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< A Usability and Universal Design Investigation into User Interface Toggle Switches >

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OSLOMET

Preface

This study is about investigating and evaluating the existing User Interface toggle switches that are found in webpages and mobile applications.

An interesting article about 'Toggle-Switch Guidelines' which was written by (Joyce, 2018) in the Nielsen Norman group inspired me to start studying and investigating UI toggle switches and other elements.

By taking on this project, I have learned how it is important to make the UI toggle switches usable and accessible to everyone. Despite these elements are simple but misusing them can confuse the user and make him/her confused about how to interact with them.

I have also learned how it is important to think of people with disabilities while designing and developing any system and product.

I am really grateful to the Department of Computer Science at Oslo Metropolitan University in Norway for allowing me to undertake a master's degree thesis.

My heartfelt thanks go out to my thesis supervisor **Dr. Pietro Murano** who provided me with invaluable advice and recommendations while I completed my master's degree coursework. For his efforts, he has my highest regard and appreciation. It is a great honor for me to have a chance to be one of his students and beneficiary as a master's student.

I would like to say thank you to my beloved family for their continued support. I would also like to extend my sincere gratitude to my friends, and colleagues from the university who agreed to participate in the testing.

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Abstract

This evaluation study is about to investigate how usable and accessible are the existing user interface (UI) toggle switches. Some articles were done to investigate UI elements such as toggle switches, checkboxes, and radio buttons. They discussed how UI toggle switches can be misused in some places. They did not make experiments and did not include participants in their studies. This evaluation study was done through user experiments; eighteen prototypes that represent different user interfaces were developed and were distributed into nine cases. These prototypes contained either toggle switches, checkboxes, or radio buttons. These prototypes were tested with twenty participants, and the participants were asked to accomplish a task. Every two prototypes were compared together, and two dependent variables were measured: **Success rate**: which represents the ability of the user to know the initial state of the UI elements, and **Subjective preference:** a preference between every two prototypes were made. At the end of the test, a Likert-type scale questionnaire was conducted to collect more thoughts about participants' perceptions toward UI toggle switches. The main aim of this study was to investigate if there are fixed guidelines that are followed by all designers and developers while designing UI toggle switches, and are these guidelines lead to accessible and usable UI toggle switches. The data collected for success rate were analysed by Wilcoxon Signed Ranks Test using IBM SPSS, while the data collected for subjective preference were analysed by descriptive statistics frequency using IBM SPSS. The main findings of this study showed that there are no fixed guidelines regarding toggle switches, and they may misuse in some places. I concluded some recommendations as guidelines regarding UI toggle switches: UI toggle switches must have an immediate response, providing (on, off) state labels, it is recommended to use green or blue color to indicate the on-state and avoid using red color, the position of the on-state should always be on the right direction, use grey color to indicate the off-state, toggle label should always be short and clear without negative words, when the answer is not on/off use another element, use checkboxes when there are several related choices to choose from, and finally, the initial state of any UI elements should always be off or unselected. All developers and designers may contribute to achieving usable and accessible toggle switches by following the above recommendations.

Keywords: UI elements, UI toggle switch, toggle label, state label, universal design, usability, accessibility, Experimental research, evaluation study, prototype design.

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1 Introduction

1.1 Background

Most of us are familiar with user interface (UI) toggle switches. We use them every day while interacting with our mobile applications and webpages.

An interesting article was done by Alita Joyce (Joyce, 2018), she said **“Every morning, I wake up, pour water into my tea kettle, and flip the switch "on". Once the water is boiling, I turn the kettle off and pour myself a cup”**. The switch on her kettle is an example of a UI toggle switch.

In general, we can say that a toggle switch is digital on/off switch that enables the user to select between two mutually exclusive options with an immediate response. The user does not expect to click save or submit to apply the changes. They are better used to change the status of device functions and preferences (Joyce, 2018).

As we know, there are other UI elements like toggle buttons, checkboxes, and radio buttons. It is very important to choose the proper UI element while designing a mobile application or a webpage otherwise this will confuse the user.

It is difficult sometimes to decide which UI element to choose. Understanding the characteristics of these UI elements helps the designers and developers to use them properly.

