

## Cookie disclaimers: Dark patterns and lack of transparency

Benjamin Maximilian Berens<sup>a</sup>, Mark Bohlender<sup>a</sup>, Heike Dietmann<sup>a</sup>, Chiara Krisam<sup>a</sup>,  
Oksana Kulyk<sup>b,\*</sup>, Melanie Volkamer<sup>a</sup>

<sup>a</sup> Karlsruhe Institute of Technology, Karlsruhe, Germany

<sup>b</sup> IT University of Copenhagen, Copenhagen, Denmark

### ARTICLE INFO

#### Keywords:

Cookies  
Privacy  
Web tracking  
User study  
Dark patterns

### ABSTRACT

While cookie disclaimers on websites have been proposed to ensure that users make informed decisions regarding consenting to data collection via cookies, such informed consent is hindered by several factors. One of them is the presence of so-called dark patterns, that is, design elements that are used to lead users to accept more cookies than needed and more than they are aware of. The second factor is lack of transparency on behalf of the service providers with regards to what happens if the user does not consent to cookie usage even despite dark patterns nudging them to do so. The contributions of this paper are (1) evaluating the efficacy of several of these factors while measuring actual behaviour; (2) identifying users' attitude towards cookie disclaimers including how they decide which cookies to accept or reject; (3) assessing the behaviour of websites regarding storing non-necessary cookies despite user's consent. We show that different visual representation of the reject/accept option have a significant impact on users' decision. We also found that the labelling of the reject option has a significant impact. In addition, we confirm previous research regarding biasing text (which has no significant impact on users' decision). Our results on users' attitude towards cookie disclaimers indicate that for several user groups the design of the disclaimer only plays a secondary role when it comes to decision making. We furthermore show that even without user's explicit consent, the majority of websites we investigated still uses non-necessary cookies. We provide recommendations on how to improve the situation for different stakeholders, namely, for developers and policy makers.

### 1. Introduction

Cookie disclaimers are nowadays an indispensable part of the Internet. According to the ePrivacy Directive, also known colloquially as the Cookie Law, website owners need to ask for informed consent before storing cookies on users' devices – other than the technically necessary ones.<sup>1</sup> But there are also many cookies which website owners want users to accept in order to collect more data and sometimes even to link data of one user from various websites. The General Data Protection Regulation (GDPR) deals more generally with the protection of personal data, which includes cookies, and consent to the processing thereof. According to the GDPR, consent needs to be “freely given, informed, specific and unambiguous”. As detailed regulations on the design are missing, so-called *dark patterns* are widely used, that is, design elements that are intended to lead the user into selecting an option for sharing

more data than they would otherwise prefer. But are all dark patterns actually achieving their goal? As such, there is an acknowledged need of empirical studies aimed at a better understanding on which design elements in cookie disclaimers can be considered dark patterns Santos et al. (2020).

However, a comprehensive analysis via such studies is challenging due to a large number of design elements used in cookie disclaimers: A number of such designs have been studied in previous research Utz et al. (2019); Kulyk et al. (2018, 2020); Machuletz and Böhme (2020); Nouwens et al. (2020); Grassl et al. (2021). Yet, given that these studies focused on different elements in different settings, and given that some of the studies came to different conclusions regarding the effectiveness of certain design elements in influencing users' behaviour, there is a need for more research that investigates a variety of elements in a systematic way.

\* Corresponding author.

E-mail addresses: [benjamin.berens@kit.edu](mailto:benjamin.berens@kit.edu) (B.M. Berens), [mark.bohlender@student.kit.edu](mailto:mark.bohlender@student.kit.edu) (M. Bohlender), [heike.dietmann@posteo.de](mailto:heike.dietmann@posteo.de) (H. Dietmann), [chiara.krisam@student.kit.edu](mailto:chiara.krisam@student.kit.edu) (C. Krisam), [okku@itu.dk](mailto:okku@itu.dk) (O. Kulyk), [melanie.volkamer@kit.edu](mailto:melanie.volkamer@kit.edu) (M. Volkamer).

<sup>1</sup> The so called technically necessary ones are those cookies which are needed for the website to provide its service.

<https://doi.org/10.1016/j.cose.2023.103507>

Received 8 June 2023; Received in revised form 7 September 2023; Accepted 22 September 2023

Available online 27 September 2023

0167-4048/© 2024 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

In this work, we select a number of design elements of cookie disclaimers to evaluate with a between-subject online user study with  $N = 521$  participants, conducted as an experiment measuring participants' behaviour when interacting with a cookie disclaimer. For this study we chose the design elements in different dimensions: (1) the visual look and feel of the options provided to the participants (*Visual*), (2) the text label on the option to reject cookies (*Label*) and (3) the text in the disclaimer aiming to explain the usage of cookies to the user (*Explanation*). The goal of our study was to identify the dimensions – as well as specific design examples within these dimensions – that have the most effect on the users' behaviour. In addition to the quantitative evaluation of how the design of the disclaimer influences users' decision, we conduct a qualitative analysis of free-text answers to better understand the reasons behind the participants' decisions. We used open coding to identify users' attitude for decision making in this context.

To further contextualise our results, we analyse 376 of 500 top websites in Germany Inc (1996) regarding their use of cookie disclaimers. We build on previous work to analyse the design disclaimers themselves, as well as use both browser-based and third-party tools to determine whether websites comply to the user's decision to reject all non-necessary cookies.

In short, our work provides the following **contributions**:

- (1) We show that two of the three studied dimensions on cookie disclaimers indeed have a potential to nudge the users into selecting the “accept” option, namely, the *Visual* and *Label* dimensions. By far the largest effect was observed for presenting the option to reject cookies as a link instead of a button. A lesser yet significant effect was furthermore identified for highlighting the “accept” option compared to highlighting the “reject” option, confirming that similar to studies in other domains Almuhiemi et al. (2015), users might gravitate towards an option that is presented as the default one. However, we did not detect a significant difference in terms of accepting cookies when the “accept” option was highlighted (while both options being presented as buttons next to each other) vs. keeping the “accept” and “reject” options the same. This is inline with the findings in Grassl et al. (2021), suggesting that the “default” effect loses its prominence in this case. With regards to the *Label* dimension, we furthermore show that the text on the “reject” button or link influences the acceptance rates independent on the visual presentation of the options, suggesting that the phrasing of these options indeed has a potential to influence users' perceptions of what the consequences of them either accepting or rejecting cookies are. (iii) We did not detect significant differences between the level of bias presented in the explanation text of the cookie disclaimer (i.e. whether the participants are told about the benefits of accepting all cookies). In this we confirm the findings in previous research suggesting that the text accompanying the disclaimer does not influence users' decisions (i.e. being either not read or not taken into account) Kulyk et al. (2018, 2020), while, as opposed to previous works, measuring actual behaviour instead of relying on self-reporting.
- (2) From the qualitative analysis, we found that users' attitudes towards decision making regarding cookie disclaimers are often influenced by factors that are orthogonal to the actual design of the cookie disclaimer. As such, we found that users accept all cookies for various reasons, such as lack of risk awareness, habituation effects, the fear of not being able to access the website, the fact that they use browser extensions or configured their browser in a way that cookies are deleted on a regular bases.
- (3) We show that only 17% of investigated websites provide an option to the users to reject all non-necessary cookies, with this option being as easily accessible as the option for accepting all cookies (i.e. requiring no more than one click) and the user not being nudged due to visual elements such as button highlighting, which were shown by our study to influence user's decisions. We furthermore

show that over 70% of the investigated websites use non-necessary cookies despite lack of user's explicit consent.

The results described in (1) and (2) have also been previously published in Berens et al. (2022). The description of the investigations related to (3) is also available in a German language publication Bohlender et al. (2023).

We conclude that the lack of structural approach to cookie disclaimers at the beginning of introduction of the relevant legislation – in particular, lack of guidelines regulating the use of dark patterns or blocking access to the website unless the user has agreed to accept all cookies – has lead to the issues of habituation, fear, and coping strategies that we observed. While we recognise that a more precise regulation of design elements is challenging, we encourage the policy makers to request conducting independent empirical studies (i.e. a kind of evaluation) before implementing cookie disclaimers or any other privacy consent dialogue in the wild.

We furthermore conclude that regulations regarding the design alone is not sufficient, as currently the user is not guaranteed to be protected from non-necessary data collection even if they choose to reject non-necessary cookies. Hence, more transparency is required from the website providers regarding which cookies they consider necessary, what functionality is ensured by these cookies and which data is collected via them. Overall, conclude that relying on users' consent does not work, as the users are not making their decisions based on full information on how their data is being collected and used.

## 2. Related work

A literature review by Schaub et al. Schaub et al. (2015) discusses challenges wrt. designing usable and understandable settings interfaces and notices. These include complexity of available notices, lack of actionable choices, users' fatigue, and lack of integration in user context. While a few researchers e.g. Barocas and Nissenbaum (2009) think that addressing these challenges is impossible, several researchers have proposed, applied, and studied guidelines for improved interfaces e.g. Renaud and Shepherd (2018). Most notably, understanding users' mental models is generally considered to be an important step towards designing usable privacy decision support measures Renaud and Shepherd (2018); Schaub et al. (2015, 2017). However, all this research assumes that the provider of the interface is interested in providing a fair UI wrt. privacy settings.

The study of effects that design elements have on users' decisions have been the subject of multiple works. Particularly relevant to our work is the concept of *nudges*, or using specific patterns to increase the likelihood of a specific behaviour Thaler and Sunstein (2008), such as getting people to stop smoking or to save water due to environmental concerns. The usage of nudges in the digital world have furthermore been studied in various domains Bergram et al. (2022); DiCosola and Neff (2022) such as choice of cloud service, password creation, encryption of smart phone, choice of public wifi Zimmermann and Renaud (2021) or installing apps Almuhiemi et al. (2015). In most studies nudges were often evaluated by looking either at the so-called *content nudges* (Zimmermann and Renaud (2021); Ma and Birrell (2022)) or *design nudges* Keller et al. (2011). In some contexts nudges appear to be more effective, when combined with information or strengthen active choice by giving more options.

Building on the concept of nudges, several works studied specific design elements to understand their effect on users' behaviour – in particular, whether these design elements are capable of increasing the likelihood of users to accept cookies (thus potentially enabling access to more data to the service providers). As such, several works investigated such *design nudges* as highlighting one of the options on the cookie disclaimers – that is, either accepting all cookies or rejecting all but necessary cookies – or leaving both options with the same look and feel Utz et al. (2019); Keller et al. (2011); Machuletz and Böhme (2020). The re-

sults were varying, with some studies finding a significant difference in users' behaviour when highlighting the "accept" option compared to presenting both the "accept" and the "reject" option equally Utz et al. (2019); Keller et al. (2011); Machuletz and Böhme (2020), yet others not detecting any effect of highlighting the "reject" option Grassl et al. (2021). Similarly varying findings resulted from investigations of the effect of the amount of clicks a user would need to make to either accept or reject Utz et al. (2019); Nouwens et al. (2020); Grassl et al. (2021) or the position of the disclaimer Utz et al. (2019); Nouwens et al. (2020). Further studies focused on *content nudges*, such as the effects of explanations texts Utz et al. (2019); Kulyk et al. (2018, 2020), showing either small effect or no significant effect.

