Investigating the Role of Task Relevance in Change Detection on Flight-Booking Websites Using the Change Blindness Paradigm.

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Sreya Chary Bavoju

First Supervisor: Dr. Rob van der Lubbe

Second Supervisor: Simone Borsci

Faculty of Behavioural, Management and Social Sciences

University of Twente

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Abstract

In a daily life, the human brain is exposed to a continuous array of visual stimuli which the cognitive system simultaneously observes, processes and understands. However, when the stimuli are unlimited and cognitive resources like attention and memory are finite, completing tasks requires the cognition to tunnel resources for successful completion. Such goal-direct behaviour can limit the individual's situational awareness leading them to overlook seemingly evident changes in their surroundings.

Digital environments, such as flight booking websites, present all necessary information required for the decision-making of the individual, but the informational density on the website could overwhelm the individual resulting in them focusing on the immediate task goals, such as, finding a cheap flight. However, a question about the individual's attention follows, does the goal-directed nature of completing tasks influence the detection of potential changes happening in an interface that are irrelevant to the task? To answer this question, this study examined the role of task relevance in change detection in simulated flight-booking interfaces using the Change Blindness paradigm.

Participants looked at a series of flight booking website images in which they were either asked to focus on the Price (e.g., "Find a flight under €200") or focus on the Date (e.g., "Fly between March–June"). Across six blocks, the participants were presented with altering task goals, while subtle visual changes such as, colour, font and size were occurring in the Price and Date. The findings of this study showed the role of task relevance in guiding what users see and don't, in complex digital environments as there was a significant impact of Task Relevance on change detection. Irrespective of the Price or Date condition, if the changes were happening in a condition that was relevant for that particular block, the participants were highly likely to detect the changes. For example, if the participant was asked to focus on Price, they noticed changes happening in Price more likely than changes in Date. These results show that Task Relevance acts as a powerful cognitive filter while performing a goal-oriented task, potentially at the expensive of overlooking changes elsewhere if they are deemed irrelevant.

Keywords: Task Relevance, Category, Date, Price, Task Order, Change Blindness, Flicker Paradigm, Signal Detection Theory, Sensitivity, Response Bias, Beta, Selective Attention, Situational Awareness, Colour, Font, Font Size.

Investigating the Role of Task Relevance in Change Detection on Flight-Booking Websites Using the Change Blindness Paradigm.

Situational Awareness (SA) is the ability to perceive elements of a surrounding environment. According to the APA Dictionary of Psychology (2018), it is the conscious knowledge of the events occurring in the environment. A popular framework named the Three-Level Model was proposed by Endsley (1995), which proposed: perception, comprehension and projection as the three levels in which Situational Awareness occurred. Any environment that the human is exposed to first becomes aware of their situation by perceiving the stimuli and elements present in the environment. Comprehension proceeds past simple perception and into understanding the significance of the elements present in the environment. Finally, the last and highest level of SA involves projection of future actions of the elements present in the environment. The three levels together aid human cognition in navigating everyday tasks with quick decision-making (Stanners & French, 2005).

In the framework, Endsley discussed working memory as one of the factors underlying and influencing the SA process. *Working Memory* (WM) also known as *Short-Term Memory* (STM), is ability to temporarily maintain and use information for goal-oriented tasks (Baddeley, 2012). WM is the foundation of everyday cognition, and in the context of SA, it is the storage for when once elements are perceived. The advancement of technology shows that this cognitive function becomes especially pivotal in digital contexts, such as, flight booking websites (Štefko et al., 2025). While booking for flights online, individuals need to make several decisions which includes remembering details such prices, travel dates, luggage options and sometimes even airlines in order to make well thought-out decisions. Decision-making in such situations emphasises the necessary use of WM in digital environments by users. However, the levels of processing in WM need to be dynamic and constant for an individual to be consistently situationally aware, this can impose a significant mental load on the individual.

Additionally, attention is one of the underlying factors influencing Situational Awareness requires constant attention and attending of elements in an environment, but complex decision-making and tasks can exceed a person's limited attention capacity. Research has shown that because visual environments contain more information that can be processed at the same time, hence, *selective attention* is of essence for prioritising goal relevant information (Desimone & Duncan, 1995). In cases such as a flight booking websites,

users are provided with an overwhelming amount of information which can be complicated for the users to navigate (Forster & Lavie, 2009). In such cases, making the right choices of the appropriate dates, prices and flight requirements becomes a primary aspect for attention and other features such as the fonts, colours and size of the text on the website become secondary. Hence, the occasional attributable changes on the website are less likely to be actively attended or encoded into WM, despite being seemingly obvious changes.

Furthermore, Endsley suggested that goal-directed behaviour is therefore a primary mechanism for managing limited attention and reducing the potential SA errors (1995). However, such intense concentration on certain goals or tasks also poses certain risks for accuracy, because such narrowed focus increases the risk of *attentional or cognitive tunnelling*. In such state, attention is primarily present in the elements that are relevant to the task, and any elements or changes occurring outside of the task at the risk of being overlooked or completely missed. This phenomenon of cognitive tunnelling can be further understood with the Time-Based Resource Sharing (TBRS) Model (Barrouillet et al., 2004), in which is it argued that STM and attention derive their information from the same limited cognitive space, suggesting that as the demand for attention increase, the performance of memory decreases.

From the aforementioned research, goal-directed behaviour plays a big role in SA and detection of potential changes in the elements of an environment. Goal-direct behaviour can be conceptualised as *Task Relevance* in this experiment as the degree to which information that is provided to an individual aligns with their current goal, which determined the information priority and cognitive processing. Whereas the other information present in environment is deemed irrelevant or secondary to their goal (Folk et al., 1992; Yantis, 2000). In complex environments like flight-booking websites, Task Relevance creates a cognitive filter of information relevant such that the user's goal is selectively enhanced, meanwhile irrelevant information is suppressed despite being perceptually available. Hence, this arises the question of what is really noticed by an individual on a digital website when they are focused on a task that is relevant for them and if this results in them failing to detect changes that are seemingly evident.

A notable demonstration of how task relevance impacts change detection is through a phenomenon named *change blindness*. Change Blindness is the failure to notice a seemingly obvious detail about a scenario when attention is directed elsewhere (Jensen et al., 2011). A

popular demonstration of this paradigm is the ‘flicker task’, in which participants are presented with an original image and a change image flickering back and forth but separated by a brief blank screen between the two images (Rensink et al., 1997). In this task, the participants often require multiple repetitions of the ‘flicker’ in order to notice and localise a change. Once the change is noticed, it is hard to miss it even with the mask. There are three steps that may be distinguished in order for a person to notice a change, first is encoding the stimuli, second is storing it into WM and third is comparing it with the subsequent display (Simons & Rensink, 2005). Hence, an error in any of these steps leads to a failure of noticing change making change blindness a useful phenomenon to examine the limitations of WM and attention.

Change blindness can also be a valuable method in testing the role of attention in WM in digital environments. Users are constantly confronted with digital stimuli such as pop-up notifications, updating layouts on desktops and mobile phones, change in prices etc. These factors can influence memory and the failure to notice the changes can provide explanation on the limitations of memory and attention. Prior studies have studied the role of WM in digital environments consisting of informational load and requiring attentional demands (Lodge & Harrison, 2019). However, it is still not clear how users allocate their memory when only some features of a digital interface are relevant to their task.

In the context of a flight-booking website, overlooking a change happening in the date or the price, albeit seemingly unimportant, might have suboptimal or unideal scenarios. The digital nature of flight booking websites, the high visually contrasting information, plethora of booking options and the time-sensitive nature of flight booking, raises new questions about attention and WM. The role of attention and memory in a digital decision-making environment remains unclear. Specifically, whether users are more sensitive to changes in critical features, such as flight prices, when these features are directly tied to task goals (e.g., staying within a budget), and whether this heightened sensitivity comes at the expense of detecting changes in irrelevant information, such as the colour, font, or size.

The research from Suhani (2022) and Bittner (2024) were used in this study to explore this topic further. Suhani (2022) found evidence that change detection is influenced by task demands and complexity of the visual stimuli, which provides the understanding that users potentially miss details when the task is demanding or complicated. Moreover, Bittner’s examined if the complexity of an item that an individual is looking for on a website

influenced the recollection of information on that website. The study included changes to multiple visual features, such as colour and font. The results showed that not all visual changes were well equally detected, signifying that attentional prioritisation is important in change detection in applied digital contexts. Although both studies provide a good foundation for the study of attention, memory and change detection, these studies did not examine how task relevance influences change detection of feature attributes in a simulated flight booking website.

To understand this further, the aim of this research is to investigate the role of task relevance in change detection in simulated flight booking websites with the use Change Blindness. This study explores how users detect changes in critical features such as price and date compared to other task irrelevant details. Based on the rationale and previous research, this study is interested in answering the following research question: *To what extent does task relevance and task order influence change detection performance for price and date information in flight booking websites?* It was hypothesised that participants are more likely to detect changes when the features are Relevant to the task they are performing (e.g., detect changes in Date when they are performing Date task) and overlook (or change blind) to features that are Irrelevant to the task they are performing (e.g., do not detect changes in Price when they are performing Date task). This study using Signal Detection Theory as a measurement tool and the results of this study are expected to show higher Sensitivity (*d'*) for task Relevant features and lower Sensitivity (*d'*) for task Irrelevant features. Moreover, Task Order is predicted to potentially influence the participant response, such that a feature that was relevant in the first block (price or date) will continue to attract attention and be detected more easily, even when it becomes irrelevant in the second block. Finally, the participants are predicted to likely to display learning effects and fatigue effects over the course of the experiment. The changes that are happening in this study are in colour, font and size of Date or Price. Font and Colour changes were chosen due to them being the common form of change employed in studies (Bittner, 2024; Miežytė, 2019; Steinweg, 2021; Suhani, 2023; Varakin et al., 2007). Size changes were employed due to the absence of research for this feature type in Change Blindness research.