(Joyce, 2018) made a comparison among toggle switch, radio button, single checkbox, and multiple checkboxes as below:

Toggle switch	**Single checkbox**	**checkboxes**	**Radio button**
One option is available	One option is available	Multiple options are available	Multiple options are available
The user can make 2 selections (on, off)	The user can make 2 selections (selected, unselected)	The user can select (0 – all)	The user can make one selection
There is a default option	There is a default option	There is no default option	There is a default option

It has mutually exclusive choices	It has mutually exclusive choices	The choices are independent of each other	The choices are mutually exclusive
It has Immediate response	Does not require immediate response	Do not require immediate response	Does not require immediate response

Table 1.1-1Comparison among toggle switch, radio button, single checkbox, and multiple checkboxes

Universal design

These UI elements should be universally designed to be accessible and usable by all people.

UN definition of Universal Design: **"Universal design means the design of products, environments, programmes and services to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design. "Universal design" shall not exclude assistive devices for particular groups of persons with disabilities where this is needed."** (UN Convention on the Rights of Persons with Disabilities, u.d.)**.**

Shawn Lawton Henry, who leads worldwide education and outreach activities promoting web accessibility for people with disabilities at the W3C Web Accessibility Initiative (WAI), explained web accessibility as the ability of individuals with impairments to utilize the internet (Lawton Henry, 2007).

There are seven principles of universal design which were developed by an interdisciplinary group at the Center for Universal Design at North Carolina State. These principles are generic and are adopted within a wide range of design disciplines, from architecture and product design to the design of ICT products and services (Alnahdi, 2014).

These **7 principles** are listed below:

1. Equitable Use
2. Flexibility in Use
3. Simple and Intuitive Use
4. Perceptible Information
5. Tolerance for Error

6. Low Physical Effort

7. Size and Space for Approach and Use (Alnahdi, 2014)

Sometimes it is difficult to know immediately the initial state of user interface toggle switches in some web pages and mobile applications.

Elderly people or people with cognitive issues may face some problems knowing the initial state of the toggle switch immediately. When there is only the color that reflects whether it is "on" or "off" then people with color vision deficiency may face a problem while interacting with these elements.

People with disabilities may need extra help that can assist them to differentiate between "on" and "off" state of UI toggle switches easily and without any effort.

In addition to that, sometimes I see radio buttons or checkboxes with no save or submit button then I try to scroll the page down and up searching for the save button then I realize that they are designed with an immediate response.

I started to investigate these UI elements by reading articles, papers, exploring webpages and mobile applications, and even by asking people.

During the investigation, I started to know that there are certain rules and guidelines that should be followed by developers and designers while designing such UI elements. Then I reached again to the same question are these rules and guidelines lead to accessible and usable UI elements?

In this project, an evaluation study with participants has been conducted. Eighteen prototypes which consisted of either toggle switches, checkboxes, or radio buttons were developed. These prototypes were tested with twenty participants, and every two prototypes were compared together. An experiment task was implemented within subjects. Quantitative and qualitative data were collected and analysed.

1.2 Toggle switches guidelines

Extensive searching about toggle switch guidelines indicated that there are no fixed guidelines that can be followed by all developers and designers. I listed below some guidelines and recommendations from Microsoft and Apple companies.

Microsoft

They described toggle switches like a light switch with two mutually exclusive options either "on" or "off". Toggle switches provide immediate response when the user makes a selection.

They are used for binary operations which take place immediately after the user flips them "on" or "off". Short label with one or two words are recommended for a better understanding of the functionality of these elements and it is by default "on" or "off" depends on the current status. If these two labels "on" and “off" do not accurately explain the operation of a toggle switch, then it is better to use another UI control (Guidelines for toggle switch controls - Windows apps | Microsoft Docs, 2021).

Toggle switches or checkboxes?

To choose between toggle switches and checkboxes, follow the following tips:

- For immediate response with binary setting, use toggle switches.
- When there is an optional item, use checkboxes.
- If the user must take further action for the modifications to take effect like press next or submit, use a checkbox.
- When the user will pick several objects that are connected to a single setting or function, use check boxes (Guidelines for toggle switch controls - Windows apps | Microsoft Docs, 2021).