While these studies provide us with some insights on the effectiveness of particular design elements in affecting users' decisions, the combination of various elements with a potentially nudging effect – such as the look and feel of the "reject" option and the explanation text – have not been systematically studied, yet. With this work, we aim to make a first step towards conducting such an investigation,

### 3. Methodology

We aim to study the effect of various design elements in cookie disclaimers on users' behaviour and how users make decisions when faced with cookie disclaimers.

#### 3.1. Investigated design elements

We look at three kinds of design elements that we found to be most frequent in real world cookie disclaimers.

##### 3.1.1. Visual representation of the "reject"-option

We study the sub-dimensions "usage of highlighting" and "highlighting type" and consider overall five ways in which the "reject"-option can be represented:

**Button-Same** Both the "reject" and the "accept" options are presented as buttons and look the same

**Button-Highlight-Accept** Both the "reject" and the "accept" options are presented as buttons, but the "accept" option is highlighted

**Button-Highlight-Reject** Both the "reject" and the "accept" options are presented as buttons, but the "reject" option is highlighted

**Link-End** The "reject" option is presented as a text link and is located at the end of the explanation text

**Link-Middle** The "reject" option is presented as a text link and is located in the middle of the explanation text

In particular, for the variants that presented the "reject"-option as a button and highlighted one of the options ("Button-Highlight-Accept", "Button-Highlight-Reject"), we conducted a pre-study to understand what kind of look and feel of buttons users perceive as highlighted.<sup>2</sup> In this pre-study, the participants were presented with three images of cookie disclaimers, containing three different variants of using colour and position – one after the other – to distinguish the "accept" and "reject" option: (D1: accept-white-right) with "reject" button with a *blue* background and to the *left*, and "accept"-button with a *white* background and to the *right*, (D2: accept-white-left) with "reject" button with a *blue* background and to the *right*, and "accept"-button with a *white* background and to the *left*, (D3: accept-blue-right) with "reject" button with a *white* background and to the *left*, and "accept"-button

<sup>2</sup> The participants of the preliminary study were recruited using personal networks and social media of the paper authors, resulting in a total of 71 participants. They were not reimbursed for their participation. The study took less than five minutes.

with a *blue* background and to the *right*. The participants were asked to select for each disclaimer, which button they perceived as most prominent, i.e. highlighted. As the result, the majority of the participants perceived the button that had a blue background as the one that is highlighted on all of the three disclaimers, with 96% of participants (68 out of 71) marking the "accept" option as highlighted on the disclaimer D3, 80% (57 out of 71) and 92% (65 out of 71) marking the "reject" option as highlighted on the disclaimer D1 and D2 respectively. We therefore concluded that the use of these colours, and to a lesser extent, of a position of the button (given the difference in responses between the disclaimers D1 and D2) would be appropriate markers for our main study in designing the buttons on the disclaimers "Button-Highlight-Accept", "Button-Highlight-Reject".

##### 3.1.2. Label of the "reject" option

For the *content*-dimension, we choose to study the effect of how the "reject" option is named on the disclaimer (sub-dimension "naming of options"). In particular, we study four of the possible labels that could be present either as a text on the corresponding button or the text to a corresponding link:

**Reject** The label states "Reject"<sup>3</sup>

**No-Additional** The label states "No additional cookies"

**Only-Necessary** The label states "Only necessary cookies"

**Save-Choice** The label states "Save choice"

##### 3.1.3. Explanation text

For the *fairness* dimension, we consider the sub-dimension "impression generated" and investigate whether composing the explanation text in a way that attempts to convince the participants to share more of their data plays a role in participants' decisions. Namely, we consider following variants for the explanation text shown to the participants:

**Bias** The explanation text contains bias nudging the participants towards accepting the cookies, stating: "This website requires some cookies to function. If you allow us, we will additionally use other cookies to use them for marketing purposes. This helps us to present you with more relevant and personalized ads. This can significantly improve your internet experience. Therefore, we recommend that you agree to these cookies."

**No-Bias** The explanation text does not contain bias nudging the participants towards accepting the cookies, stating: "This website requires some cookies to function. If you allow us, we will additionally use other cookies to use them for marketing purposes. You can change or revoke your consent later at any time."

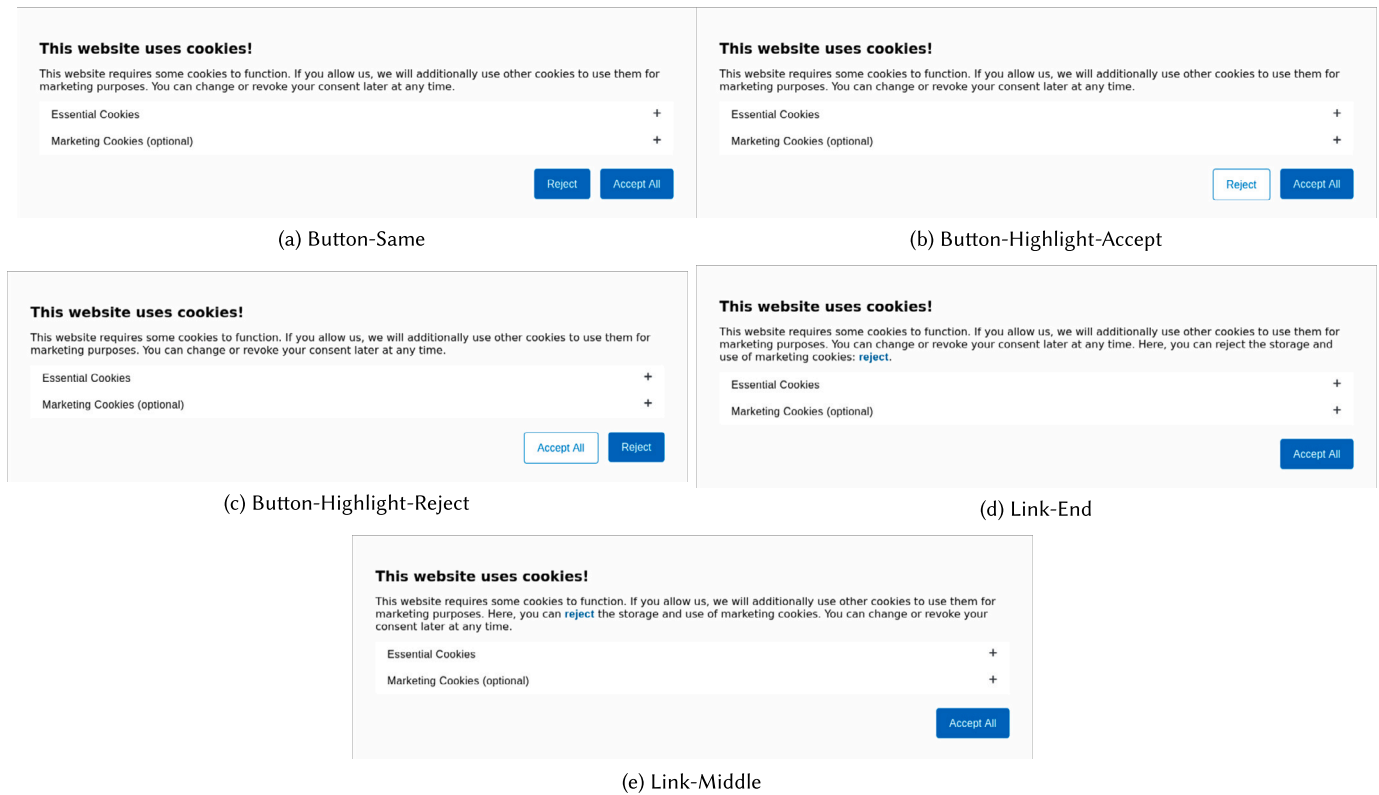
Fig. 1 shows examples of displayed disclaimer for each one of the *Visual*-Options. The screenshots of disclaimers for all the combinations of *Visual*, *Label* and *Explanation* are provided in A.5.

### 3.2. Hypotheses

We aim to study the effect of various design elements in cookie disclaimers on users' behavior. To do so, we define the following null and alternative hypotheses for each one of the studied variables:

- $H_{1,0}$ : There is no difference in terms of how likely the users are to accept all cookies, based on the *Visual* variable.
- $H_{1,1}$ : There is a difference in terms of how likely the users are to accept all cookies, based on the *Visual* variable.

<sup>3</sup> Here and in the rest of the paper, the text used in the study is translated from German.



**Fig. 1.** Examples of cookie disclaimers with different visual representations of the “reject”-option (*Visual*). In all the examples, the reject option is labelled as “Reject”, and the explanation does not include bias. Note, the text in the provided figure is translated from original German.

- $H_{2,0}$ : There is no difference in terms of how likely the users are to accept all cookies, based on the *Label* variable.
- $H_{2,1}$ : There is a difference in terms of how likely the users are to accept all cookies, based on the *Label* variable.
- $H_{3,0}$ : There is no difference in terms of how likely the users are to accept all cookies, based on the *Explanation* variable.
- $H_{3,1}$ : There is no difference in terms of how likely the users are to accept all cookies, based on the *Explanation* variable.

### 3.3. Study procedure

We use a between-subject factorial design, where each participant is randomly exposed to a cookie disclaimer with (1) either “Button-Same”, “Button-Highlight-Accept”, “Button-Highlight-Reject”, “Link-End” or “Link-Middle” for visual representation of the “reject”-option (variable *Visual*), (2) either “Reject”, “No-Additional”, “Only-Necessary” or “Save-Choice” for labelling of the “reject” option (variable *Label*) and (3) either “Bias” or “No-Bias”) for the explanation text (variable *Explanation*). Thus, participants got one of  $40 = 5 \times 4 \times 2$  possible combinations of the investigated variables.

In order to get insights of the real-world behaviour of users, we used deception in our study, where the participants were *not* told that their interaction with the disclaimer is the real subject of the study. Instead, the study was advertised using a cover story, where the users were told that the purpose of the study is to study user experience on website UIs. After clicking on the link that lead to the questionnaire, one of the 40 cookie disclaimers was randomly selected and displayed. Once the participants selected either the “accept” or the “reject” option on the disclaimer, they were forwarded to the debriefing page, where they were told about the real purpose of the study, informed that regardless of their decision no actual cookies have been stored on their devices, and were asked whether they consent to further participation in the survey. If the participants chose not to consent, their data was

not included in further evaluations. If the participants consented, they were asked further questions about their interaction with the cookie disclaimer in the study, as well as their demographics. The questions furthermore included an attention check where the participants were asked to select a particular option.

### 3.4. Recruitment and ethics

In order to test these hypotheses, we aimed to recruit at least 500 participants, following the guidelines for choosing the sample size for logistic regression Bujang et al. (2018). The guidelines recommend a sample size of  $n = 100 + 50i$ , with  $i$  as the number of independent variables, which in our case would equal to 8 (counting the dummy variables of  $4+3+1$  representing the values of *Visual*, *Label* and *Explanation* correspondingly). We furthermore decided to recruit 100 additional participants to account for possible exclusion due to insufficient response quality (e.g. due to failed attention checks, see 3.3).

The participants in both our studies were recruited using the Clickworker platform.<sup>4</sup> They were offered 1.60€, which was calculated based on the study duration of 10 minutes (as estimated by pretests of both of the studies) and the minimal hourly wage of 9.60€ in Germany, where the study was conducted. While there is no mandatory IRB approval at our institution, we took measures to avoid harms to our participants, following the guidelines for empirical research suggested by the American Psychological Association American Psychological Association et al. (2002). In particular, since our studies involved deception due to the need to test the reactions of the participants on cookie disclaimers without biasing them with the real purpose of the study, we took measures to ensure proper debriefing and obtaining informed consent for using the data provided by the participants. The study furthermore involved attention checks to ensure proper data quality. The

<sup>4</sup> <https://clickworker.com>, last accessed March 23rd, 2022.