Methods

Participants

The participants of this study were collected through convenience sampling, participation was voluntary. The present study consisted of 31 participants in total (N=31), with the age of the participants ranging from 18 to 27 years (M= 22.23, SD= 2.35). The sample consisted of 19 women (61.3%) and 12 men (38.7%). The participants of this study consisted of diverse nationalities, and the largest groups were 9 Dutch (29 %), 5 German (16%) and 4 Indonesian (12.9%) and 13 other nationalities (41.9%). All the participants had at least high school level of education (61.3%) and 10 others had a bachelor's degree (32.3%) and one person with a master's degree (3.2%). The participants used their dominant hand to perform the experiment, 3 (9.9%) were left-handed while the rest were right-handed (90.3%). Most participants reported using their computer with corrective lenses, primarily being glasses (n=17), whilst a small population reported contact lenses (n=3); the remaining sample reported no use of any corrective lenses (n= 11). On average, participants reported moderate experience with booking flights online (M = 3.29, SD = 1.04) and relatively high comfort for using flight-booking websites (M = 4.11, SD = 0.96). All participants were tested for colour-blindness with the Ishihara Colour Test, and one person who did not achieve a perfect score was excluded from the study prior to participation. This study was approved by the Ethics Committee of the Faculty of Behavioural, Management, and Social Sciences (BMS) at the University of Twente (Application Number: 252240)

Stimuli and Task

Within the experiment, two simulated flight booking websites were used, the stimuli consisted of static screenshots of flight options displaying typical information such as website name, airline logos, flight information, departure time, arrival time, date and price. The stimuli were created using Canva and closely resembled *skyscanner.net* (refer to Figure 1 and 2). One iteration of the images consisted of booking a flight to Zurich, Switzerland via, a fictitious airline, *Swizz Air* (utilised during Block / Scenario 1, 3, 5); the other iteration was on the same website to travel to Dublin, Ireland via *Airish Airlines* (utilised during Block/ Scenario 2, 4, 6). Both versions were created to resemble each other.

Figure 1

Simulated flight booking website from Amsterdam (AMS) to Zurich (ZRH)

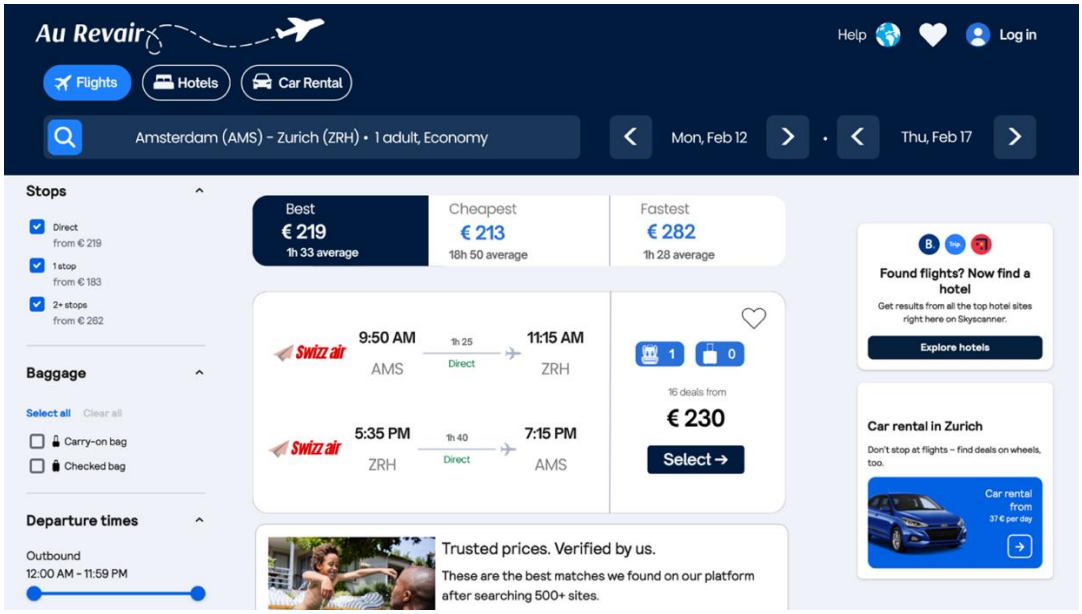
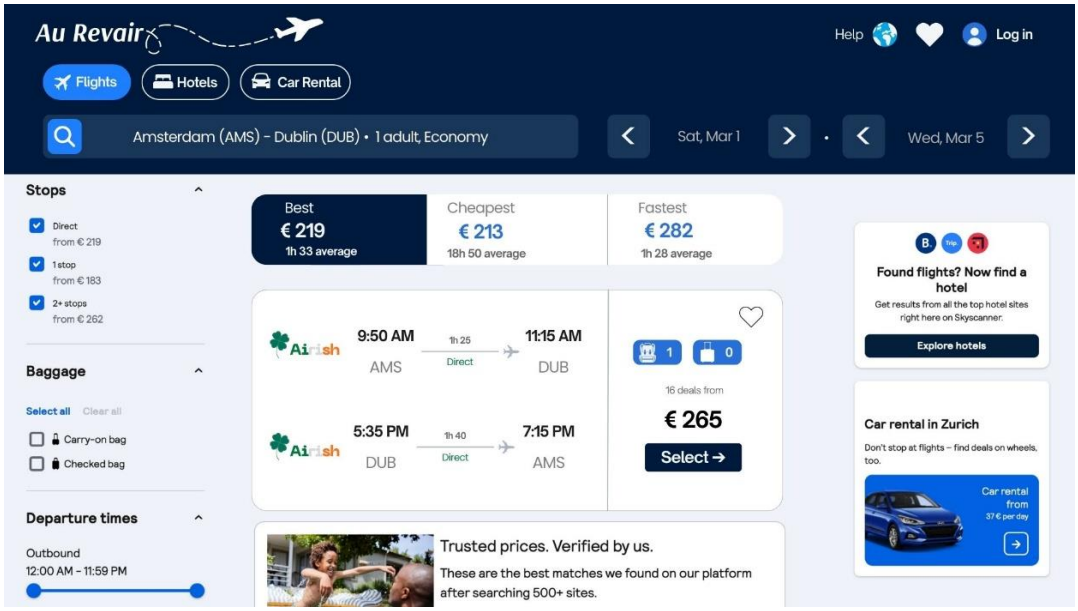


Figure 2

Simulated flight booking website from Amsterdam (AMS) to Dublin (DUB



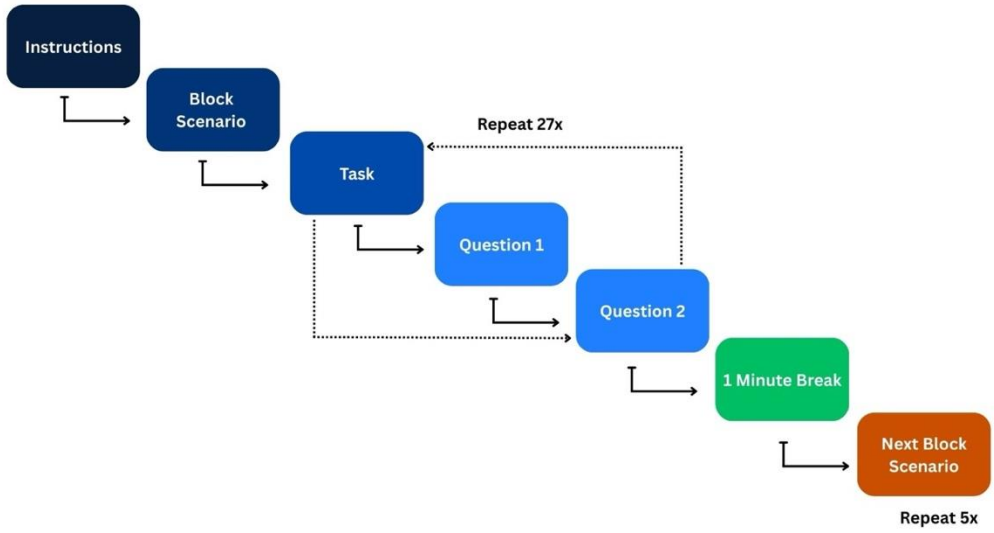
The study employed a 2 (between-subjects: Task Order) × 2 (within-subjects: Relevance) × 2 (within-subjects: Category) mixed factorial design. Task Order (Date-first vs. Price-first) was counterbalanced across participants. Relevance referred to whether a visual change occurred in the information participants were currently monitoring (Relevant) or in the non-monitored information (Irrelevant). Relevance as a factor meant whether that change occurred in the information participants were currently observing

(Relevant) or in the non-monitored information (Irrelevant). For example, in a Date-focused block, a change to Date text was Relevant, whilst a change to Price text was categorised as Irrelevant. Category referred to whether the change occurred in the Date or the Price text. It is crucial detail that the actual text on the Date and Price (e.g., "14 Jan" or "$199") did not change between pre-mask and post-mask, the changes occurred in the visual attributes of Date and Price (colour, font, size). Sensitivity (d′) and response criterion (β) were computed using signal detection theory, with no-change trials serving as the baseline for false alarms.

The visual stimuli consisted of screenshots from a simulated flight-booking website, with a total of 162 image sets which were equally divided in six blocks. Each block consisted of Scenario, the flicker task, two questions, one minute break, which repeated for 5 more times (refer to Figure 3).

Figure 3

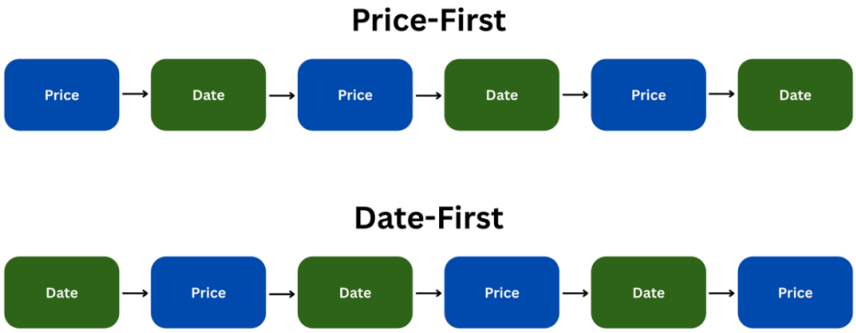
Structure of one block (total of 6 blocks in the experiment)



In the experiment, three blocks were designed for the participant to focus on Price whereas, three other blocks designed to be focused on Date (refer to Figure 4). The order of the category was counter-balanced per each participant (e.g., participant one started with Date-relevant; participant two started with Price-relevant).