Below we can see a screenshot that shows a user interface toggle switch for windows 10:

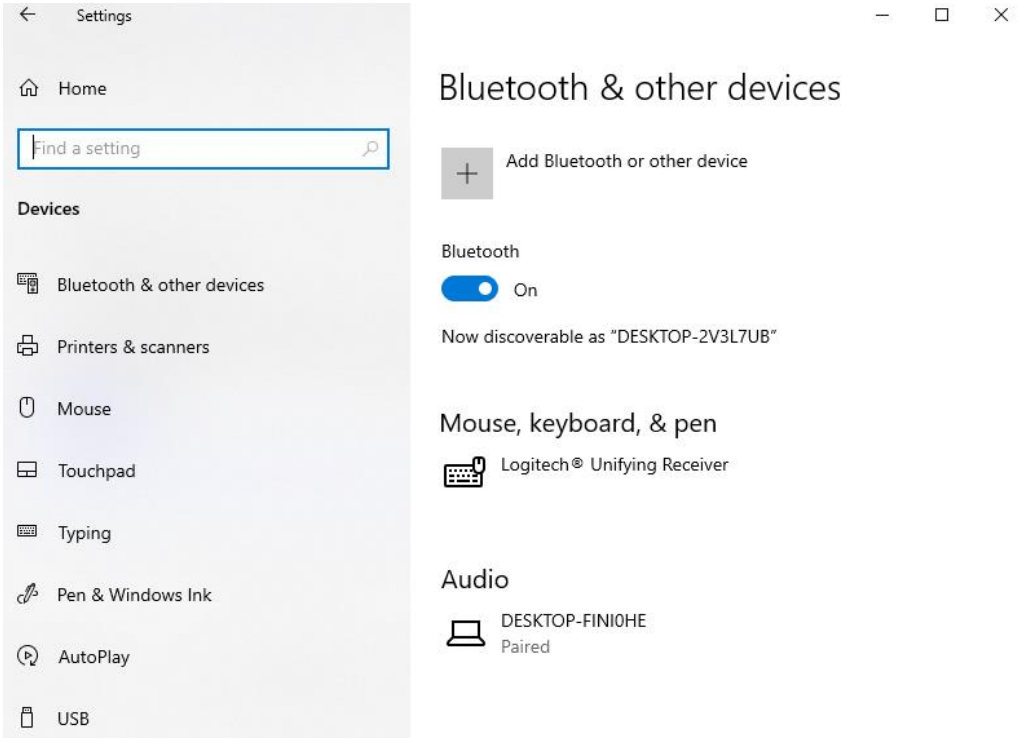


Figure 1.2-1 Screenshot that shows a user interface toggle switch for windows 10

Apple iOS

They described toggle switches as graphical switches with a mutual exclusive state which is either "on" or "off". They mentioned some guidelines and tips regarding toggle switches' design as below (Switches - Controls - iOS - Human Interface Guidelines - Apple Developer, n.d.):

- Consider coloring a switch to fit the application's design.
- It is recommended to use toggle switches just in the form of table's rows. An example of that is a list of setting and it is better to use a button instead of a toolbar or navigation bar if there is a need to identical features with two distinct icons to express the states.
- They recommend avoiding using labels to describe whether the toggle switch is "on" or "off". These labels are unnecessary and may confuse the user.
- Toggle switches are used to control some features that affect other content on the screen. For example, switch "off" Airplane mode will disable other components like Cellular, Wi-Fi, and Personal Hotspot (Switches - Controls - iOS - Human Interface Guidelines - Apple Developer, n.d.).

1.3 Problem statements

There is a misuse of UI toggle switches in some mobile applications, webpages, etc. There are some cases that the UI toggle switches are not the best choice and should be replaced by other UI elements like checkboxes or radio buttons. In some other cases, UI toggle switches are poorly designed.

As we know user expects an immediate response when they flip toggle switches "on" or "off", but regarding this article (Joyce, 2018), she provided an example with United Airlines iOS app where nothing happens when users tap the toggle switch, and this can lead to confusion.