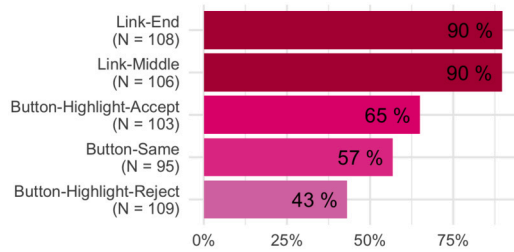


Fig. 2. Percentage of participants accepting all cookies for each visual representation of the “reject”-option (*Visual*).

participants were informed about the presence of such checks, as well as about the fact that they would not get any reimbursement if they fail these checks, at the beginning of the study.

#### 4. Study results

There were 644 participants completing our study (excluding participants who started the study but decided to drop out at any point). Of them, 123 were excluded from further analysis for the following reason: 47 failed the attention check, 66 were cases of suspected or confirmed repeated participation,<sup>5</sup> five did not have their decision recorded by the survey system due to a technical error, two reported using smartphone instead of a computer,<sup>6</sup> one reported not seeing the disclaimer, thus suspecting that there was a technical problem with the study, one suspected that the shown disclaimer is a part of the study due to the fact that cookie disclaimers are usually blocked for them because of browser addons, and one reported that they would act differently if it were not for participating in the study.

Out of the remaining participants, 306 were men, 209 women, one non-binary person, one person identifying as both man and woman and three participants who did not input their gender.<sup>7</sup> The most common age group of the participants was 30 to 34 years old (107 participants, of them 63 men, 44 women), followed by 25 to 29 years old (81 participants, of them 45 men, 33 women) and 20 to 24 years old (65 participants, of them 29 men, 36 women). Further demographic data, including education and employment status of the participants is provided in A.2.

Overall 69% of participants (360 out of 521) selected the option for accepting all cookies. The majority of the participants reported reading the header of the disclaimer (74%, 385 out of 521) and the labels on the buttons (73%, 381 out of 521); on the other hand, only around a third of the participants (34%, 178 out of 521) reported reading the explanation text, and less than 15% reported reading detailed information about marketing cookies (13%, 67 out of 521) or essential cookies (14%, 74 out of 521).

##### 4.1. Comparison between groups

The distribution of participants into groups according to the variables *Visual*, *Label* and *Explanation* is provided on Table 1. Fig. 2, 3 and 4 show the rate of participants accepting all cookies grouped by variables *Visual*, *Label* and *Explanation* correspondingly.

<sup>5</sup> Note, the recruitment for the study was performed in two rounds, and due to technical issues in some cases repeated participation could not be conclusively excluded.

<sup>6</sup> While the behaviour of the users with devices with smaller screens with regards to cookie disclaimers is an interesting research question, we decided to exclude such participants from our study, since the way the disclaimers were displayed to them would be too different compared to the rest of the participants.

<sup>7</sup> Note, it was possible to select multiple options as one’s gender.

Table 1

Number of participants in the group for each combination of *Visual*, *Label*, *Explanation*.

Visual	Label	Explanation	
		Bias	No-Bias
Button-Highlight-Accept	No-Additional	14	14
	Only-Necessary	7	13
	Reject	11	13
	Save-Choice	17	14
Button-Highlight-Reject	No-Additional	12	15
	Only-Necessary	17	14
	Reject	11	12
	Save-Choice	13	15
Button-Same	No-Additional	11	11
	Only-Necessary	14	13
	Reject	8	14
Link-End	Save-Choice	12	12
	No-Additional	15	15
	Only-Necessary	16	11
Link-Middle	Reject	13	12
	Save-Choice	13	13
	No-Additional	12	15
	Only-Necessary	15	10
	Reject	14	14
	Save-Choice	15	11

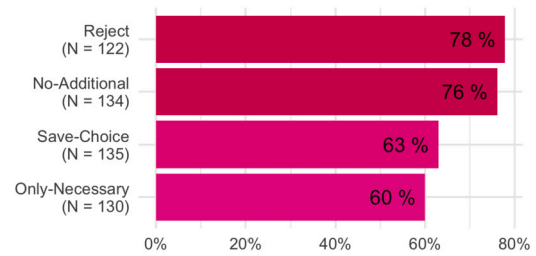


Fig. 3. Percentage of participants accepting all cookies for each label of the “reject”-option (*Label*).

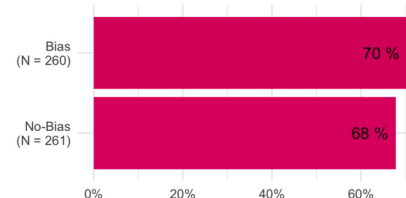


Fig. 4. Percentage of participants accepting all cookies for each explanation (*Explanation*).

We use a logistic regression model,<sup>8</sup> with the participants’ decision to accept all cookies as the outcome and the variables *Visual*, *Label* and *Explanation* as predictors. The analysis of deviance for the model is provided on Table 2, showing significant effects of the variables *Visual* and *Label*. Thus,  $H_{1,0}$  and  $H_{2,0}$  are rejected, but  $H_{3,0}$  could not be rejected.

We furthermore computed pairwise comparisons for the variables *Visual* and *Label*, with the odd ratio values and their confidence intervals shown on Fig. 5 and 6. The analysis shows significant differences between disclaimers that displayed the “reject”-option as the link (Link-End, Link-Middle) and the ones that displayed both the “reject” and “accept” options as buttons (Highlighted-Accept, Highlighted-Reject, Same), with users being 5 to 12 times less likely to accept cookies if the “reject” option was presented as a button (OR from 0.0835[0.0299, 0.234]

<sup>8</sup> The statistical analysis is performed using R packages “stats” and “emmeans”. The assumption for applying logistic regression to the data have been fulfilled.

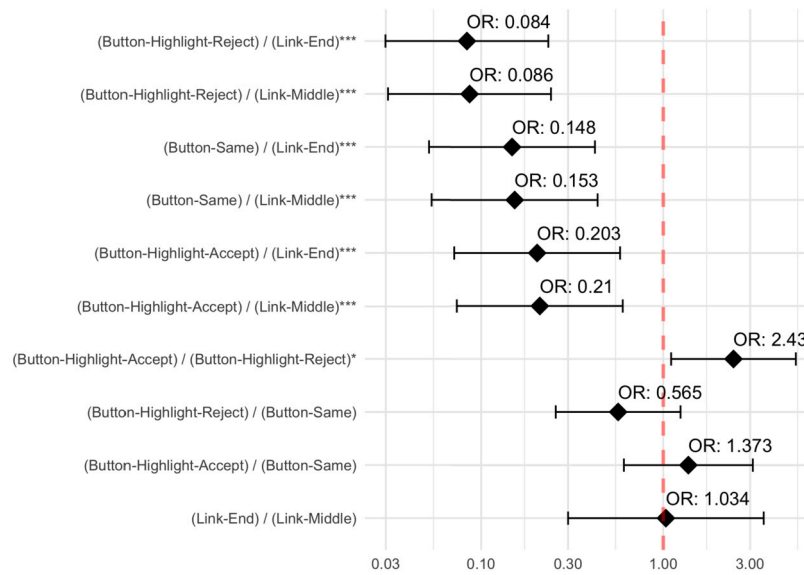


Fig. 5. Odds ratios and their 95% confidence intervals for pairwise comparison of *Visual* variable. The x-scale is logarithmic, \*\*\* signifies p-value < .001, \* signifies p-value between .01 and .05.

**Table 2**  
Analysis of deviance for the logistic regression model.

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Visual	4	18.05	4.51	25.50	<.0001
Label	3	2.52	0.84	4.75	0.0028
Explanation	1	0.04	0.04	0.23	0.6311
Residuals	512	90.63	0.18		

to 0.2098[0.0735, 0.599]). Smaller, albeit still statistically significant differences were furthermore identified between displaying the “reject”-button as highlighted, versus highlighting the “accept”-button, with users more than twice more likely to accept cookies in the later case ( $OR = 2.43[1.1045, 5.346]$ ). We detected smaller effects with regards to the “Label” variable. As such, labelling the “reject” option “Only necessary cookies” made it 2.5 times less likely to accept cookies compared labelling this option as “Reject” ( $OR = 0.404[0.183, 0.893]$ ). Similarly, changing the label from “No additional cookies” to “Only necessary cookies” makes it more than twice as likely for the users to accept cookies ( $OR = 2.25[1.049, 4.828]$ ). No further significant differences between the different labels were identified. The full statistical output of the pairwise comparisons is provided in the Appendix, see Tables 8 and 9.

#### 4.2. Users’ attitudes

In order identify the attitudes of users regarding cookie disclaimer that affected their decisions, we conducted an open-coding analysis of their answers to the question “Why have you chosen this option on the cookie disclaimer?”. The coding was done by two researchers. The code-book was developed in the following steps: Two of the authors developed a code book based on 10% of the responses (randomly selecting while making sure those from different groups were covered as well as those from participants having accepted all cookies). The two code books were discussed during a meeting. It was agreed on a common code-book. Afterwards each author coded the entire code-book. During this step new codes were identified and discussed. Afterwards these new codes were applied. The resulting coding has reached the agreement between the coders of Cohen’s  $\kappa = 0.88$ .

The code-book containing all the codes (including description for each individual code and quotes from the participants exemplifying the code) is provided in the Appendix. The code were classified in the following categories:

- UI:** Participants’ response makes it clear that their decision was due to the design of the disclaimer, e.g. stating that they selected the highlighted option, or that there was only one option available.
- Attitude:** The response of the participant reflects their attitude towards cookies in general, e.g. stating that they always just accept as a habit, that they don’t have the time to read text on disclaimers, or that they are not concerned about cookies.
- Deliberation:** The response indicates that the participant has thought about their decision before making their choice, e.g. stating that they always choose the option that accepts the minimal amount of cookies, or on the contrary, that they decided to accept all cookies because they thought that they would otherwise be unable to access the website. But also that they accept all because they configured their browser to delete cookies. Note, this category includes codes explaining why accepting all cookies and others explaining why all non-technically necessary ones were rejected.
- Emotions:** The response was very emotional, e.g. Participant stating that they find cookies annoying or feel anxious when asked to share their data. Note, these codes was usually assigned in addition to another code.
- Accident:** The response indicates that the participant might have selected the option (usually the accept all option) by accident.
- Others/Nonsense:** We also had a few statements which could not be assigned to one of the categories/codes above but were only mentioned by one or two participants. Furthermore, a few statements had to be assigned as nonsense.

Fig. 7 shows how frequently codes from a specific category (excluding 32 responses that were coded as “others/nonsense”) were mentioned by participants, depending on the visual presentation of the “reject”-option (*Visual*) on the cookie disclaimer they saw, and the decision they made.<sup>9</sup> Note, several of those coded as attitude in the group Button-highlight-reject-group thought they have accepted all cookies, although they actually rejected the non-technically necessary ones.

The frequencies for each of the individual codes are provided in 10. The category that was most often assigned is attitude (assigned to 280 participants), closely followed by the category deliberation’ with 272

<sup>9</sup> Note, that some responses were assigned multiple codes (at most three).

