the context of e-commerce digital nudges, a lack of transparency can make it difficult for users to determine whether scarcity cues represent genuine sales promotions or deceptive tactics. Our findings show how this lack of verifiability might affect the trust relationship between the online vendor and customers. Combined with the results from Bongard-Blanchy et al. (2021), it is clear that users perceive scarcity cues as manipulation attempts. Online vendors who intend to appear more benevolent towards potential users should refrain from using scarcity cues. According to our findings, avoiding scarcity cues altogether should also give companies a competitive advantage regarding the ease of use of their sites. The mere sight of limited-time cues causes frustration related negative feelings among users, and lowers the usability and utility qualities of the site.

Although perceived as equally less benevolent, limited-quantity cues are not as irritating to customers. Perhaps because limited-quantity cues are perceived as more context relevant and as less arbitrary than limited-time cues. Truthful limited-quantity cues, in the sense of conveying honest stock information about the product, could be perceived as informative and useful. Nevertheless, the contents of scarcity cues should be well specified to reduce the possibility of manipulation. Consumer protection authorities in the United Kingdom¹⁹ and the European Commission²⁰ have already raised concerns about several design practises, and in the case of scarcity cues, urged hotel booking sites to specify the exact availability of their offers. These best practises should be kept in mind when considering the use of scarcity cues in e-commerce.

6. Conclusion

Many types of companies use scarcity cues on their websites. For example, consider fast-fashion companies

whose e-commerce sites are filled with dizzying amounts of scarcity cues. Fast-fashion companies' success, and their continued decision to bombard users with scarcity cues, are telling. Scarcity cues are profitable. Literature shows how scarcity cues can effectively change shopping behavior by increasing click-through rates, purchases and the perceived value of products (Aggarwal, Jun, and Huh 2011; Lynn 1991; Shuey 2014; Song, Choi, and Moon 2021; Wang et al. 2021; Wu et al. 2012). Arguably, this is the case for most dark patterns. The negative emotions they cause do not stop consumers from making purchases. The benefits to companies seem to outweigh the costs to consumers' financial and psychological welfare. The evidence gathered in this paper also points in this direction. As researchers, we oppose using these design elements for deceptive marketing purposes. We also acknowledge that not all online vendors wish to prioritise user welfare over dark patterns' commercial benefits. But what would discourage companies from using dark patterns? One possible motivator we found is reputation and customer trust. As more and more consumers are aware of design practises that change their behavior, companies risk losing face when they rely too much on such strategies, implying that there is an optimal level at which dark patterns are both acceptable and profitable. Unless legislative bodies step in to regulate digital environments where important decisions are made, the markets will continue rewarding companies that rely on dark patterns such as scarcity cues. In this context, dark patterns researchers must continue providing the evidence that is needed for meaningful policy decisions in terms of user welfare.

To conclude, our findings effectively point to various drawbacks of scarcity cues from the perspective of customers. Across multiple dimensions, we show that an e-commerce design without salient limited-time or limited-quantity cues provides the best overall shopping experience for participants. This paper contributes to the literature on the welfare effects of scarcity cues in four ways: (i) we show that limited-time cues cause negative emotions during users' online shopping experience; (ii) that scarcity cues do not significantly affect perceived task load while shopping, subjective estimates of time spent on task, and feelings of being time pressured; (iii) and that users associate the use of both types of scarcity cues with opportunistic behavior from online vendors.

Notes

1. Also called deceptive design patterns. Retrieved March 30, 2022, from <https://www.deceptive.design/hall-of-shame/all>.