Designers and developers should be aware of Visibility of System Status which is the first of Jakob Nielsen's 10 Usability Heuristics for User Interface (Nielsen, 10 Usability Heuristics for User Interface Design, 2020). In Windows10, when the toggle switch is "off", off word will appear on the right of the toggle switch and the toggle dot is on the left. This attribute is unclear and can confuse the user (Joyce, 2018).

Misuse of UI toggle switches can make the user skeptical and uncertain about what to do. In this article (Anthony, Stop Misusing Toggle Switches, 2019), Anthony mentioned that when designers and developers misuse toggle switches, this can lead to confusion and frustration. He also mentioned in another article (Anthony, When to Use a Switch or Checkbox, 2016) that the user interface would be more intuitive to use if these controls are used in the right way. When they are used incorrectly, though, users can think something is wrong.

Human perception of the online form is an important aspect, as we know that other UI elements like checkboxes and radio buttons can be part of the online form. There is an evidence shows that unusable webform can lead to loss of profit because some people are struggling while filling a form to purchase an item for example and they may not complete their aim (Bargas-Avila, et al., 2010).

When UI toggle switches are designed in an inconsistency way, the interaction between the user and UI will be slow and confusing. Another Jakob Nielsen's 10 Usability Heuristics is **Consistency and standards** (Nielsen, 10 Usability Heuristics for User Interface Design, 2020), he mentioned that inconsistency can increase the cognitive load of users by requiring them to learn new information.

Guidelines and rules that are found to achieve a usable system are sometimes ignored.

Regarding this article (Whitenton, 2016), they explained that the usability of online forms is not a new topic. It has been discussed in several resources like some books of NN/g Nilsen Norman Group, and other resources, but the issues that many poor web forms have, which are not complicated, should have been avoided with a simple clarification of these rules and guidelines.

1.4 Research questions

- Are the existing UI toggle switches universally designed?
- Is there any guidelines that are followed by all designers and developers which lead to accessible and usable UI toggle switches?
- How can we achieve accessible and usable UI toggle switches?

1.5 Research aim

This study aims to investigate and evaluate UI toggle switches, compare them with other control elements like checkboxes, and radio buttons, and explore how people interact with these elements.

Eighteen prototypes were developed during this study, these prototypes represent user interface elements as we will see later in the method chapter. Every two prototypes were compared and tested with twenty participants. Quantitative and qualitative data were collected and analysed.

At the end of the test, a Likert-type scale questionnaire was conducted to collect more information from the participants regarding these user interface elements.

As we will see later in the literature review chapter, some people investigated and explored these UI components, they realized that UI toggle switches are misused in some places. Some of them made a comparison between toggle switches and checkboxes to explain that sometimes UI toggle switches are used in the wrong place.

The limitation in their work is that they did not include users to validate their findings. They did not implement any kind of experiment or survey to understand what people think about these UI elements and how they interact with them.

Human participants are usually involved in human-computer interaction (HCI). It is very important to involve users in a work, whether this work is related to conducting a focus group,

leading a collaborative design process, performing controlled research, or conducting an anthropological inquiry (Lazar, Feng, & Hochheiser, 2010).

User engagement is an important part of the system development cycle in the field of information systems. Users can provide additional information if they participate in the system development cycle (Sun, 2013).

1.6 Study overview

We can see below the steps that have been done to complete this project:

- **Investigation:**

  Investigating the existing UI elements in webpages and mobile applications and investigating other people's works that have been done with these UI elements.
- **Research questions:**

  Three questions
- **Evaluation study:**
  - **Independent variables:**

    Eighteen prototypes were developed. These prototypes represent different user interfaces with either toggle switches, radio buttons, or checkboxes. These prototypes were distributed into 9 cases, two prototypes under each case. Every two prototypes were compared together, quantitative, and qualitative data were collected and analysed.
  - **Experiment task which consisted of the following:**
    - After viewing each prototype, the participants were asked to answer this question: **'What is the current state of the UI element?'** I considered a task as successful if the participant would be able to know the initial state of the UI element before interacting with it.
    - The participants were asked to answer this question: **'Which prototype do you prefer? why?'** a comparison between every two prototypes was made.