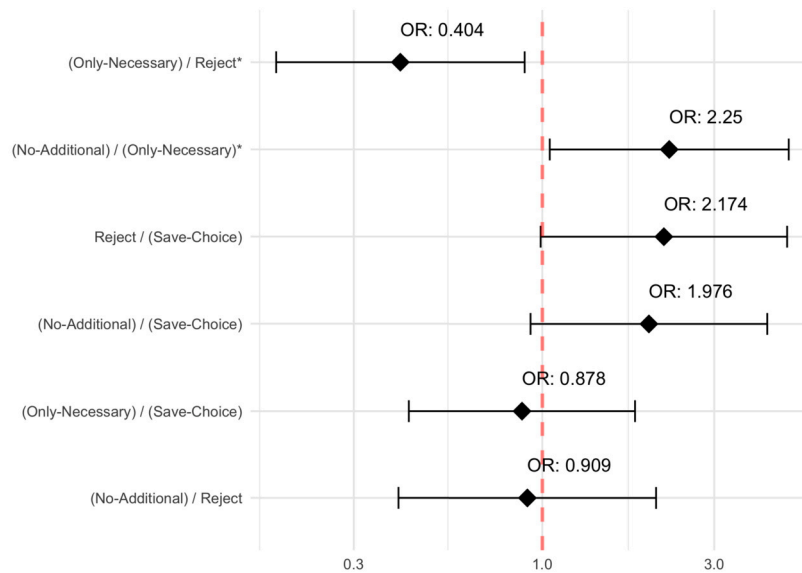


Fig. 6. Odds ratios and their 95% confidence intervals for pairwise comparison of Label variable. The x-scale is logarithmic, \*\*\* signifies p-value < .001, \* signifies p-value between .01 and .05.

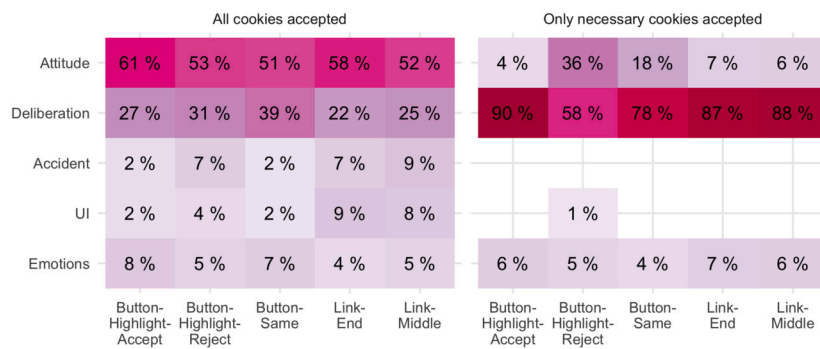


Fig. 7. Frequency of codes from each category being mentioned by participants (as a percentage of total codes mentioned by participants shown a notice with a particular Visual and making a particular decision). Note, the responses of some participants were assigned multiple codes.

assignments. The appearance of the other three categories was much less: emotions with 35, accident with 26, and UI with 26, too. The individual code that was assigned most often is 'effort factor', i.e. want to use the web page as soon as possible, which is a code under 'attitude': It was assigned 125 times. The individual code that was assigned second often is 'habit (routine)', also a code under 'attitude': It was assigned 80 times. 62 times we assigned the code 'if possible, only essential cookies' (while several referred to if easily possible) an 58 times the code '(Protection of) Privacy - abstract'. While these are the top four, it might be worth mentioning that 14 answers were assigned to the individual code 'Perceived only one option', 21 to the individual code 'trust in the site', and 41 to the individual code 'website functionality', i.e. those were afraid that they cannot use the website if they do not accept everything.

### 5. Investigation of the use of only necessary cookies

In order to understand the impact of users consenting to collection of "only necessary" cookies, we have conducted an investigation of popular websites, looking into whether the cookies they collect can indeed be reasonably concluded to be necessary. In particular, we based our investigation on previous work Krisam et al. (2021) which analysed cookie disclaimers on Top 500 German websites Inc (1996), resulting in the analysis of cookie disclaimers on 389 websites (excluding websites that were in language other than English or German). Of these websites, only 376 were still available at the time of our analysis (July

2022), hence, we focused on these 376 for the sake of comparison with previous work. Our analysis is performed in two steps. First, we categorise the websites according to the design of the disclaimers and the options they offer to the user regarding rejecting non-necessary cookies. Second, we analyse the cookies that are set by the website in case the option to reject non-necessary cookies is selected (or if no option to reject such cookies is provided to the user) via browser tools and third-party tools to check whether these cookies are indeed necessary for the website functionality. We describe both of these steps in the subsections below.

#### 5.1. Disclaimer design and options provided to the users

One third of the investigated websites (128 of 376, 34%) did not offer website visitors any opportunities to reject the use of cookies on the website, either not showing any cookie disclaimer (87 of 376, 23%), or showing a disclaimer mentioning usage of cookies either with only the "accept all" option without further information (1 of 376) or with a link to further information but without any further options (40 of 376, 11%). A further third of the disclaimers (120 of 376, 32%) provided a choice of either accepting all cookies via clicking on a button, or configuring the cookies one wants to accept either on the disclaimer itself (11 of 376, 3%) or on a separate page (109 of 376, 29%). The rest of the disclaimers (128 of 376, 34%) corresponded to the ones we investigated in our experiment, containing both an "accept" and a "reject" option directly on the disclaimer. Note that there has been a significant change to the

**Table 3**

Websites categorised by cookie disclaimer design and options provided to the user. Note, as 13 of the websites investigated in 2021 were not available in 2022, the total number of websites differs.

	2021	2022
<b>No choice for the user</b>	<b>208</b>	<b>128</b>
No disclaimer	134	87
Disclaimer without link to further information	5	1
Disclaimer with link to further information	69	40
<b>Choice for the user with single click to reject</b>	<b>39</b>	<b>138</b>
“Reject”-Button without highlighting	7	62
“Reject”-Button with “accept” option highlighted	21	66
Config dialog without highlighting	2	3
Config dialog with “accept” option highlighted	9	7
<b>Choice for the user with several clicks to reject</b>	<b>142</b>	<b>110</b>
Config dialog without highlighting	1	0
Config dialog with “accept” option highlighted	1	1
Config page without highlighting	16	13
Config page with “accept” option highlighted	124	96
<b>Total</b>	<b>389</b>	<b>376</b>

investigation in Krisam et al. (2021) which was conducted a year earlier, with previous results showing only 7% of the disclaimers showing an explicit “reject” option, and the majority of the websites (58%) either not showing any disclaimer (34%) or showing a disclaimer without any option to reject cookies (19%). The full overview of the categorisation of the disclaimers, together with the comparison with the previous study, is provided on Table 3.

Out of the websites that provided the user with an option to either accept all or to reject non-necessary cookies (248 of 376), the majority allowed choosing the “reject” option with a single click, either by clicking on “Save settings” button with all non-necessary cookies deactivated by default (10 websites) or by clicking on the explicitly provided “Reject” button (128 websites). However, only 65 websites displayed both the “accept” and the “reject” option in an equal way (26% of all disclaimers that provided both options).

This allows us to conclude that at least 49% of websites (183 of 376) collect non-necessary cookies while nudging the user to accept them, either via requiring additional clicks to select the “reject” option or via presenting the “accept” option in a highlighted way. The remaining 51% require further investigation to determine whether the cookies they store – either by default, if no decision is available to the user, or with the user explicitly choosing to reject non-necessary cookies – are indeed necessary for the functionality of the website.

## 5.2. Use of non-necessary cookies

In order to understand whether the cookies stored by the website are necessary for its functionality, we have conducted an identification process consisting of 3 levels. First, the websites are manually examined using the developer tools, which can be accessed in the browser. In the next step, a web-based tool is used and in the last step the privacy policies are used to identify non-necessary cookies. In the following the identification process is described in more detail.

### 5.2.1. 1st level

The Developer Tools can be accessed by right-clicking in most browsers. They contain information about the cookies that are set on a website. This allows us to identify the name and value of the cookies. In this step, it was assumed that Google Analytics cookies are not technically necessary. The reason for this assumption is that GA collects data about the user’s interaction and creates statistics for the website operator based on this data Google (2023). Without these cookies, the website would be still functional. GA cookies are always found with

“\_ga”, “\_gid” or “\_gat\_<number>” names, so when checking the lists, these cookies were searched for.

- If no cookies are displayed in the cookie list, the website is classified as one without cookies.
- If no GA cookie is detected, the website moves to the 2nd level of the identification process.
- If a GA cookie is detected, it is classified as a website with cookies that are not technically necessary.

### 5.2.2. 2nd level

The web-based tool “Cookie Checker” is a tool from CookieYes Limited to identify the cookies that are set on a website. First, the tool scans the website, activates all cookies and collects necessary details about the cookies found. After that, an automatic scan report is generated and provided to the user Limited (2023).

In this step, it was assumed that the “Cookie Checker” works reliably, and outputs correct information about the cookies’ functions in the report. Since the provider of the Cookie Checker offers a Cookie Consent Management Tool, the information in the scan report was trusted.

- If only necessary cookies are found in the scan report, the website is classified as one that only sets technically necessary cookies.
- If no non-necessary cookies are found in the report and at least one cookie is found that does not have a clear function assignment, then the website moves to the 3rd level of the identification process.
- If at least one non-necessary cookie was found in the scan report, which was also found in the 1st Level Cookie List, the website is classified as one with cookies that are not technically necessary.

### 5.2.3. 3rd level

The privacy policy is available on most websites by clicking on a link at the bottom of the website and contains information about the cookies that are set on the website.

In this step, it was assumed that the information in the privacy statement is correct.

- If the use of non-necessary Cookies, which were also found in the 1st Level Cookie List, could be derived from reading the privacy policy, the website will be classified as one with cookies that are not technically necessary.
- If it could be derived from the privacy policy that only technically necessary cookies, which were also found in the 1st Level Cookie List, are set by reading the privacy policy, the website is classified as one that only sets technically necessary cookies.
- Otherwise, the website will be finally classified as a website without a clear statement.

The full process is summarised on Fig. 8.