Figure 4

Order of the categories presented to the participants

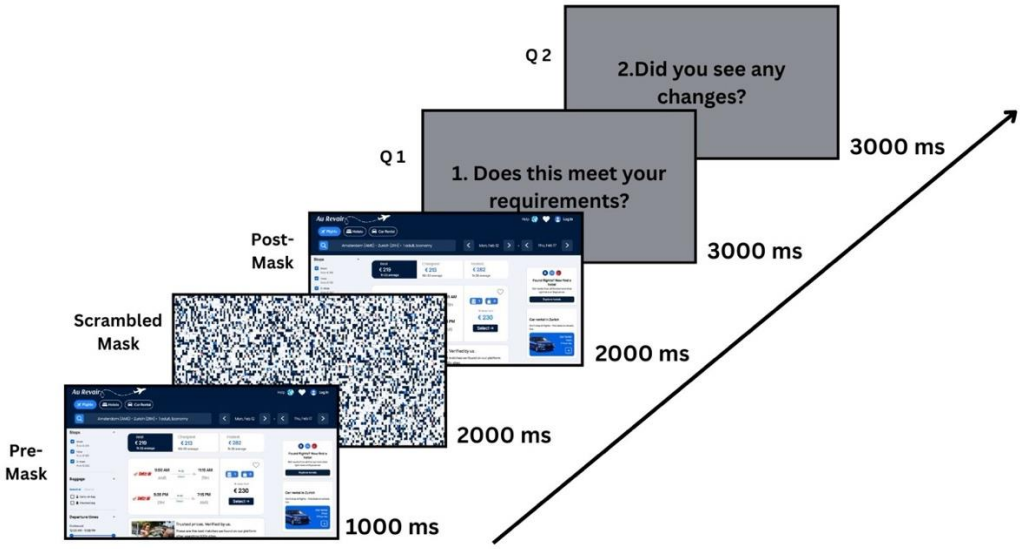


Each block consisted of 27 trials using a flicker paradigm (refer to Figure 5). In each trial, participants viewed:

1. A pre-change image (1000 ms)
2. A scrambled mask (2000 ms)
3. A post-change image (2000 ms)

Figure 5

The order of events in one trial (per one scenario)



The scrambled mask was created by randomly distributing the pixels of one flight booking screenshot, so it preserved the original luminance and colour palette but disrupted the continuity. A scrambled mask was chosen to interrupt the participants iconic memory and prevent them from remembering the pre-mask image details as a strategy (Rensink et al.,

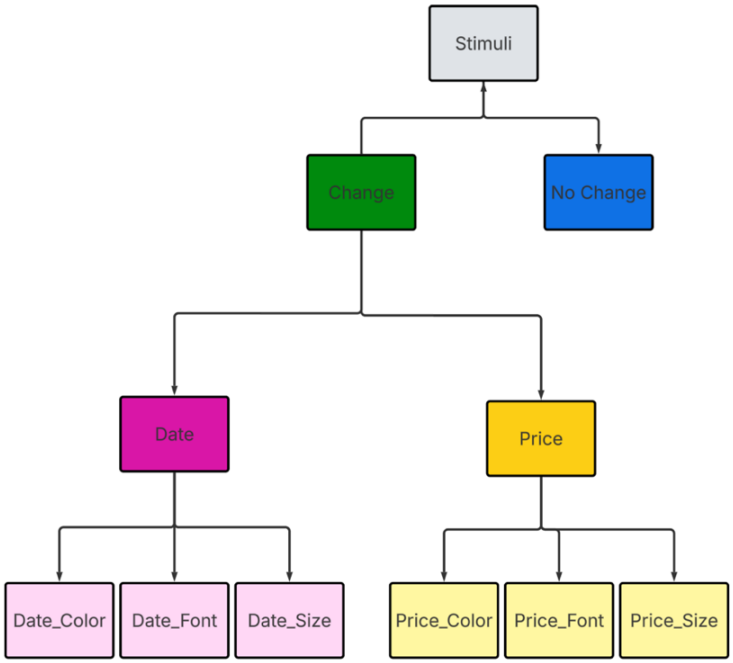
1997; Enns & Di Lollo, 2000). Moreover, the scrambled mask was designed to simulate real life digital interruptions such as, pop-up notifications, glitches and loading-pages transitions during online browsing and increasing the study's ecological validity.

The shorter pre-change duration was decided to allow for initial encoding of the pre-mask and preventing familiarising of the stimuli and creating memory strategies (Rensink et al., 1997). The longer mask and post-image allowed for effective iconic memory disruption of the pre-mask and provided the participant for longer time to evaluate potential changes in the post-image (Enns & Di Lollo, 2000).

The post-mask images consisted either of Task Relevant changes (9 price and 9 date related), or Task Irrelevant (e.g., changes happening in the date during the price task), or 9 No Changes occurred. The changes involved alterations to visual attributes of the stimuli, specifically font colour, font style, and font size (see Figure 6)

Figure 6

Division of visual stimuli



The aforementioned colours were chosen was because they aligned with the colours of the simulated flight booking website so if the participants failed to notice the change, it is due to change blindness and not due to pop-out effects, in which a visually distinct captures the attention of the individual instead of the independent task goals (Nagy & Thomas, 2003). Moreover, the font style was changed either into bold or italics for both the price and date

information. Finally, the size increased by 5 points for both date and price in the size change category (see Table 1)

Table 1
Types of changes in Date and Price with Hex codes of colours

Change	Feature	Original	Modified into
Price	Font Colour	Black (#000000)	Dark blue (#396aa6) or light blue (#1f80ff)
Date	Font Colour	White (#f2f6f8)	Grey (#808080) or light blue (#1f80ff)
Price	Font Style	Open sauce	Bold or Italic
Date	Font Style	Poppins	Bold or Italic
Price	Font Size	30	Increased by 5 points
Date	Font Size	20	Increased by 5 points

Procedure

The experiment took place in a quiet room with the researcher present. An informed consent form was provided to the participant which explained the rights of the participants, and the purpose of the experiment. The informed consent also consisted of the demographic's questions (refer to Appendix A)

The researcher presented the participant with the welcome screen of the experiment (refer to Appendix E), which explained the duration of the task, the expectations from the participants and some general instructions about the experiment itself. The participants could press SPACE on the keyboard to continue into the first block. Each block began with a short scenario description providing the participant with the travel context, the airline, luggage requirements, reason for travel, and a specific goal for the block (e.g., "Find a flight under €200" or "Fly between 1 March – 31June") (refer to Appendix B). After each flicker task, the participants were asked two questions one after the other: "1. Does this flight meet your requirements"; "2. Did you see any changes?". The participants responses were made via the 'Y' (yes) or 'N' (no) keys on the keyboard. The participants are given 3000 milliseconds each to respond as a deliberate choice, so the participants provided intuitive, first-pass judgments instead of reflective and re-analysing the stimulus for the reason of accuracy (Wilen & National Education Association, 1991, p. 10). Between blocks, participants took a 1-minute break. After completing all six blocks, a final screen appeared thanking them for their

involvement (refer to Appendix F). The complete aim of the study is disclosed (the study of change blindness), and their rights as a participant to withdraw for participants were reiterated; and in case of questions, the contact information of the researcher was also provided.

Finally, the participants were asked some questions to understand their interpretation of the study, what changes they saw, moments of uncertainty and overall experience. This informal interview was recorded with the verbal consent of the participants and later transcribed for qualitative research purposes.

Apparatus

The experiment was programmed and presented using PsychoPy (Version 2025.1.1) on a 13.6-inch MacBook Air (M2 chip, macOS). The display resolution was 2560 × 1664 pixels. Responses were recorded via the laptop keyboard. Stimuli were designed in Canva to closely resemble *skyscanner.net*, and colour vision was assessed using the online Ishihara Colour Test (hosted by Colorlite) (refer to Appendix C). The analysis was conducted on R Statistical software (v4.3.1)(refer to Appendix H). All sessions were conducted in a quiet room under normal lighting conditions

Data Analysis

Prior to testing for the inferential statistics, the sensitivity distributions and bias metrics were assessed for normality (refer to Appendix D). The results were calculated using Signal Detection Theory to check for Change Blindness in each participant. Sensitivity (*d'*) was calculated in this study to measure the detection of change meanwhile accounting for false alarms. Response Bias was calculated using Beta (β) as a Decision criterion to separate performance accuracy from strategy that is developed by the participants. Applying SDT to this experiment, 'Hit' rates are proportions of trials in which the participant correctly answered correct detections and correct rejections (Relevant or Irrelevant), whereas 'False Alarm' rates occur when the participants responded that there is change when there are none (No Changes). Sensitivity (*d'*) is calculated as the difference between z-transformed hit rates and z-transformed false alarm rates (refer to Formula 1 & 2).

Formula 1 & 2

$$d' = z(\text{Hit Rate}) - z(\text{False Alarm Rate})$$

$$\beta = \exp\left(-\frac{1}{2}[z(\text{Hit Rate})^2 - z(\text{False Alarm Rate})^2]\right)$$

A counterbalanced design was employed, with participants assigned to either the Date-First (DF)or Price-First (PF) condition. This manipulation allowed for the examination of how task relevance influenced change detection across Category (Price vs. Date). Moreover, Repeated Measures ANOVAs were used to measure the effects of Relevance and Category on *d'* and β. Decision Strictness which helps us understand whether the observed sensitivity was due to genuine response or because the participants developed a response strategy. Conservative response indicates that no significant response strategy and Liberal response suggests that participants had a low threshold for what they considered a change. The experiment followed a mixed factorial design with Relevance (Relevant vs Irrelevant) and Category (Price vs Date) as within-subject factors, and Task Order (Price-First vs Date-First) as a between-subjects factor. The analysis was done in two steps, the first analysis, a 2 (between-subjects: Task Order) × 2 (within-subjects: Relevance) × 2 (within-subjects: Category) mixed-model ANOVA was conducted separately on d′ and β to test for potential effects of the counterbalanced task order. Second, Task Order was collapsed and then analysis was conducted using two separate 2 (Relevance) × 2 (Category) repeated-measures ANOVAs for d′ and β. Finally, one-sample t-test was used to test decision strictness and if β differed significantly from the neutral value of 1.

Results

The sensitivity distributions and bias metrics were assessed for normality. The analyses display no drastic deviation from normality, and the data is adhering to the diagonal line (refer to Appendix D), hence this study continued with the use of parametric ANOVA and t-tests.

To statistically test these observed patterns, inferential analyses were conducted. A 3-way mixed ANOVA with Task Order as a between-subjects was conducted to assess whether the counterbalanced task order influenced performance (refer to Table 2). The results showed that there is a marginal significance Task Order, $F(1, 29) = 3.91$, $p = .058$, suggesting that the order in which the tasks were presented to the participants might have a marginal effect on their performance. The interaction between Task and Category, $F(1, 29) = 3.94$, $p = .057$, also showed a marginally significant effects which could imply that the performance of the participant depended on which category they were first assigned to (Price vs. Date). A visual depiction of these results is presented in Figure 7, as interpreted by the researchers of this study, indicates that Price-First (PF) group seemingly had a stark increase in the sensitivity

(*d'*) as compared to Date-First (DF) group who had a more gradual increase. The combined results of the marginal significant results and the visual representation combined provide suggestive evidence that Task Order may influence performance. However, given that the statistics are meeting the borderline threshold, the results should be taken with caution and require replication.