    For some prototypes, participants were asked other questions regarding these UI elements.
  - **Dependent variables:**

- **Success rate:** It is related to knowing the initial state for UI elements.
- **Subjective preference:** It is related to which prototype the participants preferred under each case.

- **Likert-type scale questionnaire**

  It consisted of thirteen questions and ranging from (1= Strongly Disagree, 2= Disagree, 3= Neutral, 4= Agree, 5= Strongly Agree)

- **Real experiment:**

  Within subject design

- **Result and analysis**

  All the results were analysed using IBM SPSS Statistics. Data collected for success rate were analyzed by Wilcoxon Signed Ranks. Data collected for subjective preference were analysed by descriptive statistics frequency, and the results for the Likert-type scale questionnaire were analysed by descriptive statistics.

- **Discussion**
- **Conclusion**

2 Literature Review

A lot of articles mentioned that there is a misuse of UI toggle switches. In this chapter, I will mention and give examples of some previous work that has been done by other people. Some of them made a comparison between toggle switches and checkboxes, others emphasized the importance of understanding the different types of toggle states and options.

2.1 Toggle switches vs checkboxes

Instant response

Regarding this article (Minhas, 2018), Saadia Minhas made a comparison between toggle switches and checkboxes. She mentioned the following:

- If the action for the UI element is on/off or it will show other options, it is better to use a toggle switch.
- Toggle switch is preferred to use when there is an option or setting that requires immediate response without any need for confirmation like save or submit (Minhas, 2018).

Anthony in this article (Anthony, Stop Misusing Toggle Switches, 2019) mentioned that when users turn on switches, they expect them to have an instant impact.

Since the toggle switch mimics a real-life switch, it functions as a clear and explicit UI component that anyone can recognize and use. It is important for this reason for toggle switches to have an immediate response. In fact, this means that toggle switches do not require clicking on save or submit to make changes take place (JUSTINMIND, 2020).

We can see that from the image below:

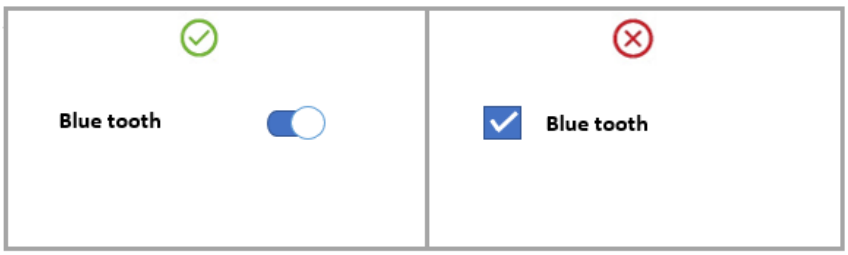


Figure 2.1-1 Toggle switches are preferred with options that demand an immediate response

Settings confirmation

Saadia Minhas (Minhas, 2018) mentioned that it is recommended to use checkboxes over toggle switches as below:

- When the user needs to select some settings and review these settings before applying the changes.
- When the user must click save, ok, apply, and Next to apply the changes.

The figure below shows the case above

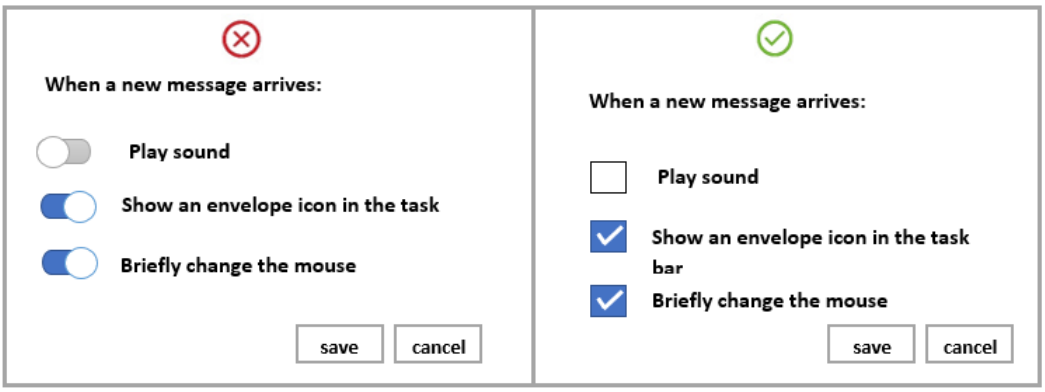


Figure 2.1-2 Checkboxes are preferred with setting confirmation

Multiple choices

It is recommended to use the checkbox in case there is a list of options, and the user needs to select one or more between them. With toggle switches, it will take more time to process each option (Minhas, 2018).