The analysis has shown that out of all websites, only 14% (52 of 376) did not set any non-necessary cookies before the user explicitly consented to it. Such cookies were set on 72% websites (269 of 376), and the results were inconclusive for 18% (67 of 376) websites. Out of websites that did not provide any choice to the visitor, only 20% (26 of 128) did not use any non-necessary cookies, while 72% (92 of 128) were found to use cookies not essential for the website functionality, and the analysis results for 10 of 128 websites were inconclusive. Among the websites that provided the user an option to reject non-essential cookies, only 11% (27 of 248) did not set any non-essential cookies without user’s consent, 71% (177 of 248) did set such cookies and the analysis of 18% (of 248) was inconclusive. In particular among the websites that provided a cookie disclaimer without dark patterns – that is, with a “reject” option that is accessible via single click and has the same look and feel as the “accept” option – only 5% (3 of 65) did not set any non-essential cookies without the user consenting to it, while 78% (51 of



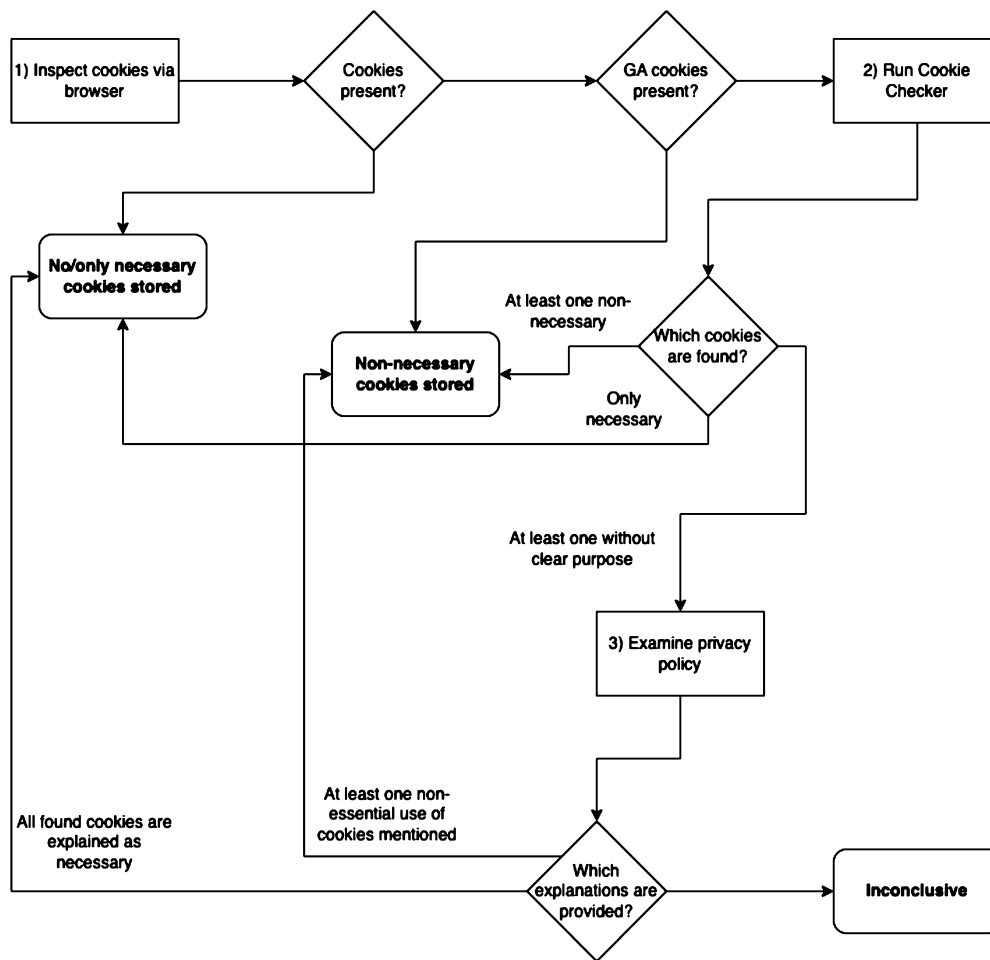


Fig. 8. Process for determining whether a website stores non-necessary cookies without user's consent.

**Table 4**  
Types of cookies set by the website without user's explicit consent.

	2021	2022
<b>No choice for the user</b>	<b>208</b>	<b>128</b>
No disclaimer	134	87
Disclaimer without link to further information	5	1
Disclaimer with link to further information	69	40
<b>Choice for the user with single click to reject</b>	<b>39</b>	<b>138</b>
“Reject”-Button without highlighting	7	62
“Reject”-Button with “accept” option highlighted	21	66
Config dialog without highlighting	2	3
Config dialog with “accept” option highlighted	9	7
<b>Choice for the user with several clicks to reject</b>	<b>142</b>	<b>110</b>
Config dialog without highlighting	1	0
Config dialog with “accept” option highlighted	1	1
Config page without highlighting	16	13
Config page with “accept” option highlighted	124	96
<b>Total</b>	<b>389</b>	<b>376</b>

65) were shown to do so. The full overview of the analysis of different categories of disclaimers is shown on Table 4.

## 6. Discussion

### 6.1. Effect of the design of cookie disclaimers

Our results show that participants indeed are swayed to share more data just by modifying the design elements of the cookie disclaimers.

Thus, our research once again stresses the ephemeral nature of consent in the context of web tracking: if the users tend to select different options depending on the web design, it can hardly be argued that the consent they provide is indeed informed.

In particular, the design nudges that was shown to affect the participants the most was the visual representation of the “reject”-option: Only very few participants (10%) chose the option that would allow them to reject all but necessary cookies, if that option was represented as a link instead of a button. The participants’ follow-up explanations furthermore have shown that some of them (14 participants) stated that they did not notice the “reject”-option at all. Others accepted because they thought there is no easy way to reject.

Thus, we underline the request from Utz et al. (2019) “for regulation to not just require consent, but also provide clear requirements or guidance for how this consent has to be obtained in order to ensure that users can make free and informed choices.”. In particular it should be regulated that presenting the “reject”-option as a link while showing the “accept” option as a button is illegal. It is worth mentioning that presenting the “reject”-option as a link while showing the “accept” option as a button has already been criticized by data protection agencies, in particular, the data protection agency in Denmark issuing guidelines cautioning against such practice Danish Data Protection Authority (2017).

Our results show that without highlighting and with highlighting the reject option (bright pattern), an accept-all rate of 57% and 43% respectively was measured. Furthermore, our study did not reveal significant differences between presenting both the “accept” and “reject” option as buttons with similar look and feel and highlighting either one of them.

Our findings regarding the visual nudges of the “reject”-option can be seen as complementing previous research: as such, we did not find a significant difference between highlighting the “reject” button versus presenting both options as buttons with the same look and feel, as opposed to the findings of Utz et al. (2019). While it might indicate that the effect is too small to be detectable given our study sample, it is worth noting that our findings are inline with the results of Grassl et al. (2021); given the time gap between these studies, it is possible that the effect of highlighting a button has reduced as the participants became more familiar with the cookie disclaimers (hence, those of them who were concerned about their privacy knew not to click on the highlighted button). Given these distinctions, however, and the variety of highlighting effects that were not yet investigated (e.g. positioning of the button), future work is needed to understand which of these effects might have played a role in the participants’ choice as well.

However, already from our study, we can conclude that it is not enough to legally require a change of the design, although it is a first step. To get more insights, we tried to understand how participants made decisions and found that more than half of those participants having accepted all cookies mentioned attitude related and less than one third of those participants mentioned in their answers anything that could indicate an informed decision (classified as deliberation). This influence on decision is discussed further in 6.2.

The text-changes we made to generate some bias towards accepting, had no effect on participants decision to accept all cookies or not, similar to findings in Kulyk et al. (2018, 2020). One of the reasons can very well be the fact that only a relatively small amount of users actually reads the text at all; as such, only 34% of our participants reported reading the explanation text, and looking at the analyses of the free-text answers reveals reasons for such low engagement: e.g. 110 mentioned time related issues and 66 (see Table 10 for the numbers) that they just click it away (habit). This also explains that 13, see Table 10, specifically mention that they did not notice the link in the text and that the accept-all rate for the groups with the reject-link is so high. Not reading is also supported by the following finding: We had several participants believing that they would not be able to use the website afterwards – ostensibly overlooking the fact that the explanation on our mock cookie disclaimers explicitly mentioned that the website functionality would not be impaired. Note, also from those rejecting only one mentioned something related to the text ‘criminal way in phrasing text in cookie disclaimers’. Thus, it looks like the actual text has limited effect also on those who try reject all cookies other than essential one.

While the main text nudge seems to have little influence the text on the button for the reject option makes a difference: Participants were more likely to reject all but essential cookies if the corresponding option was labelled as “Only necessary cookies” as opposed to “Reject” or “No additional cookies”. A possible reason for this can be deduced from the analyses of the free-text answers: 49 participants mentioned that they were afraid that they would either not be able to use the website at all, or use it with limited functionality if they do not accept all cookies. Some refer even to past experience. Thus, it might be that negative phrasing should be avoided to enable more informed decisions. In general more clear labelling of options is needed which shows the percentages of participants who misunderstood the options and thus selected one option but misinterpreted them (see category accident in Section 7). While this is due to the best of our knowledge the first study analyzing different labelling of options, more research in this direction is needed. In case future research can support our findings it is highly recommended that labelling of options is also discussed in future legal regulations.

## 6.2. Influence of non-design aspects

Participants’ explanations regarding their interactions with the cookie disclaimer shed light on their decision-making process. Parti-

cipants reporting using both of *Kahnemann’s systems* Kahneman (2011) in their reactions to the cookie disclaimer: System 1 (i.e. decision making that relies on quick heuristics) – in particular codes assigned to the ‘attitude’ category – and System 2 (decision making that relies on some level of deliberation) – in particular codes assigned to the ‘deliberation’ category. This finding confirms the findings in Grassl et al. (2021): The authors also discussed the distinction between System 1 and System 2 decision process when it comes to reactions to cookie disclaimers. It is worth mentioning, that despite using system 2, several participants made a deliberate choice to accept all cookies, in particular there were 48 of our 521 participants believing that they would not be able to use the website afterwards – while some mention corresponding negative experience in the past. This is of particular interest as the idea of technically necessary cookies is that the website should work with only these cookies. Thus, either the websites they visited in past did not implement this concept properly and/or these participants are not entirely aware of the concept of technically necessary cookies.

Note, some having the attitude towards accepting all cookies, seem to have ‘learned’ that this is usually the highlighted option. This may also explain the 36% codes related to the category ‘attitude’ in group ‘button-highlight-reject’ (see 7). It might be that several of those who rejected the marketing cookies only rejected by accident as they just followed their *habit* to click on the highlighted option without reading it. One may argue that this is also not an informed decision, anymore. While it is not likely that many websites would actually highlight the reject option. This result shows that – due to the habituation effect after having interacted with so many cookie disclaimers – it is not recommendable to highlight the reject option but rather show both or all options the same way.

Several individual codes – in particular in the category ‘attitude’- indicate a *lack of awareness*: A general lack of awareness for privacy risks and countermeasures (confirming past research such as Kulyk et al. (2018)) and regarding the concept of technically necessary cookies as well as questioning trust in the service as such versus trust in their privacy policies. Thus, our results show once more, that it is important to raise peoples awareness for privacy risks – in general but also for specific contexts. Note, our finding regarding the missing awareness of the concept of technically necessary cookies, may also explain the findings regarding the n text for the rejection-option, e.g. ‘reject’ may sound more scaring than just ‘only necessary’ or ‘only necessary’.

We identified several codes, i.e. users’ attitude, which indicate that *decisions are made independent from the actual design/text*: There are all those which are likely to accept all cookies independent from the actual design and without reading the text, either due to their ‘attitude’ (e.g. don’t care, no risk), because they are afraid not to be able to use the website without accepting all cookies (‘Website functionality’ and partially ‘Obligatory’), because they ‘trust in the site’, or because they delete them either manually or automatically (‘Regular deletion of cookies’, ‘habit as cookies are deleted’). Then there are those which are likely to reject all non-technically necessary cookies and would take the extra steps: ‘(Protection of) privacy - abstract’, ‘As little advertising as possible’- which are 73 of the 521 participants. There are only few codes related to the actual design (not related to the actual text): ‘If possible, only essential Cookies’ and the ‘UI’ category – in total only 62 of the 521 responses we analyzed. Thus most have developed their coping strategies after having seen for months/years cookie disclaimers on almost all websites. Also note that still 57% of our participants in the ‘Button-Same’ group selected the ‘accept all’ option. Thus, it is questionable whether just adopting the regulations towards prohibiting dark patterns actually makes a big difference. It looks like, as a privacy community we also need to focus more on awareness and/or tool support – if possible – which would decide based on our pre-configured privacy settings.