Table 2

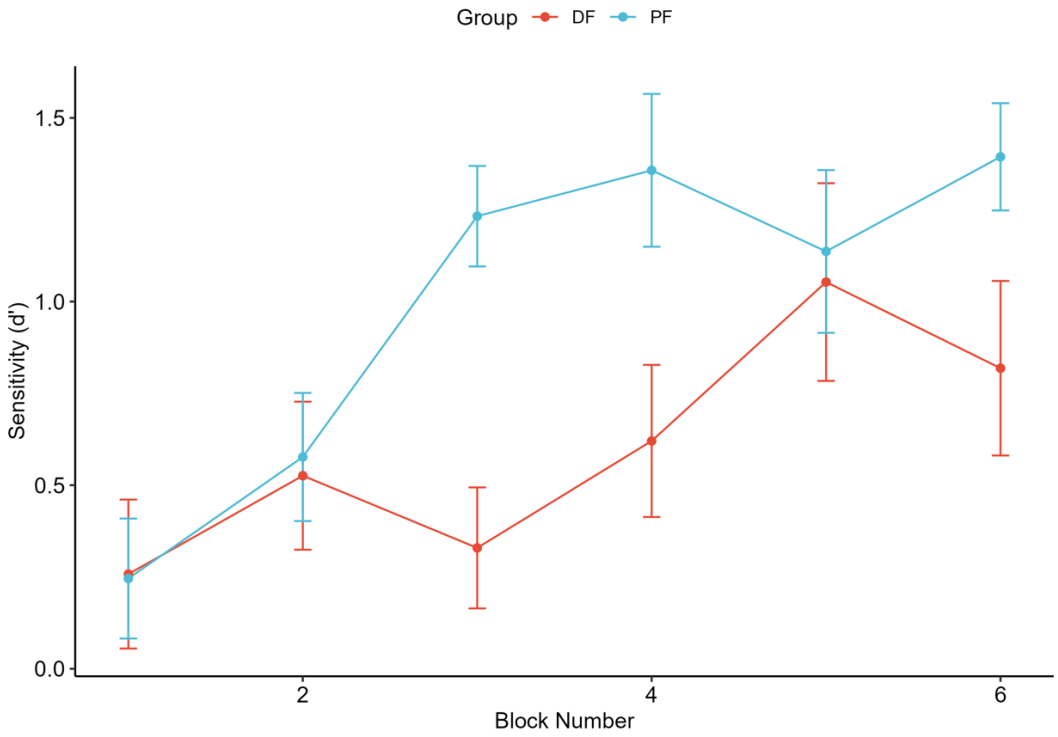
3- Way Mixed ANOVA using Sensitivity (d') with Task Order as a within-subjects factor

Effect	DFn	DFd	*F*	*p*	Significance
Task Order	1	29	3.91	0.058	ns
Relevance	1	29	31.88	< .001	***
Category	1	29	0.66	0.415	ns
Task Order x Relevance	1	29	2.87	0.101	ns
Task Order x Category	1	29	3.94	0.057	ns
Relevance x Category	1	29	<0.01	0.977	ns
Interaction*	1	29	2.49	0.125	ns

Note. *Interaction = Task Order x Category x Relevance

Figure 7

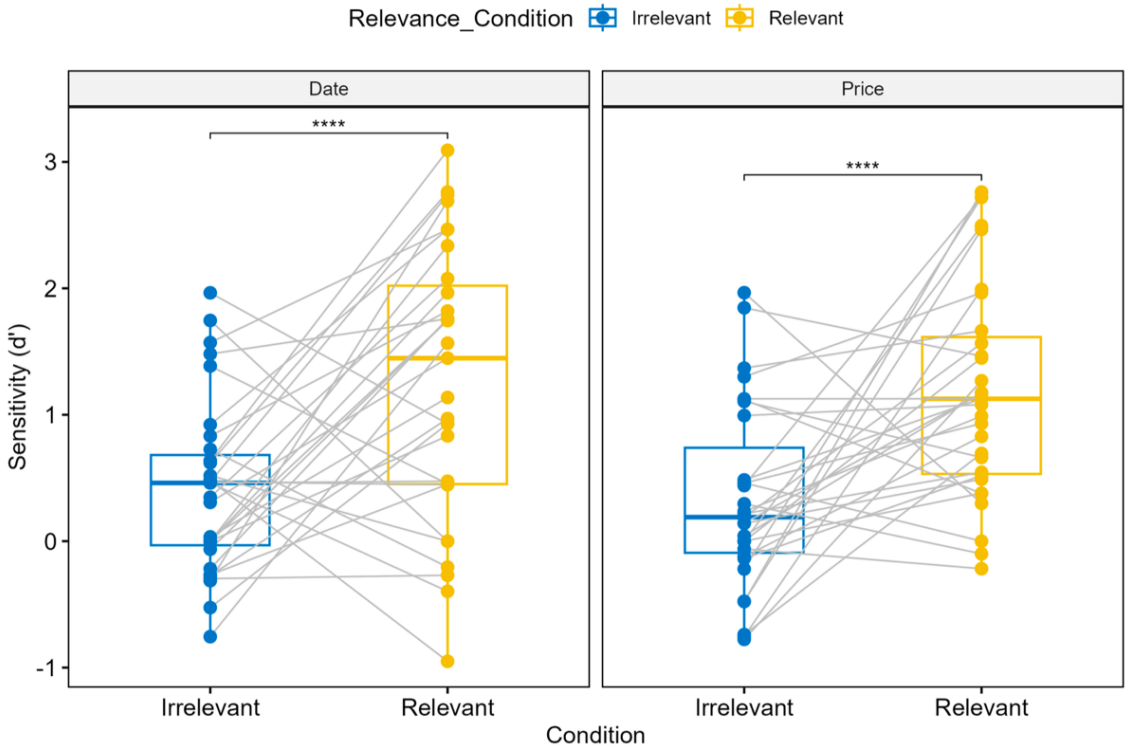
Sensitivity (d') of Date-First (DF) group and Price-First (PF) across blocks



Furthermore, Table 2 also shows whether task Relevance (Relevant vs. Irrelevant) impacts the change detection. The results showed a highly significant main effect of Relevance on sensitivity, $F(1, 29) = 31.88$, $p < .001$, reflected substantially higher sensitivity for Relevant changes (Price-Relevant: M = 0.98, SD = 0.76; Date-Relevant: M = 1.18, SD = 0.94) compared to Irrelevant changes (Price-Irrelevant: M = 0.17, SD = 0.62; Date-Irrelevant: M = 0.30, SD = 0.61). Further analysis of Relevance (Relevant vs. Irrelevant) on Sensitivity (*d'*) shows that sensitivity was significantly higher for Relevant changes than for Irrelevant changes, with no differential effect based on Category (Date vs. Price) (refer to Figure 8). The results of the interaction between Category and Relevance also show no significance, implying that sensitivity did not differ between Price and Date tasks. Overall, the significance lay in the task Relevance. Moreover, in Figure 8, Relevant conditions show significantly higher discriminability ($p < .001$) as opposed to the Irrelevant condition *d'* which is much closer to zero.

Figure 8

Paired t-test results of Effect of Task Relevance on Sensitivity (d')



Note. Relevant changes: information participants were currently monitoring (e.g., Date changes during a Date-focused block). Irrelevant changes: non-monitored information (e.g., Price changes during a Date-focused block).

Furthermore, a repeated-measures ANOVA with Relevance and Category as factors was conducted on Response Bias (β) to assess whether task relevance influenced decision strictness. The results in Table 3 show that β showed a significant effect in Relevance $F(1, 30) = 4.58$, $p = .04$.

Table 3

Repeated Measure ANOVA of Relevance and Category using Beta (β)

Effect	DFn	DFd	F	p	Significance
Relevance	1	30	4.58	0.04	***
Category	1	30	0.04	0.85	ns
Interaction	1	30	0.002	0.97	ns

Note. Relevance (Irrelevant vs. Relevant) and Category (Date vs. Price)

Further analysis to assess the direction of the shift was conducting using one sample t-tests with the neutral value of $\mu = 1$. According to SDT, $\beta > 1$ signifies a conservative criterion, meaning that the participants were had a high threshold for certainty, so they were likely to say there were no changes unless they were certain there was a change. The results are shown in Table 4, Price-Relevant (M = 1.36, SD = 0.47, $p = .004$), Price-Irrelevant (M = 1.05, SD = 0.42, $p = .004$), Date-Relevant (M = 1.66, SD = 0.88, $p = .019$), and Date-Irrelevant (M = 1.29, SD = 0.55, $p = .019$). The results showed that β greatly differed above 1 for Price conditions in Relevant and Irrelevant conditions (both $p < .004$). The Date conditions also showed significance but slightly below in Relevant and Irrelevant conditions (both $p = .019$).

Table 4

One-sample t-test for Beta (β) neutrality. (μ = 1)

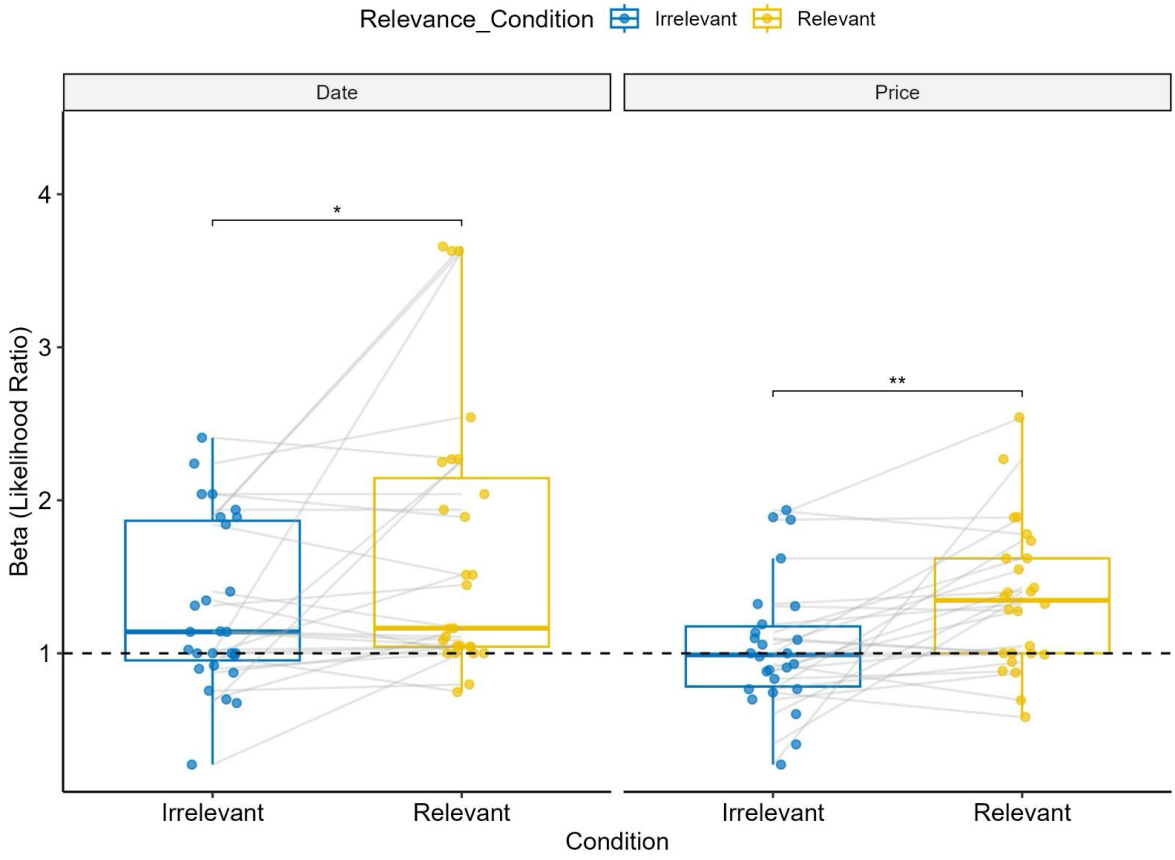
Condition	Task	*Mean*	*SD*	*p*	Significance
Relevant	Date	1.66	0.88	0.019	*
Relevant	Price	1.36	0.47	0.004	**
Irrelevant	Date	1.29	0.55	0.019	*
Irrelevant	Price	1.05	0.42	0.004	**