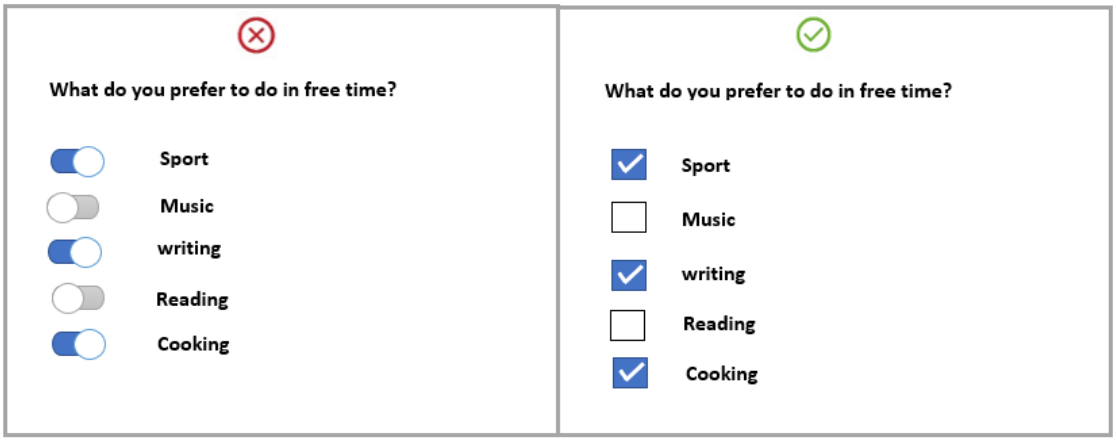


Figure 2.1-3 Checkboxes are preferred with multiple choices

Indeterminate state

Where there are several sub-options are gathered under the main option, an intermediate selection state is required. In this case, using checkboxes are preferred over toggle switches as

the image below (Minhas, 2018):

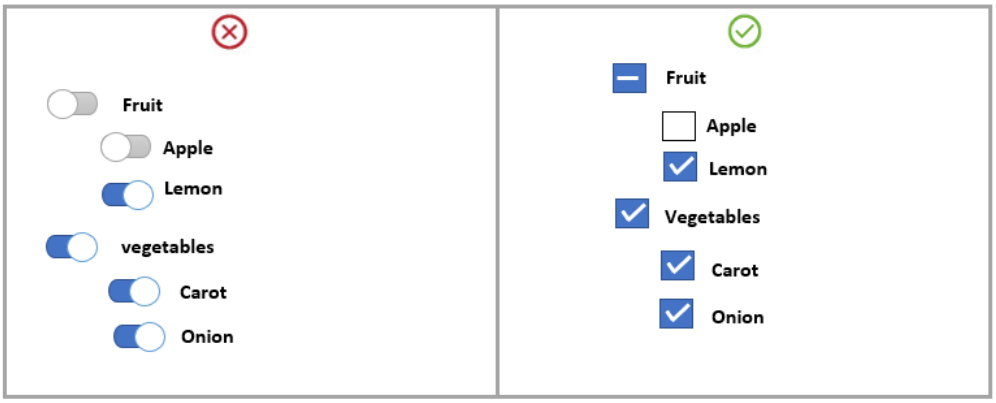


Figure 2.1-4 Checkboxes are preferred when there is an indeterminate state

Clear visual state

It is better to use checkboxes when there is a chance of confusion about the on/off state of a toggle switch. When we are uncertain whether this toggle switch shows state or action, do not use the toggle switch (Minhas, 2018).