### 6.3. Limitations

Our participants were younger and more educated compared to the general German population. As participants in the crowdsourcing platforms, they were also likely to be more active as Internet users. It is also possible they were more likely to trust the website advertised on the platform they actively use, and more incentivised to continue browsing the website (hence, less likely to risk not being able to access the website due to rejecting cookies) in order to get their monetary reward. However, if they would have read the cookie disclaimer they would have noticed that they can continue to the actual study without actually accepting marketing cookies. Thus, in world in which people read these disclaimers the influence should be very limited. However, as our study results also show, many do not read the disclaimers, instead being influenced by their expectations of the particular web service – in this case, our survey platform. Hence, it is likely that on other webpages with the same cookie disclaimers less participants would have accepted the marketing cookies. We expect that this would be the case of all groups. We furthermore had to rely on self-reporting with regards to participants reading the disclaimer or its specific parts, as well as regarding their reports on how they interact with cookie disclaimers outside of the study setting. Nonetheless, the differences observed in our study – in particular, the fact that the disclaimer design did have an influence on participants' decisions – provide us with some insights about participants' attitudes towards cookie disclaimers and their role in informing them about their data protection. Finally, in our evaluation of whether the collected cookies can be classified as necessary, we relied, among other characteristics, on an analysis by a third-party tool "Cookie Checker". The reliability of this analysis, as well as our methodology in general, can be further studied, e.g. by conducting interviews with developers to better understand whether they consider the collected cookies as necessary or not, and how their opinion can differ from the output of "Cookie Checker".

## 7. Conclusion

With our research, we show that not everything that looks like a dark pattern actually has a significant effect on peoples decision. Thus, studying different instantiating of design elements is worth to continue. Furthermore, we demonstrate that some design elements of cookie disclaimers influence peoples decision significantly. Thus, while legal regulations could and should be more precise, it is very difficult to be very precise as there are so many different ways to design cookie disclaimers and so many ways to change the text description. To address this shortcoming, we invite the data protection community to discuss the following alternative way to address dark patterns: Regulations could require the owner of informed consent dialogues such as cookie disclaimers to conduct empirical studies to kind of proof that there is no nudging affect – while ideally the study would be conducted by independent institutions.

Our study also reveals that adopting legal regulations will not be enough to only observe informed decisions. Habituation effects need to be addressed, too. This can be achieved via complementary approaches of (1) increasing privacy awareness among the end users, (2) working with service providers in ensuring that the information and control options provided to the users are actually meaningful for their decision making (so that the users would not be tempted to click the disclaimers away because they perceive the disclaimers to be useless). While there are valid criticisms towards relying on user awareness to make privacy-protective decisions Fassl et al. (2021), there is value for the users in involving them user in such decisions in their data, as acknowledged by both legislation and empirical studies (see e.g. Kulyk and Renaud (2021)), so that effective ways of enabling such involvement should be a topic of future investigations. In particular, given known challenges of providing understandable and actionable privacy-related communication (see Section 2), insights from the explainable AI field can be

investigated regarding their applicability in privacy notices. As such, the framework described by Cabitza et al. Cabitza et al. (2023) can be used to guide the development of privacy-related explanations provided by different stakeholders to different target groups: as such, the developers can focus on providing the *justificatory* explanations on why the cookies used on a website are actually necessary for its function, or why accepting cookies would benefit the user, while independent entities (e.g. experts/third-party tools evaluating a service) can focus on *informative* explanations of the privacy policy of the server, or *cautionary* explanations on possible consequences for the users of shared data. Furthermore, given the diversity of user experience, as demonstrated by our qualitative data, and the fact that privacy decisions and preferences are subjective and context- and user-dependent, methods to develop and evaluate solutions accounting for this diversity need to be applied, such as the use of personas Holzinger et al. (2022).

Finally, the problem of lack of transparency regarding the use of cookies remains, as our analysis allowed us to conclude only for 14% of the investigated websites, that no cookies that were not essential were set without user's consent. For the rest of the websites, we either could not come to a decisive conclusion due to ambiguity of the information provided by the website provider (14%), or were able to detect setting cookies that serve purposes other than ensuring the website functionality (e.g. analytics) before the users consent (71%). This complicates the decision processes of the users even more, as even the users who are deliberate about their privacy decisions and avoid consenting to collection of data they deem unnecessary would not have their choices honoured by website providers. While it might be challenging to determine the necessity of particular types of cookies, especially for complex web services, more transparency on behalf of service providers regarding which cookies they find essential and why would potentially be helpful for users as well as for policy makers in determining proper source of action.

### CRedit authorship contribution statement

**Benjamin Maximilian Berens:** Methodology, Writing – review & editing. **Mark Bohlender:** Investigation, Writing – original draft. **Heike Dietmann:** Investigation, Methodology, Writing – original draft. **Chiara Krisam:** Investigation, Methodology, Writing – original draft. **Oksana Kulyk:** Conceptualization, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Melanie Volkamer:** Conceptualization, Methodology, Supervision, Writing – review & editing.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### Data availability

Data will be made available on request.

### Acknowledgements

This research was further supported by funding from the topic Engineering Secure Systems, subtopic 46.23.01 Methods for Engineering Secure Systems, of the Helmholtz Association (HGF) and by KASTEL Security Research Labs as well as by the ministry of Science, Research and the Arts Baden-Württemberg as part of the DIGILOG@BW - joint research project with funds from the digilog@bw State Digitization Strategy.

## Appendix A

### A.1. Debriefing and informed consent

The following text was shown to the participants in our survey as their debriefing, also asking them to give consent to participation in the study now that they know its real purpose (translated from German):

Thank you for participating in this survey. In the following you will be informed about the **study on cookie disclaimers**. Please read the rest of the information carefully:

You should have been presented with a **cookie disclaimer** to interact with at the beginning of the survey. This disclaimer was already **part of the study**. Contrary to what is stated in Clickworker, the **real goal** of the study was to evaluate how you deal with cookie disclaimers in your everyday life. Therefore, we could not tell you the true goal of the study at the beginning. We apologize for this. Note that **no cookies were stored by us**. It was only stored within this survey on which option you clicked on the cookie disclaimer.

In their everyday lives, users usually do not encounter cookie disclaimers as a primary task. Rather, they are an additional step required to use websites. We wanted to create such a situation as well by displaying what appeared to be a cookie disclaimer from SoSci Survey. Since we wanted to create a **situation as realistic as possible** for the cookie disclaimer, we could not inform you beforehand what the real content of this study is.

The study is part of a **thesis at the Karlsruhe Institute for Technology**. The aim is to find out whether the presentation of the options on cookie disclaimer has an effect on the behaviour of users. The participants of the study are therefore shown different disclaimers, which always give the option to accept all cookies with one click or to accept only essential cookies with one click.

Cookies are small text files that are stored by website operators on users' devices in order to recognize them during future visits. This can be used, for example, to save shopping baskets when shopping online, even if the page is closed. However, cookies can also be passed on to third parties in order, for example, to be able to display suitable advertisements.

Cookie disclaimers are required to inform users and obtain their consent. It is mandatory for website operators to inform their users which cookies they store for which purpose and to whom they are passed in case of doubt. In addition, it must be possible to object to the storage and use of cookies. Technically necessary cookies (referred to here as essential cookies) are an exception. These are required by law to operate the website and do not require consent.

By interacting with the disclaimer just displayed, **no cookies were stored on your device**. The data was collected within the study and stored on a server of SoSci Survey in Germany. This data can only be viewed by those conducting the study and is only used for study purposes. The SoSci Survey tool itself also does not use cookies. Due to a unique user ID within a survey, which is transmitted from one page to the next, no data is permanently stored on your end device.

You have the option to cancel the survey at this point. In this case, the data collected so far (i.e. your click behaviour at the cookie disclaimer) will not be used for the study. Please note: If you do not agree to the use of your data, Clickworker will consider your order as "cancelled". You will then not receive any fee from Clickworker.

### A.2. Demographics of our participants

See Tables 5–7.

**Table 5**

Age and gender of the participants (note, the participation was only allowed for participants who were at least 18 years old).

	Women	Men	Non-binary/Other
19 or younger	0	5	0
20-24	36	28	1
25-29	33	45	3
30-34	44	63	0
35-39	23	39	0
40-44	16	40	1
45-49	12	24	0
50-54	21	19	0
55-59	15	21	0
60-64	7	13	0
65 or older	2	9	0
Not answered	0	0	1

**Table 6**

Employment.

	Number of participants
Pupil	2
In apprenticeship	12
Student	64
Employee	281
Official	11
Self-employed	93
Unemployed/Looking for work	30
Other	27
Not answered	1

**Table 7**

Education.

	Numb. of part.
School finished without graduation	0
Elementary or lower secondary school leaving certificate, Quali	5
Intermediate or secondary school leaving certificate, or equivalent qualification	26
Completed apprenticeship	81
Vocational baccalaureate, entrance qualification & for a university of applied science	38
Final secondary-school examinations, university entrance qualification	141
University of Applied Sciences school diploma/ university degree	223
Still a pupil	1
Other degree	5
Not answered	1

### A.3. Statistical analysis

See Tables 8,9.



**Table 8**  
Pairwise comparisons of different visual representations of the “reject”-option (variable *Visual*).

contrast	odds.ratio	SE	asyp.LCL	asyp.UCL	z.ratio	p.value
(Button-Highlight-Accept) / (Button-Highlight-Reject)	2.4299	0.7024	1.1045	5.3460	3.072	0.0181
(Button-Highlight-Accept) / (Button-Same)	1.3733	0.4104	0.6078	3.1031	1.062	0.8262
(Button-Highlight-Accept) / (Link-End)	0.2030	0.0780	0.0711	0.5793	-4.148	0.0003
(Button-Highlight-Accept) / (Link-Middle)	0.2098	0.0807	0.0735	0.5991	-4.060	0.0005
(Button-Highlight-Reject) / (Button-Same)	0.5652	0.1635	0.2568	1.2440	-1.973	0.2792
(Button-Highlight-Reject) / (Link-End)	0.0835	0.0315	0.0299	0.2337	-6.581	<.0001
(Button-Highlight-Reject) / (Link-Middle)	0.0864	0.0326	0.0308	0.2418	-6.490	<.0001
(Button-Same) / (Link-End)	0.1478	0.0568	0.0518	0.4215	-4.976	<.0001
(Button-Same) / (Link-Middle)	0.1528	0.0587	0.0535	0.4360	-4.887	<.0001
(Link-End) / (Link-Middle)	1.0338	0.4687	0.3002	3.5604	0.073	1.0000

Results are averaged over the levels of: Label, Explanation  
 Confidence level used: 0.95  
 Conf-level adjustment: tukey method for comparing a family of 5 estimates  
 Intervals are back-transformed from the log odds ratio scale  
 P value adjustment: tukey method for comparing a family of 5 estimates  
 Tests are performed on the log odds ratio scale

**Table 9**  
Pairwise comparisons of different variants of labelling the “reject”-option (variable *Label*).

contrast	odds.ratio	SE	asyp.LCL	asyp.UCL	z.ratio	p.value
(No-Additional) / (Only-Necessary)	2.2500	0.6687	1.0485	4.8283	2.728	0.0323
(No-Additional) / Reject	0.9087	0.2910	0.3992	2.0686	-0.299	0.9907
(No-Additional) / (Save-Choice)	1.9759	0.5817	0.9275	4.2095	2.313	0.0950
(Only-Necessary) / Reject	0.4039	0.1248	0.1826	0.8932	-2.934	0.0176
(Only-Necessary) / (Save-Choice)	0.8782	0.2469	0.4265	1.8083	-0.462	0.9673
Reject / (Save-Choice)	2.1743	0.6665	0.9893	4.7789	2.534	0.0549

Results are averaged over the levels of: Visual, Explanation  
 Confidence level used: 0.95  
 Conf-level adjustment: tukey method for comparing a family of 4 estimates  
 Intervals are back-transformed from the log odds ratio scale  
 P value adjustment: tukey method for comparing a family of 4 estimates  
 Tests are performed on the log odds ratio scale

A.4. Coding results

**Table 10**

Number of times each code was mentioned by participants shown a notice with a particular *Visual* and making a particular decision. Note, the responses of some of the participants were assigned multiple codes.