The visual representation of the “conservative shift” is presented in Figure 9, in which majority Beta values of the participants display an upward trend from Irrelevant to Relevant

conditions. Additionally, Relevant conditions are significantly elevated above the neutral line (y = 1).

Figure 9

Response Strategy (β). Values above 1 indicate conservative criterion, while below 1 indicate liberal.



Discussion

The aim of this study was to investigate the role of Task Relevance in change detection in task-oriented digital environments using the Change Blindness paradigm. The marginal significant results of Task Order could be interpreted that the order in which information is presented to people may subtly change the perception of the environment or the elements in the environment. However, the near significance of Task Order also poses uncertainty about the strength of its influence on change detection and requires further research. Furthermore, as hypothesised, individuals are more likely to detect changes happening in a task that they are currently focusing on, and less likely to detect changes when they were not relevant to the task they were focusing on. The results of the task relevance and performance are in line with the TBRS Model (Barrouillet et al., 2004) and the response can be supported with the consistent strong effect of task Relevance on Sensitivity and Response Bias. Moreover, However, further analysis showed that people are also more cautious when they are reporting changes happening in Price slightly more likely than Date, this was assessed using response bias decision strictness which showered that showed that participants responses were more conservative in the task Relevant changes of Date and more for Price.

The key findings of this study about the task relevance were consistent with Selective Attention (Desimone & Duncan, 1995), TBRS Model (Barrouillet et al., 2004) and Change Blindness (Rensink et al., 1997; Jensen et. al., 2011) proposed earlier in this study. The participants displayed that, irrespective of the change happening in colour, font or size, they were a significantly higher detection for change when the changes were Relevant in Price and Date. As Forster and Lavie (2009) concluded in their study, when individuals exhausting their attentional capacity with task-relevant stimuli reduces their perceptual load to focus on other task-irrelevant information. The aforementioned study explained the reasons why participants consistently accurately reported change when the change was occurring in the task they were focusing on (e.g., Price changes during a Price-focused task.), whereas detection was significantly lower for changes in the task-Irrelevant category (e.g., price changes during a date-focused task). Rensink (1997) stated that individuals detect changes quicker and more often in objects that are central in the interest than lower interest changes irrespective of the size or magnitude of the change. This explains that although the information was spatially adjacent and even encoded in the previous blocks, all the information for the current Category (Price or Date) that was perceived as not important by the participant received less

attentional focus, thereby potentially leading to Change Blindness (Simons & Rensink, 2005). The significant main effect of Relevance on Sensitivity (*d'*) and the findings by Suhani on the role of STM in feature changes (2022) and Bittner on Relevance and Cognitive Load (2025) is in line the results of this study as the influence of task Relevance on change detection generalises across different digital interfaces and experimental paradigms.

The Response Bias (β) results have shown that the heightened focus of the task relevance, also might have potentially led to increased caution in reporting a potential change. The participants seemed to have adopted a slightly conservative approach in Relevance and Category but especially in Price Relevant. According to SDT, a higher conservative bias implies that the participants exhibit a high threshold of certainty before they answer, 'yes' to the question 'Did you see a change?'. The research by Jensen et. al. (2011) states that some changes are detected because of central interest, but also because some objects hold semantic value in a scene. The innate nature of Price detection in humans, especially in a flight-booking context may elicit extra caution and increase the individual's threshold of certainty. The increase in caution for the other variables may also be explained by the increased caution and uncertainty amongst individuals. As stated earlier, the higher sensitivity could imply the presence of attentional focus, this could also bore a greater sense of uncertainty of the information. In a task where the participant had to also focus on meeting their task goals (Price or Date), the participants could adopt a cautious strategy where the possibility of falsely reporting a change minimised. In the post-experiment interview, some of the participants noted that, in the very initial stages of the experiment, even when they noticed subtle changes (colour/ font/ size) in the relevant condition, they hesitated to report them because they were unsure if the change was intentional or a design error (see appendix J.2). However, they also reported they simply did not register the Irrelevant changes as their attentional focus and gaze was fixated on the task Relevant changes. This strategic adjustment of the participants response aligns with the TBRS Model in which participants are likely to apply conservative strategies when their attentional resources are devoted to task-relevant processing and they were under-confidence in reporting a subtle change (Barrouillet et al., 2004).

The findings of this study provided nuanced insights into potential design features for information-heavy digital interfaces like flight booking websites. The high sensitivity to task Relevant changes observed in this study was specifically for detection of alterations in visual

attributes (colour, font, size) of the information, not to the semantic content itself. Previous literature (Jensen et. al, 2011) states that people typically do not notice information that is changing in an unattended stream, even if it is even if it is unexpected or distinctive. However, a semantic change in an object has the highest chance of the individual attending, noticing and reporting the change. Post-experiment interviews confirmed that participants actively extracted and used primary task information (e.g., price airline, date, luggage) to meet scenario requirements (see appendix J.3). However, their attention was directed toward content meaning, not stylistic presentation. When a user is focused on booking a flight according to their budget requirements, the features changes happening across the interface are not immediately in the focus of the user. Hence, subtle changes in the design or formatting of, for example, advertisements, illustrations, logos and infographics could be overlooked by the participant (Štefko et al., 2025).

Several limitations in the current study provide understanding and opportunity for future research. First, asking the participant if they observed a change after each image stimuli, potentially primed them to seek for change. The explicit instruction was necessary in order to make the SDT analysis may have increased the alertness and scepticism for the stimuli. Participants have agreed that the reason for their potentially high accuracy might be due to them realising that a change was potentially ought to occur which they would have missed in a natural browsing setting (see appendix J.5). Conversely, the same reason could be used to explain that individuals are more change-blind in naturalistic settings. In a real-life, where there is increased noise and attentional focus is not directed, Change Blindness may occur significantly more. Forster and Lavie (2011) have stated that daily life distraction may not only exist in the form of external environmental distraction but also internal task-unrelated thoughts (TUTs) which is in line with a participant's post-interview stating that they had to prevent themselves from getting distracted so they could finish the task (see appendix J.6). Hence, it could be argued that they are more likely to miss seemingly evident changes in real life if they are not in the direct attentional stream or the task that the individual is performing.

Second, the use of flight booking website screenshots for a rapid, force-paced flicker differs from the interactive, slow-processing and careful decision-making nature of booking flights. The use of flight booking websites which were information heavy and consisted of a lot of textual information contributed to a large amount of cognitive load for the participant in

the duration of the experiment (Forster & Lavie, 2011). The participants were required to look for information within four seconds which they normally would take minutes and hours for. One participant stated that the time-sensitive nature of the current experiment was contrary to their usual slow and mindful procedure of flight booking (see appendix J.4). However, another participant stated that the stress that they felt during the experiment was similar to that of a real flight booking experience (see appendix J.1). The flicker paradigm in the current experiment was required to measure change blindness, but future studies could benefit by employing a task that is not as decision-heavy or stress-inducing as flight booking. For example, online grocery shopping.

Finally, the static images that were provided to the participant could have fixated their gaze (even with the mask present) or familiarised them to the website layout. Change Blindness in a naturalistic setting occurs in a location and at a time that the individual is not aware of. Participants stated that after a few trials, they knew what to look for and where. Changing the layout of the flight booking website was not an option in this study as it would increase fatigue and also potentially have carry-over effects. Although learning effects are hard to avoid in a flicker task with multiple trails, changing the nature of the stimuli and how it is presented could potentially make a difference and be the solution to the aforementioned limitation. For example, making the stimuli dynamic, by providing the participant the options to interact with the website could potentially make the participate stop fixating on a certain area of the screen, and also not be as familiar with the website as there are more factors to remember.

Future studies could utilise the findings and reduce the limitations from this study by incorporating changes in the type of stimuli, the context of stimuli. By changing the context of the stimuli itself, especially into lighter and less cognition required task such as grocery shopping or garment shopping online can change the perception of the participants. The change in context could show a more realistic online website task which can be performed in a shorter span of time, while still maintaining a broad attention across the website. Moreover, the change in context could also result in new findings in the context of bias, the participants likelihood to either be conservative or liberal, which could be a potential topic of interest for future researcher. Additionally, changing the stimuli from static screenshots to dynamic and interactive flight-booking website opens the possibility of studying the topic of change blindness in a more active setting where the researcher can also account for details in which

changes can occur, such as eye movement, saccades and blinking with the help of eye-tracking technology.

Conclusion

This study investigated the role of task relevance on change detection performance for simulated information in flight-booking websites. The finding proving a clear answer that the relevance of task does in fact play a significant role in change detection. The results from inferential statistics showed that Task Order could potentially influence the change detection perception of the participant, however, further research is required. By Change Blidness paradigm and Signal Detection Theory, the study revealed that participants were significantly more sensitive to visual changes (in colour, font, and size) when those changes occurred in information relevant to their immediate goal. Hence, Relevant task features are more likely to be detected than Irrelevant features. Moreover, participants showed a conservative bias towards Relevant changes implying that they had a high threshold of certainty before they stated that they saw a change, implying that users may hesitate to act if changes are subtle or ambiguous. Finally, this study uses Change Blindness research into an applied goal-oriented contexts, which showed that Relevance of the goal plays a significant role in what users see and miss online. Practically, it offers a cognitive explanation for why subtle interface updates often go unnoticed, showing that task relevance, task complexity and attentional focus all play a role sensitivity of changes and strategies developed to minimise errors.