2. Retrieved April 4, 2022, from <https://www.prolific.co/>.
3. Retrieved March 11, 2022, from <https://www.psychologie.hhu.de/arbeitsgruppen/allgemeine-psychologie-und-arbeitspsychologie/gpower>
4. Retrieved April 4, 2022, from <https://www.limesurvey.org/>.
5. Researchers were asked to generate an image of a non-existing person using <https://thispersondoesnotexist.com/>. Based on this image, and the content of products on the e-commerce sites, each researcher was tasked with creating at least one persona. We also asked the researchers to take into account what their persona would prefer in terms of colors, country of origin, or sizes for the clothing items.
6. Digital Shop template. Retrieved May 16, 2022, from <https://www.ceylonthemes.com/>
7. Retrieved March 14, 2022, from <https://woocommerce.com/>.
8. More than 26 percent of all e-commerce sites use WooCommerce. Retrieved March 14, 2022, from <https://www.tooltester.com/en/blog/wocommerce-market-share/>.
9. Retrieved March 24, 2022, from <https://unsplash.com/>
10. Original images from left to right are from Branding (2019); Hausmann (2020); Meyer (2018); Redd (2016); Saeng (2019); Vaithiyathan (2020); where-slugo (2017); Winegeart (2020)
11. Retrieved March 23, 2022, from <https://www.statista.com/statistics/568735/e-commerce-website-visit-duration/>
12. Our datasets are available in online supplementary materials.
13. Notably, 4 participants who identified as non-binary were randomly distributed to female and male groups. 20 participants between ages 35–44 were merged with 5 participants between ages 45–54 and with 2 participants in the group ‘55 and more’ forming the age group ‘35 or more’ ($n = 27$). 2 participants who had less than high school education were merged with 42 participants who had at most high school education, forming the group ‘high school diploma or less’ ($n = 44$). 11 participants who had associate degrees were merged with 55 participants who had bachelor’s degrees and formed the bachelor’s or equivalent group ($n = 66$).
14. The entire analysis in this section was done in Python and is available on OSF: https://osf.io/xgdpm/?view_only=6f91710638f64c21ae9ebf2aa8b1e290.
15. Even though bootstrapped confidence intervals pointed to a difference between stock and control conditions, we refer to the more conservative estimate based on the correction for multiple comparisons.
16. Meaning the countdown timers never ran out and no product became out of stock after being put in the shopping cart.
17. We are thankful to the anonymous referees for their valuable contributions in this section.
18. Certain higher range brands refrain from showing prices of products on their online stores as they do in brick and mortar shops.
19. Referred to in the Competition & Markets Authority (2022) report under the CMA probe hotel booking sites. Retrieved May 6, 2022, from <https://www.gov.uk/government/news/hotel-booking-sites-to-make-major-changes-after-cma-probe>
20. Retrieved May 6, 2022, from https://ec.europa.eu/commission/presscorner/detail/en/ip_19_6812

Acknowledgments

We want to express our gratitude to Romain Toebosch and Aleksei Udovenko for their help with the experimental websites design and implementation. We would also like to give special thanks to Etienne Le Bihan for his support in the data analysis. We thank our participants for their time and insights and the members of our research group for their participation in pretests and valuable comments about our research plan.







Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the Fonds National de la Recherche (FNR) PRIDE (19/14302992) and DECEPTICON (IS/14717072).

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Appendix. Instructions for the shopping task

Please put a pen and paper in front of you or open any text editor (e.g. Microsoft Word, Notepad). You will be asked to take notes.

Now, read the descriptions of the 3 persons below:

- This is Robert. He was born in the late '80s in Hungary and is a programmer. Robert is very organised and somewhat reserved. He loves rock music and plays drums with his local band. He also maintains a website documenting medieval Hungarian music. His clothing style can be described as comfortable yet stylish. He does not enjoy wearing light colors. He is also very interested in nature conservation and finds it essential only to wear clothes made ethically using recycled or natural materials.
- Lucas values having fun with fashion, making unusual combinations, and experimenting with colors, forms, and shapes. Even though he is not rich, he occasionally buys expensive clothing items and considers them good investments. Lucas struggles to find big enough shoes (he wears size 47). He loves Italian style and would like to visit Milan.
- This is Gabriel. He is a bourgeois French man who knows how to save money but appreciates things of quality. He is always classy, slender, and tall. He looks attractive for his age but is a bit of a killjoy when it comes to what he considers 'silly things'. He avoids wearing black because it makes him look older, but he also hesitates to wear something extravagant, afraid to make a clown of himself.

Link to the shopping site (clicking opens a new window)

On this shopping site, choose 2 pieces of clothing (for example t-shirt and jacket, or jeans and sneakers, or two coats...) for EACH of the individuals above. Select items that suit the individuals' taste: what Robert, Lucas, or Gabriel will probably like to wear based on their descriptions. Note briefly which items you choose for each of the 3 persons and why.

For example, you could write: 'I decided to choose the "Homer" shirt for Robert, because it is not very expensive, has a nice pattern, and is made from recycled cotton, which reflects his environmental attitude.'

There are no right or wrong answers to this exercise. Don't overthink too much (usually people spend 7–10 minutes on that task) but try to find good options according to the person's profile.

Check that you selected and wrote down 6 items (2 for each described person). We will ask you about your choices in the following questions.

Please choose only one of the following:

- I read the instructions and will move to the second part of the study ONLY AFTER finishing the task.