	All cookies cookies accepted	Only necessary cookies accepted
<b>UI</b>		
Perceived only one option		
Button-Highlight-Accept	0	0
Button-Highlight-Reject	1	0
Button-Same	0	0
Link-End	8	0
Link-Middle	5	0
Highlighted option		
Button-Highlight-Accept	2	0
Button-Highlight-Reject	1	1
Button-Same	1	0
Link-End	2	0
Link-Middle	5	0
<b>Attitude</b>		
No specific reason		
Button-Highlight-Accept	10	0
Button-Highlight-Reject	5	6
Button-Same	3	2
Link-End	10	0
Link-Middle	12	0
Effort factor		
Button-Highlight-Accept	26	0
Button-Highlight-Reject	11	11
Button-Same	11	3
Link-End	34	1
Link-Middle	28	0
Habit (Routine)		
Button-Highlight-Accept	11	1
Button-Highlight-Reject	12	8
Button-Same	10	4
Link-End	18	0
Link-Middle	15	1
Nothing bad/ Something good		
Button-Highlight-Accept	3	0
Button-Highlight-Reject	1	1
Button-Same	4	0
Link-End	0	0
Link-Middle	3	0
Carelessness		
Button-Highlight-Accept	4	1
Button-Highlight-Reject	0	1
Button-Same	1	0
Link-End	4	0
Link-Middle	4	0
<b>Accident</b>		
Clicked on accident		
Button-Highlight-Accept	2	0
Button-Highlight-Reject	4	0
Button-Same	1	0
Link-End	8	0
Link-Middle	11	0
<b>Deliberation</b>		
If possible, only essential cookies		
Button-Highlight-Accept	2	16
Button-Highlight-Reject	0	17
Button-Same	0	10
Link-End	0	6
Link-Middle	3	8

**Table 10 (continued)**

	All cookies cookies accepted	Only necessary cookies accepted
Regular deletion of cookies		
Button-Highlight-Accept	2	1
Button-Highlight-Reject	4	0
Button-Same	0	0
Link-End	5	0
Link-Middle	7	0
Habit as cookies are deleted		
Button-Highlight-Accept	2	1
Button-Highlight-Reject	1	3
Button-Same	0	3
Link-End	3	1
Link-Middle	4	0
(Protection of) privacy - abstract		
Button-Highlight-Accept	0	16
Button-Highlight-Reject	0	15
Button-Same	0	17
Link-End	2	4
Link-Middle	0	4
As little advertising as possible		
Button-Highlight-Accept	0	3
Button-Highlight-Reject	0	6
Button-Same	1	4
Link-End	1	2
Link-Middle	0	2
Obligatory		
Button-Highlight-Accept	5	0
Button-Highlight-Reject	1	0
Button-Same	5	0
Link-End	4	0
Link-Middle	2	0
Website functionality		
Button-Highlight-Accept	8	2
Button-Highlight-Reject	8	0
Button-Same	10	2
Link-End	4	0
Link-Middle	7	0
Trust in the site		
Button-Highlight-Accept	4	0
Button-Highlight-Reject	3	1
Button-Same	4	1
Link-End	5	0
Link-Middle	5	0
Informed decision - non-specific		
Button-Highlight-Accept	1	3
Button-Highlight-Reject	0	2
Button-Same	2	3
Link-End	1	0
Link-Middle	2	0
<b>Emotions</b>		
Cookies messages annoy		
Button-Highlight-Accept	6	3
Button-Highlight-Reject	2	3
Button-Same	4	1
Link-End	4	1
Link-Middle	6	1
Anxiety		
Button-Highlight-Accept	1	0
Button-Highlight-Reject	1	1
Button-Same	0	1
Link-End	0	0
Link-Middle	0	0

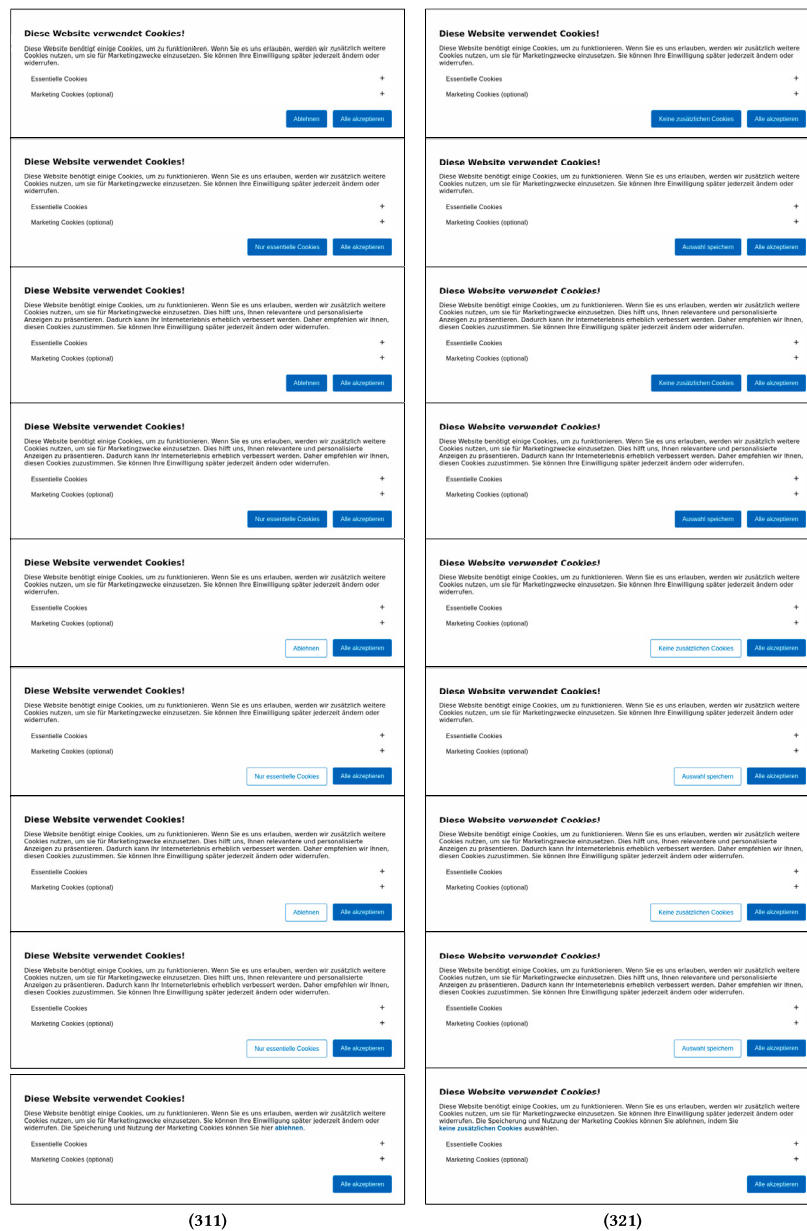


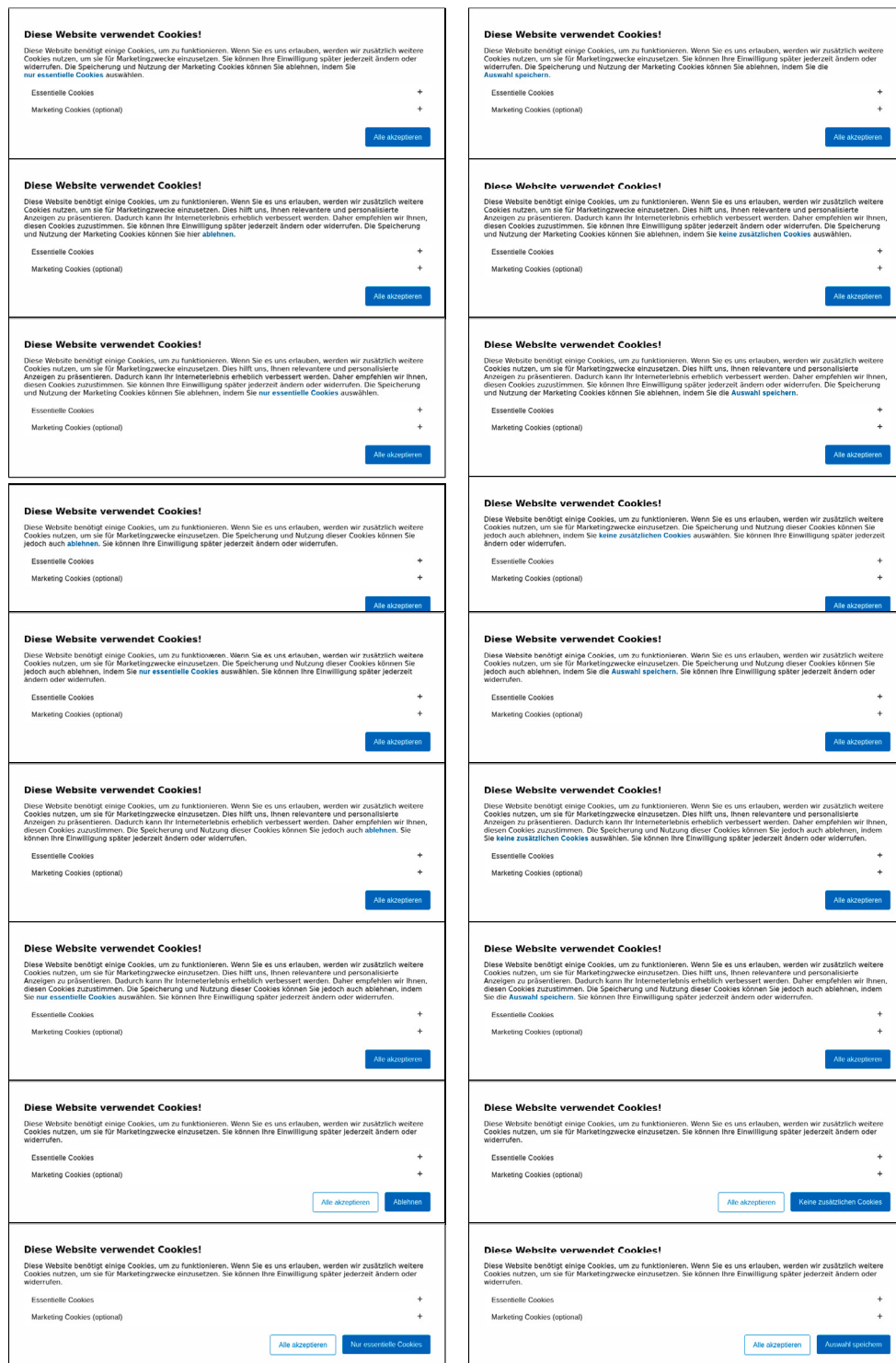
Fig. 9. Fictitious cookie dialogs (5 × 4 × 2 = 40) in the original language German. (source: own picture).