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Appendices

AI STATEMENT

During the preparation of this work the author used [ChatGPT (OpenAI)] in order to [to brainstorm ideas, clarification of doubts, help with debugging R code and clarification of doubts using PsychoPy builder view]. Author also used [Microsoft Word grammar check, Grammarly, and Google Gemini] to [improve grammar and spelling]. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the work.

Appendix A- Informed Consent

Participant Number:

Dear Participant,

Thank you for your interest in this study aimed at understanding the interaction between users and interfaces, specifically, flight booking websites. The study will take approximately 30 minutes to complete. This study is being done by Sreya Chary Bavoju from the bachelor's program psychology, faculty Behavioural, Management, and Social Studies at the University of Twente. This study is supervised by Dr. Rob van der Lubbe.

The purpose of the study is to explore how participate perceive and process visual and written information in a realistic online task, in this case, interacting with a flight booking website. In this experiment, you will be given as a series of flight-booking websites and asked to make simple decisions based on the provided scenarios.

Your privacy is of utmost importance to us. All information collected during this study will be kept strictly confidential and will only be accessible to authorized research personnel. Your personal data will be anonymized and stored securely in accordance with data protection regulations. Your participation in this study is voluntary, and you have the right to withdraw at any time without penalty.

1. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.

Yes ☐
No ☐

2. I understand that information I provide will be used for the research paper and reports of the researchers.
Yes☐
No ☐

3. I understand that personal information collected about me that can identify me, such as [e.g. my age, my nationality, my gender and email], will not be shared beyond the study team.
Yes ☐
No ☐

4. I am 18 years or older.
Yes ☐
No ☐

If you have any questions or concerns regarding the study, please feel free to contact: Sreya Chary Bavoju (s.c.bavoju@student.utwente.nl). If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee/domain Humanities & Social Sciences of the Faculty of Behavioural, Management and Social Sciences at the University of Twente by ethicscommittee-hss@utwente.nl

Thank you for your valuable contribution to our research efforts.

Sincerely,
Sreya Chary Bavoju

Appendix - Demographics

1. Participant ID: _____
2. Age (years): _____
3. Sex assigned at birth:

☐Female

☐Male

☐Prefer not to say

4. Nationality:
   - ☐ Dutch
   - ☐ German
   - ☐ Indian
   - ☐ Other: _____

5. Native language: _____

6. Highest completed education:

   ☐ High school

   ☐ Bachelor

   ☐ Master ○ PhD or higher

7. Do you normally wear corrective lenses when using a computer?

   ☐ No

   ☐ Yes — glasses

   ☐ Yes — contact lenses

   ☐ Other: _____

8. How often do you book flights online? 1 (Never) — 5 (Very often):_____

9. How comfortable are you using booking websites? 1 (Not at all) — 5 (Very comfortable):____

10. (The participants were asked which is their dominant hand after the study for demographic research)

Appendix B-Task Instructions per category and task order

Price-First:

Block 1

Scenario 1:

After a long few weeks of studying, you've decided to take a short trip to Switzerland to unwind. You're open to flying out on any day and the exact dates don't matter. You'll be flying with Swizz Air. You want to make sure the flight costs no more than €200. The goal is

to find a cheap and easy option (under €200) that lets you get away for a few days without spending too much.

Press SPACE when you are ready to begin

Block 2:

Scenario 2:

You have recently accepted a new position at your company, and the job requires you to relocate to Dublin by August. Before the move, you have requested the company to visit Dublin to view several potential houses so you can choose where you will live for the upcoming year. To make the process easier, your employer has arranged for Airish Air to cover all travel expenses. Importantly, they have also given you a four-month window from March through June to fly to Dublin, tour the available homes, and return with your final recommendation. During the task, you will be browsing Airish Air flight options. Your need to decide whether each flight falls within your allowed travel period (March, April, May or June)so you can plan your house-hunting trip accordingly.

Press SPACE when you are ready to begin

Block 3:

Scenario 3:

Your close friend has been studying in Switzerland for a while, and you've decided to surprise them with a visit. You'll be booking your own ticket through Swizz Air, and only take a carry-on suitcase. Your friend has told you that you're welcome to visit anytime during the year, what matters most is finding a good deal, so, ideally a ticket that costs under €150, keeping it under budget is very important since you're covering the expenses yourself.

Press SPACE when you are ready to begin

Block 4:

Scenario 4:

You have been preparing for months to begin a professional certification program in Dublin. Before the program starts, you are required to attend an in-person visa verification appointment at the immigration office in Dublin. The office has given you a strict appointment window: you may schedule your visit any time between October 1st and December 25th. Missing this window would delay your certification by an entire year, so it is extremely important that your flight falls within these allowed dates. Your organization has partnered with Airish Air to make the process smoother. They will cover your travel expenses, but it's still up to you to select a flight that ensures you arrive in Dublin at the correct time.

Press SPACE when you are ready to begin

Block 5:

Scenario 5:

You are planning a trip to Switzerland to attend a popular summer music festival. Tickets are limited, and the festival runs for several days, so flights need to be booked carefully. Your main concern is staying within your budget, because you also need to cover festival tickets, meals, and local transportation. You have set a maximum spending limit for a flight at €300, but ideally, you want to find a flight priced between €200 and €300. Flights above €300 are too expensive. You will be browsing available flights with Swizz Air to check each flight's price and decide whether it falls within your preferred price window (€200–€300), so you can enjoy the festival without overspending.

Press SPACE when you are ready to begin

Block 6:

Scenario 6:

Every year, Dublin hosts the Spring Lights Festival, a city-wide cultural event where neighbourhoods light up with temporary art installations, projected animations, and night-time performances. The festival only happens once a year, and the displays are visible for a short period between March 1st and April 30th. You decide to fly with Airish Air, which offers flexible options to Dublin during the festival season. While completing the task, you check whether each flight's departure date lies between the time period (March 1st and April 30th), ensuring that you arrive during the short period when the Spring Lights Festival is taking place.

Press SPACE when you are ready to begin

Date-First:

Block 1:

Scenario 1:

You have recently accepted a new position at your company, and the job requires you to relocate to Switzerland by August. Before the move, you have requested the company to visit Zurich to view several potential houses so you can choose where you will live for the upcoming year. To make the process easier, your employer has arranged for Swizz Air to cover all travel expenses. Importantly, they have also given you a four-month window from March through June to fly to Zurich, tour the available homes, and return with your final recommendation. During the task, you will be browsing Swizz Air flight options. Your need to decide whether each flight falls within your allowed travel period (March, April, May, or June) so you can plan your house-hunting trip accordingly.

Press SPACE when you are ready to begin

Block 2:

Scenario 2:

After a long few weeks of studying, you've decided to take a short trip to Dublin to unwind. You're open to flying out on any day and the exact dates don't matter. You'll be flying with. Airish Airlines. You want to make sure the flight costs no more than €200. The goal is to find a cheap and easy option (under €200) that lets you get away for a few days without spending too much.

Press SPACE when you are ready to begin

Block 3:

Scenario 3:

You have been preparing for months to begin a professional certification program in Switzerland. Before the program starts, you are required to attend an in-person visa verification appointment at the immigration office in Zurich. The office has given you a strict appointment window: you may schedule your visit any time between October 1st and December 25th. Missing this window would delay your certification by an entire year, so it is extremely important that your flight falls within these allowed dates. Your organization has partnered with Swizz Air to make the process smoother. They will cover your travel expenses, but it's still up to you to select a flight that ensures you arrive in Zurich at the correct time.

Press SPACE when you are ready to begin

Block 4:

Scenario 4:

Your close friend has been studying in Dublin for a while, and you've decided to surprise them with a visit. You'll be booking your own ticket through Airish Airlines, and only take a carry-on suitcase. Your friend has told you that you're welcome to visit anytime during the year, what matters most is finding a good deal, so, ideally a ticket that costs under €150, keeping it under budget is very important since you're covering the expenses yourself.

Press SPACE when you are ready to begin

Block 5:

Scenario 5:

Every year, Switzerland hosts the Spring Lights Festival, a city-wide cultural event where neighbourhoods light up with temporary art installations, projected animations, and night-time performances. The festival only happens once a year, and the displays are visible for a short period between March 1st and April 30th. You decide to fly with Swizz Air, which offers flexible options to Zurich during the festival season. While completing the task, you check whether each flight's departure date lies between the time period (March 1st and April 30th), ensuring that you arrive during the short period when the Spring Lights Festival is taking place.

Press SPACE when you are ready to begin

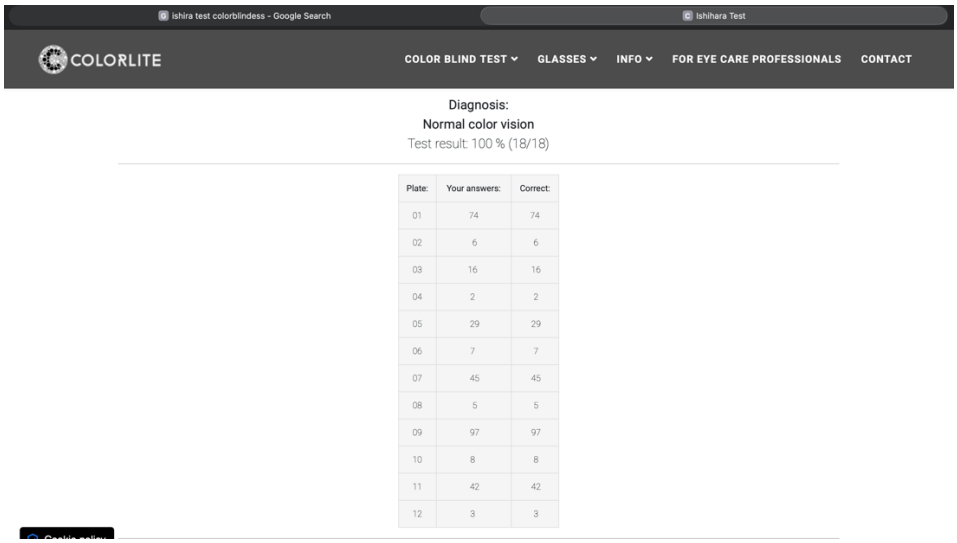
Block 6:

Scenario 6:

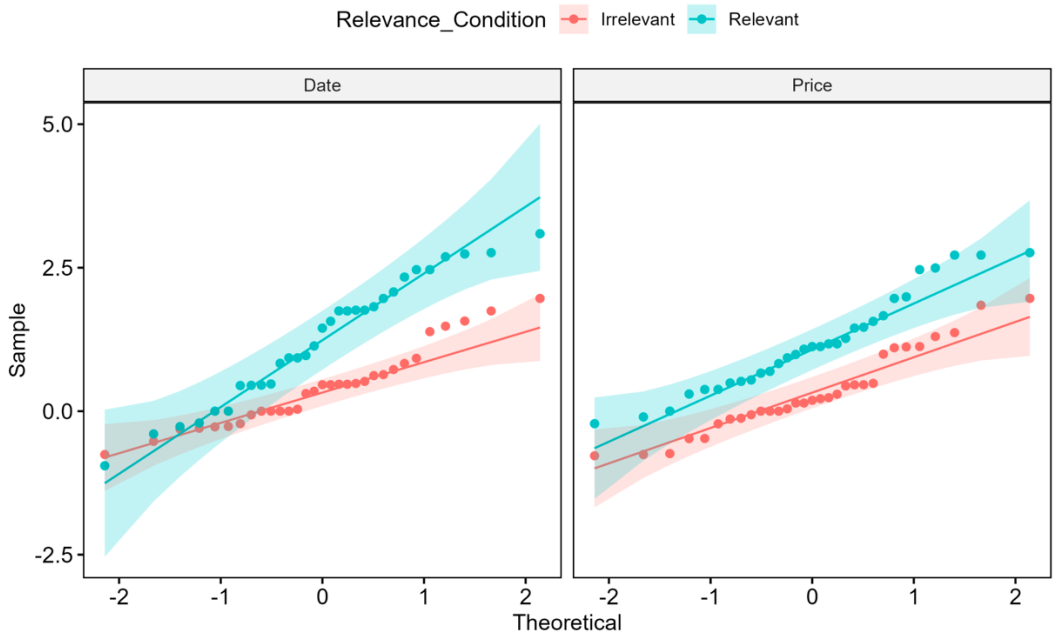
You are planning a trip to Dublin to attend a popular summer music festival. Tickets are limited, and the festival runs for several days, so flights need to be booked carefully. Your main concern is staying within your budget, because you also need to cover festival tickets, meals, and local transportation. You have set a maximum spending limit for a flight at €300, but ideally, you want to find a flight priced between €200 and €300. Flights above €300 are too expensive. You will be browsing available flights with Airish Airlines to check each flight's price and decide whether it falls within your preferred price window (€200–€300), so you can enjoy the festival without overspending.

Press SPACE when you are ready to begin

Appendix C- Ishihara Test results



Appendix D– Assumption check for normality (Q-Q plot for Sensitivity (d') data.)



Appendix E– Introduction in PsychoPy

Hello!

Thank you for choosing to participate in this study.

The session will take approximately 30 minutes. Please make sure you focus on the screen for the entire duration of the task.

You will be presented with a series of short travel-related scenarios. Each scenario will describe a situation in which you are choosing between different flight options. After that, you will see a series of flight search pages. Your task is to check whether the flight information matches the requirements of your scenario. After some images, you will also be asked a short follow-up question about what you saw.

There will be short breaks to relax your eyes between sections of the task.

Press SPACE when you're ready to begin

Appendix F– Thank you page on PsychoPy

Thank you very much for taking part in this study!

The purpose of this experiment was to investigate change blindness which is a phenomenon where people often fail to notice visual changes in their environment, even when these changes are significant. In this case, the changes occurred within a simulated flight booking website, such as variations in price, date, or visual design features (e.g., font, color or size). Your responses will help us better understand how people attend to visual information on web interfaces.

All the data collected in this study will remain strictly confidential and anonymized. Your participation is completely voluntary, and you have the right to withdraw your data at any time without providing a reason. If you wish to have your data removed, please contact the researcher using the details provided in the consent form.

If you have any questions or would like to learn more about the study, feel free to reach out after the session.

Thank you again for your time and participation, your contribution is greatly appreciated :)

Press SPACE to finish.

Appendix G- Stimuli Images naming convention (abbrevations)

stim# = stimulus number

OG= original (before mask)