Table 10 (continued)

	All cookies accepted	Only necessary cookies accepted
<b>Nonsense / Others</b>		
<b>Nonsense</b>		
Button-Highlight-Accept	2	0
Button-Highlight-Reject	4	2
Button-Same	4	1
Link-End	4	1
Link-Middle	7	0
<b>Others</b>		
Button-Highlight-Accept	0	0
Button-Highlight-Reject	0	1
Button-Same	1	2
Link-End	3	0
Link-Middle	0	0

### A.5. Cookie disclaimers used in the study

Fig. 9.

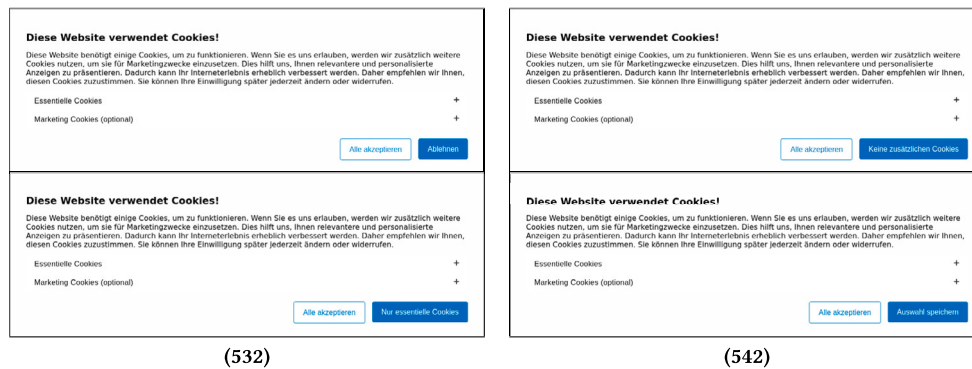


(531)

(541)

Fig. 9. (continued)





(532)

(542)

Fig. 9. (continued)

## References

- Inc, 1996. 2021 Alexa Internet. 2021. Alexa - top sites in Germany. <https://www.alexa.com/topsites/countries/DE>. (Accessed 17 November 2020).
- Almuhimedi, Hazim, Schaub, Florian, Sadeh, Norman, Adjerid, Idris, Acquisti, Alessandro, Gluck, Joshua, Cranor, Lorrie Faith, Agarwal, Yuvraj, 2015. Your location has been shared 5,398 times! A field study on mobile app privacy nudging. In: Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (Seoul, Republic of Korea) (CHI '15). Association for Computing Machinery, New York, NY, USA, pp. 787–796.
- American Psychological Association, et al., 2002. Ethical principles of psychologists and code of conduct. *Am. Psychol.* 57 (12), 1060–1073.
- Barocas, Solon, Nissenbaum, Helen, 2009. On notice: the trouble with notice and consent. In: Proceedings of the Engaging Data Forum: The First International Forum on the Application and Management of Personal Electronic Information.
- Berens, Benjamin Maximilian, Dietmann, Heike, Krisam, Chiara, Kulyk, Oksana, Volkamer, Melanie, 2022. Cookie disclaimers: impact of design and users' attitude. In: Proceedings of the 17th International Conference on Availability, Reliability and Security, pp. 1–20.
- Bergram, Kristoffer, Djokovic, Marija, Bezençon, Valéry, Holzer, Adrian, 2022. The digital landscape of nudging: a systematic literature review of empirical research on digital nudges. In: CHI Conference on Human Factors in Computing Systems (New Orleans, LA, USA) (CHI '22). Association for Computing Machinery, New York, NY, USA, 62.
- Bohlender, Mark, Dietmann, Heike, Volkamer, Melanie, 2023. Cookie-Nutzung nach Inkrafttreten des TTDSG: Zur Datenschutzkonformität des Cookie-Einsatzes auf den meistgenutzten deutschen Websites. *Datenschutz* 47 (5), 283–288.
- Bujang, Mohamad Adam, Sa'at, Nadiyah, Mohd Ikhwan Tg Abu Bakar, Tg, et al., 2018. Sample size guidelines for logistic regression from observational studies with large population: emphasis on the accuracy between statistics and parameters based on real life clinical data. *Malays. J. Med. Sci.* 25 (4), 122.
- Cabitz, Federico, Campagner, Andrea, Maligneri, Gianclaudio, Natali, Chiara, Schneeberger, David, Stoeger, Karl, Holzinger, Andreas, 2023. Quod erat demonstrandum? Towards a typology of the concept of explanation for the design of explainable AI. *Expert Syst. Appl.* 213, 118888.
- Danish Data Protection Authority, 2017. Nye retningslinjer om behandling af personoplysninger om hjemmesidesbesøgende. <https://www.datatilsynet.dk/presse-og-nyheder/nyhedsarkiv/2020/feb/nye-retningslinjer-om-behandling-af-personoplysninger-om-hjemmesidesbesoegende/>. (Accessed 3 October 2020).
- Fassl, Matthias, Theresa Gröber, Lea, Krombholz, Katharina, 2021. Stop the consent theater. In: Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems, pp. 1–7.
- Google, 2023. Google analytics. <https://developers.google.com/analytics/devguides/platform/>. (Accessed 3 February 2023).
- Grassl, Paul, Schraffenberger, Hanna, Borgesius, Frederik Zuiderveen, Buijzen, Moniek, 2021. Dark and bright patterns in cookie consent requests. *J. Digit. Soc. Res.* 3 (1), 1–38.
- Holzinger, Andreas, Kargl, Michaela, Kipperer, Bettina, Regitnig, Peter, Plass, Markus, Müller, Heimo, 2022. Personas for artificial intelligence (AI) an open source toolbox. *IEEE Access* 10, 23732–23747.
- Kahneman, Daniel, 2011. *Thinking, Fast and Slow*. Macmillan.
- Keller, Punam Anand, Harlam, Bari, Loewenstein, George, Volpp, Kevin G., 2011. Enhanced active choice: a new method to motivate behaviour change. *J. Consum. Psychol.* 21 (4), 376–383. <https://doi.org/10.1016/j.jcps.2011.06.003>. Special Issue on the Application of Behavioral Decision Theory.
- Krisam, Chiara, Dietmann, Heike, Volkamer, Melanie, Kulyk, Oksana, 2021. Dark patterns in the wild: review of cookie disclaimer designs on top 500 German websites. In: Proceedings of the 2021 European Symposium on Usable Security, pp. 1–8.
- Kulyk, Oksana, Gerber, Nina, Hilt, Annika, Volkamer, Melanie, 2018. "This website uses cookies": users' perceptions and reactions to the cookie disclaimer. In: 3rd European Workshop on Usable Security (EuroUSEC). London, England, April 23, 2018. Internet Societa, Reston. 8VY.
- Kulyk, Oksana, Gerber, Nina, Hilt, Annika, Volkamer, Melanie, 2020. Has the GDPR hype affected users' reaction to cookie disclaimers? *J. Cybersecurity* 6 (1). tya022.
- Kulyk, Oksana, Renaud, Karen, 2021. "I need to know I'm safe and protected and will check": users want cues to signal data custodians' trustworthiness. In: 2021 Workshop on Human Centric Software Engineering and Cyber Security.
- Limited, CookieYes, 2023. CookieYes - free online cookie checker for websites. <https://www.cookieserve.com/>. (Accessed 3 February 2023).
- DiCosola III, Blake M., Neff, Gina, 2022. Nudging behaviour change: using in-group and out-group social comparisons to encourage healthier choices. In: CHI Conference on Human Factors in Computing Systems (New Orleans, LA, USA) (CHI '22). Association for Computing Machinery, New York, NY, USA, 475.
- Ma, Eryn, Birrell, Eleanor, 2022. Prospective consent: the effect of framing on cookie consent decisions. In: CHI Conference on Human Factors in Computing Systems Extended Abstracts (New Orleans, LA, USA) (CHI EA '22). Association for Computing Machinery, New York, NY, USA, 400.
- Machuletz, Dominique, Böhme, Rainer, 2020. Multiple purposes, multiple problems: a user study of consent dialogs after GDPR. In: Proceedings on Privacy Enhancing Technologies 2020 2, pp. 481–498.
- Nouwens, Midas, Liccardi, Ilaria, Veale, Michael, Karger, David, Kagal, Lalana, 2020. Dark patterns after the GDPR: scraping consent pop-ups and demonstrating their influence. *arXiv preprint. arXiv:2001.02479*.
- Renaud, Karen, Shepherd, Lynsay A., 2018. How to make privacy policies both GDPR-compliant and usable. In: 2018 International Conference on Cyber Situational Awareness, Data Analytics and Assessment (Cyber SA). IEEE, pp. 1–8.
- Santos, Cristiana, Bielova, Natalia, Matte, Célestin, 2020. Are cookie banners indeed compliant with the law? *Technol. Regul.* 2020, 91–135.
- Schaub, Florian, Balebako, Rebecca, Cranor, Lorrie Faith, 2017. Designing effective privacy notices and controls. *IEEE Internet Comput.* 2017.
- Schaub, Florian, Balebako, Rebecca, Durity, Adam L., Cranor, Lorrie Faith, 2015. A design space for effective privacy notices. In: 11th Symposium on Usable Privacy and Security (SOUPS 2015), pp. 1–17.
- Thaler, Richard H., Sunstein, Cass R., 2008. Nudge: improving decisions about health. *Wealth Happiness* 6, 14–38.
- Utz, Christine, Degeling, Martin, Fahl, Sascha, Schaub, Florian, Holz, Thorsten, 2019. (Un)informed consent. In: Proceedings of the 2019 ACM SIGSAC Conference on Computer and Communications Security, pp. 973–990.
- Zimmermann, Verena, Renaud, Karen, 2021. The nudge puzzle: matching nudge interventions to cybersecurity decisions. *ACM Trans. Comput.-Hum. Interact.* 28 (1), 1–45.
- Benjamin Maximilian Berens** is a research assistant Karlsruhe Institute of Technology (KIT). He works at the Security, Usability and Society (SECUSO) research group doing research on topics related to usable security/privacy and communication of knowledge on security/privacy.
- Mark Bohlender** has done research on the topic of cookies at the Security, Usability and Society (SECUSO) research group while studying for his Bachelor in Business Informatics at the Karlsruhe Institute of Technology.
- Heike Dietmann** has a degree in Mathematics and has worked as a research assistant at the Security, Usability and Society (SECUSO) research group at Karlsruhe Institute of Technology (KIT).
- Chiara Krisam** has done research on the topic of cookies at the Security, Usability and Society (SECUSO) research group as a part of her studies for Bachelor in Business Informatics at the Karlsruhe Institute of Technology.
- Oksana Kulyk** is professor at the IT University of Copenhagen. She works at the Center of Information Security and Trust and works on topics related to human factors in security and privacy.
- Melanie Volkamer** is professor at the Karlsruhe Institute of Technology. She is leading the Security, Usability and Society (SECUSO) research group and is a PI for the KIT Security Research Labs.