P = price

D = date

NC= No change

p_c = price_color

p_s = price_size

p_f = price_ font style

d_c = date_color

d_s = date_size

d_f = date_font style

Appendix H- code for R

```
#=============================================================
# TITLE: Task Relevance & Visual Working Memory - Final Integrated Analysis
# AUTHOR: Sreya Chary Bavoju
#=============================================================
setwd("E:/Rworks/SreyaChary/BScThesis") #dont forget make sure the is path is correct

# 1. Installing and Loading LIBRARIES ----------------------------------------------------
if (!require("pacman")) install.packages("pacman")
pacman::p_load(tidyverse, readxl, rstatix, ggpubr, scales, knitr, pwr,
               moments, corrplot, gridExtra, broom, ggsci, psycho)
```

```
# Set final output directory
output_dir <- "sreya_final_plots14012026"

#setting it up on Overleaf
theme_set(theme_pubr(base_size = 14) +
          theme(legend.position = "top", plot.title = element_text(face = "bold", hjust = 0.5)))

# 2. DATA LOADING & PROCESSING ------------------------------------------------
process_participant_file <- function(filepath) {
  raw <- read_csv(filepath, show_col_types = FALSE, col_types = cols(.default = "c"))
  if(nrow(raw) == 0) return(NULL)

  fname <- basename(filepath)
  pid <- str_extract(fname, "P[0-9]+")
  group <- case_when(str_detect(fname, "_PF_") ~ "PF", str_detect(fname, "_DF_") ~ "DF",
TRUE ~ NA_character_)

  key_col <- names(raw)[str_detect(names(raw), "changes\\.keys$")][1]
  rt_col <- names(raw)[str_detect(names(raw), "changes\\.rt$")][1]

  clean <- raw %>%
    filter(!is.na(og_img)) %>%
    mutate(
      Participant = pid, Group = group,
      Block_Num = as.numeric(str_extract(og_img, "(?<=Block_)[0-9]+")),
      Response_Key = str_remove_all(.data[[key_col]], "\\[|\\]|'"),
      Response_RT = as.numeric(.data[[rt_col]]),
      Change_Dimension = case_when(
        str_detect(chg_img, "_p_") ~ "Price",
        str_detect(chg_img, "_d_") ~ "Date",
        str_detect(chg_img, "_NC") ~ "None",
        TRUE ~ "Unknown"
      ),
      Feature_Type = case_when(
        str_detect(chg_img, "_c") ~ "Color", str_detect(chg_img, "_f') ~ "Font",
        str_detect(chg_img, "_s") ~ "Size", str_detect(chg_img, "_NC") ~ "No Change",
        TRUE ~ "Value"
      )
    )
  return(clean)
}
files <- list.files(pattern = "P[0-9]+.*\\.csv$", full.names = TRUE)
master_df <- map_dfr(files, process_participant_file)
```

```
# 3. SETTING UP LOGIC & METRIC CALCULATION -----------------------------------------
coded_df <- master_df %>%
  mutate(
    Current_Task = case_when(
      Group == "PF" & (Block_Num %in% c(1,3,5)) ~ "Price",
      Group == "PF" & (Block_Num %in% c(2,4,6)) ~ "Date",
      Group == "DF" & (Block_Num %in% c(1,3,5)) ~ "Date",
      Group == "DF" & (Block_Num %in% c(2,4,6)) ~ "Price"
    ),
    Relevance_Condition = case_when(
      Change_Dimension == "None" ~ "Noise",
      Change_Dimension == Current_Task ~ "Relevant",
      TRUE ~ "Irrelevant"
    ),
    SDT_Outcome = case_when(
      Relevance_Condition != "Noise" & Response_Key == "y" ~ "Hit",
      Relevance_Condition != "Noise" & Response_Key == "n" ~ "Miss",
      Relevance_Condition == "Noise" & Response_Key == "y" ~ "False_Alarm",
      Relevance_Condition == "Noise" & Response_Key == "n" ~ "Correct_Rejection",
      TRUE ~ "Invalid"
    )
  ) %>% filter(SDT_Outcome != "Invalid")

write.csv(coded_df,"coded_df.csv")

calc_sdt <- function(h, m, fa, cr) {
  hr_adj <- (h + 0.5) / (h + m + 1); fa_adj <- (fa + 0.5) / (fa + cr + 1)
  z_hr <- qnorm(hr_adj); z_fa <- qnorm(fa_adj)
  list(d_prime = z_hr - z_fa, c_bias = -0.5 * (z_hr + z_fa), beta = dnorm(z_hr) / dnorm(z_fa))
}

noise_stats <- coded_df %>%
  filter(Relevance_Condition == "Noise") %>%
  group_by(Participant, Current_Task) %>%
  summarise(FAs = sum(SDT_Outcome == "False_Alarm"), CRs = sum(SDT_Outcome ==
"Correct_Rejection"), .groups = 'drop')

sdt_main <- coded_df %>%
  filter(Relevance_Condition %in% c("Relevant", "Irrelevant")) %>%
  group_by(Participant, Group, Relevance_Condition, Current_Task) %>%
  summarise(Hits = sum(SDT_Outcome == "Hit"), Misses = sum(SDT_Outcome == "Miss"),
.groups = 'drop') %>%
  left_join(noise_stats, by = c("Participant", "Current_Task")) %>%
  rowwise() %>%
```

```
  mutate(metrics = list(calc_sdt(Hits, Misses, FAs, CRs))) %>%
  unnest_wider(metrics) %>%
  mutate(across(c(Participant, Relevance_Condition, Current_Task, Group), as.factor),
log_beta = log(beta))

write.csv(sdt_main,"sdt_main.csv")
# Block-wise SDT metrics
sdt_learning <- coded_df %>%
  group_by(Participant, Group, Block_Num) %>%
  summarise(
    Hits = sum(SDT_Outcome == "Hit"),
    Misses = sum(SDT_Outcome == "Miss"),
    FAs = sum(SDT_Outcome == "False_Alarm"),
    CRs = sum(SDT_Outcome == "Correct_Rejection"),
    .groups = 'drop'
  ) %>%
  rowwise() %>%
  mutate(metrics = list(calc_sdt(Hits, Misses, FAs, CRs))) %>%
  unnest_wider(metrics)

write.csv(sdt_learning,"sdt_learning.csv")


# Load data (assuming files from previous turn are in working directory)
sdt_main <- read.csv("sdt_main.csv")
sdt_learning <- read.csv("sdt_learning.csv")
coded_df <- read.csv("coded_df.csv")

# Factor preparation
sdt_main <- sdt_main %>%
  mutate(
    Participant = as.factor(Participant),
    Group = factor(Group, levels = c("DF", "PF"), labels = c("Date-First", "Price-First")),
    Relevance_Condition = factor(Relevance_Condition, levels = c("Irrelevant", "Relevant")),
    Current_Task = factor(Current_Task, levels = c("Date", "Price"))
  )

# 2. ANOVA TABLES & CSV EXPORT ------------------------------------------------

# Table A: 3-Way Mixed ANOVA for Decision Strategy (beta)
# Between: Group (Task Order); Within: Relevance, Task
res_beta_3way <- sdt_main %>%
  anova_test(dv = beta, wid = Participant, between = Group, within = c(Relevance_Condition,
Current_Task))
```

```
write.csv(as.data.frame(get_anova_table(res_beta_3way)),
          file.path("Table_5_3Way_ANOVA_Beta.csv"))

# Ensure factors are correctly typed for the mixed model
sdt_main <- sdt_main %>%
  mutate(
    Participant = as.factor(Participant),
    Group = as.factor(Group),              # Between: Task Order (PF vs DF)
    Relevance_Condition = as.factor(Relevance_Condition), # Within
    Current_Task = as.factor(Current_Task) # Within
  )

# 2. RUN 3-WAY MIXED ANOVA (Sensitivity - d_prime) ----------------------------
res_dprime_3way <- sdt_main %>%
  anova_test(
    dv = d_prime,
    wid = Participant,
    between = Group,
    within = c(Relevance_Condition, Current_Task)
  )

# 3. GENERATE TABLE 5 STYLE OUTPUT --------------------------------------------
table_5a_dprime <- get_anova_table(res_dprime_3way)
print(table_5a_dprime)

#Export to CSV for thesis folder
write.csv(as.data.frame(table_5a_dprime), "Table_5_3Way_ANOVA_Dprime.csv")

# Table B: 2-Way ANOVA for Sensitivity (d_prime)
res_dprime_2way <- sdt_main %>%
  anova_test(dv = d_prime, wid = Participant, within = c(Relevance_Condition,
Current_Task))
write.csv(as.data.frame(get_anova_table(res_dprime_2way)),
          file.path("Table_X_2Way_ANOVA_Dprime.csv"))

# Table C: Follow-up simple main effects for d_prime Interaction
pwc_dprime <- sdt_main %>%
  group_by(Current_Task) %>%
  pairwise_t_test(d_prime ~ Relevance_Condition, paired = TRUE, p.adjust.method =
"bonferroni")
write.csv(as.data.frame(pwc_dprime),
          file.path("Table_X_Dprime_FollowUp.csv"))

# 3. PLOT GENERATION & SAVING -------------------------------------------------
```

```
# Plot 1: Restructured Sensitivity (d')
# Panels = Current Task; X-axis = Relevance
plot_dprime <- ggline(sdt_main, x = "Relevance_Condition", y = "d_prime",
                      color = "Current_Task", palette = "jco",
                      add = c("mean_se", "jitter"), facet.by = "Current_Task",
                      title = "Sensitivity (d') by Task Relevance",
                      ylab = "Sensitivity (d')", xlab = "Condition") +
  stat_compare_means(method = "t.test", paired = TRUE, label = "p.signif") +
  theme_pubr()
ggsave(file.path("Sreya_Plot_Sensitivity_dprime.png"), plot_dprime, width = 8, height = 6)

# Plot 2: Decision Strategy (beta) Shift
plot_beta <- ggboxplot(sdt_main, x = "Relevance_Condition", y = "beta",
                       color = "Relevance_Condition", palette = "jama",
                       add = "jitter", facet.by = "Current_Task",
                       title = "Decision Strategy (Beta) Shift",
                       ylab = "Beta (Likelihood Ratio)", xlab = "Condition") +
  geom_hline(yintercept = 1, linetype = "dashed", color = "darkgrey") +
  stat_compare_means(method = "t.test", paired = TRUE, label = "p.signif") +
  theme_pubr()
ggsave(file.path("Sreya_Plot_Decision_Strategy_Beta.png"), plot_beta, width = 8, height =
6)

# Plot 3: Learning Curve (Sensitivity across Blocks)
plot_learning <- ggline(sdt_learning, x = "Block_Num", y = "d_prime",
                        color = "Group", palette = "npg", add = "mean_se",
                        title = "Learning Effect: Sensitivity Across Blocks",
                        ylab = "Sensitivity (d')", xlab = "Block Number") +
  theme_pubr()
ggsave(file.path("Sreya_Plot_Learning_Effect.png"), plot_learning, width = 8, height = 6)

# Plot 4: Visual Attribute Salience (Hit Rates)
feat_stats <- coded_df %>%
  filter(SDT_Outcome %in% c("Hit", "Miss")) %>%
  group_by(Current_Task, Feature_Type) %>%
  summarise(Hit_Rate = mean(SDT_Outcome == "Hit"),.groups = 'drop')

plot_salience <- ggbarplot(feat_stats, x = "Feature_Type", y = "Hit_Rate",
                           fill = "Feature_Type", palette = "simpsons",
                           facet.by = "Current_Task",
                           title = "Hierarchy of Visual Salience",
                           ylab = "Hit Rate", xlab = "Visual Attribute") +
  theme_pubr()
```

```
ggsave(file.path("Sreya_Plot_Salience_Hierarchy.png"), plot_salience, width = 8, height = 6)
# --- Step 1: Clean Outliers & Keep Only Complete Pairs ---
sdt_no_outliers <- sdt_main %>%
  group_by(Current_Task, Relevance_Condition) %>%
  mutate(
    Q1 = quantile(beta, 0.25),
    Q3 = quantile(beta, 0.75),
    IQR = Q3 - Q1,
    is_outlier = beta < (Q1 - 1.5 * IQR) | beta > (Q3 + 1.5 * IQR)
  ) %>%
  filter(!is_outlier) %>%
  group_by(Participant, Current_Task) %>%
  # This filter ensures a participant only stays if they have both conditions
  filter(n() == 2) %>%
  ungroup()

# --- Step 2: Calculate Stats ---
stat.test <- sdt_no_outliers %>%
  group_by(Current_Task) %>%
  t_test(beta ~ Relevance_Condition, paired = TRUE) %>%
  add_significance() %>%
  # y.position manually set based on your data max (approx 4.5 after outlier removal)
  add_xy_position(x = "Relevance_Condition", step.increase = 0.1)

# --- Step 3: Plot ---
custom_colors <- c("Irrelevant" = "#0073C2FF", "Relevant" = "#EFC000FF")

plot_beta <- ggboxplot(sdt_no_outliers, x = "Relevance_Condition", y = "beta",
                       color = "Relevance_Condition", palette = custom_colors,
                       outlier.shape = NA, facet.by = "Current_Task",
                       ylab = "Beta (Likelihood Ratio)", xlab = "Condition") +
  geom_line(aes(group = Participant), color = "darkgrey", alpha = 0.3) +
  geom_jitter(aes(color = Relevance_Condition), width = 0.1, alpha = 0.7) +
  geom_hline(yintercept = 1, linetype = "dashed", color = "black") +
  # Use stat_pvalue_manual to force the labels to appear
  stat_pvalue_manual(stat.test, label = "p.signif", tip.length = 0.01) +
  scale_y_continuous(expand = expansion(mult = c(0.05, 0.2))) +
  theme_pubr() +
  theme(legend.position = "top")

print(plot_beta)

ggsave(file.path("Sreya_Plot_Decision_Strategy_Beta.png"), plot_beta, width = 8, height =
6)
```

Appendix I – PsychoPy code (made in Builder View, converted to Code)

The code can be found in GitHub by following this link:

https://github.com/sreyachary26/FlightBooking_FlickerTask

Appendix J – Post- Interview Responses

J.1 – Participant 01

Researcher: And did you at any point feel rushed?

Participant 01: Yeah. During the entire thing, I felt kind of rushed, which kind of feels like real life, you know, if you stand on the website too long, it like refreshes. So it's like, oh, if you don't book soon, it's more expensive now. So I would say it's very applicable to real life, yes.

J.2 – Participant 02

Researcher: How did you experience the task overall?

Participant 02: I felt a bit overwhelmed in the beginning because I didn't expect it to be that quick. Yeah, Also was trying to figure out like the differences because sometimes it felt subtle, but then. and then it was kind of clear that font could also change because before I thought it was just a minor mistake. I thought it was I thought it was not going to be a part of the study, but then apparently. It is. Yeah. So, yeah, after the next few rounds and then it was it was fine.

J.3 – Participant 03

Researcher: How did you experience the task overall?

Participant 03: Stressful. Yeah, it went fast like if you don't know what's like… (inaudible) how's everything, hmm, it took a while for me to get in there, get into it cause everything was present all at once in such short time. But after a while, I think I knew where to look at now, like quicker and also to answer quicker and everything. So it just took a while to get used to but I did and it got easier.

Researcher: What were the elements you were looking at?

Participant 03: I was looking for the flight logos and stuff, like if it was swizz or Airish, and then sometimes if I had extra time I was looking at the luggage. Oh and obviously the price and date

J.4 – Participant 04

Researcher: Okay. How did you experience the task overall?

Participant 04: It was hard, at first, but it got better.

Researcher: Okay. Perfect. Did you at any part of the experiment feel confused?

Participant 04: Yeah. At the start. Yeah.

Researcher: did you feel like it was rushed?

Participant 04: Yeah. Yeah, I would normally do a little longer before I fly.

Researcher: Can you describe what you were focusing on while evaluating each flight option?

Participant 04: Yeah, so if the focus was on date, I look at the data and if the focus is on price, I looked at the price, there was no one with the price and the date, right?

Researcher: No.

Participant 04: No, it's just price or dates. And just there. And I looked for changes throughout the page, but I could never find.

J.5 – Participant 08

Researcher: Did you develop a strategy over time for detecting changes?

Participant 08: I think it took me a while, but like the last few ones, it was mostly, okay, I get it now. I just have to focus on this. It's the issue the question, so I just have to look at this and you could see the change right there. I had to really pay attention because I don't think I would have noticed it otherwise

J.6 – Participant 10

Researcher: How did you experience the task overall?

Participant 10: it was hard to do the task at first, but that was mostly on me because I have ADHD and it's really hard for me to do a task without thinking about other things. Like there are times in the experiment where I'm thinking 'hmm what should I eat for dinner?', but I have to immediately bring my attention back because this needs me to give correct answers.