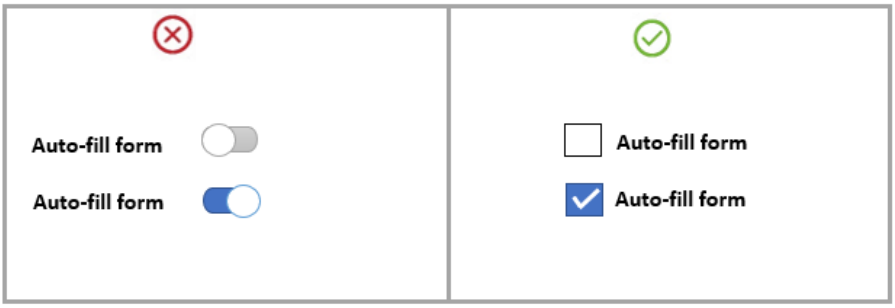


Figure 2.1-5 Checkboxes are preferred when there is a chance of confusion about the on/off state of a toggle switch

Related items

When there are some related options to select, using checkboxes over toggle switches is preferred (Minhas, 2018).

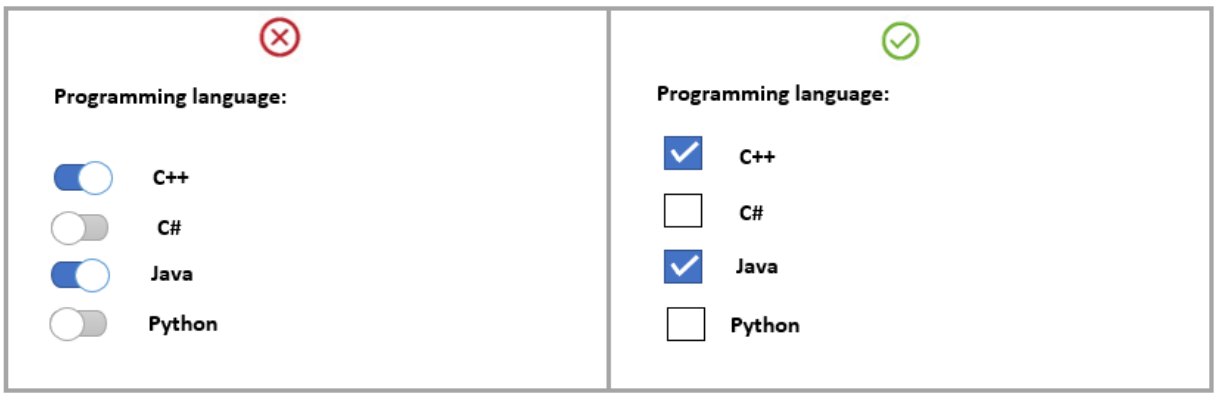


Figure 2.1-6 Checkboxes are preferred with several related choices

Independent items

Toggle switches are the best option in case there are independent features or behaviors (Minhas, 2018).

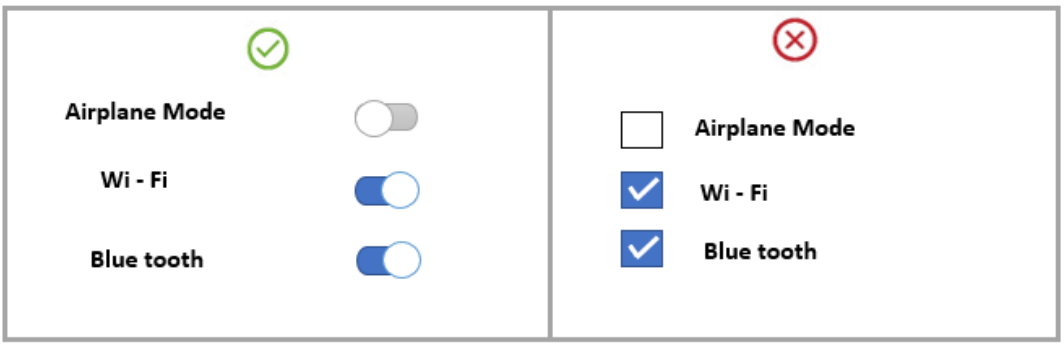


Figure 2.1-7 Toggle switches are preferred with independent items

Single option

When there is only one option and the answer is Yes/No, and this option can be selected or deselected then using checkboxes will be more reasonable (Minhas, 2018).

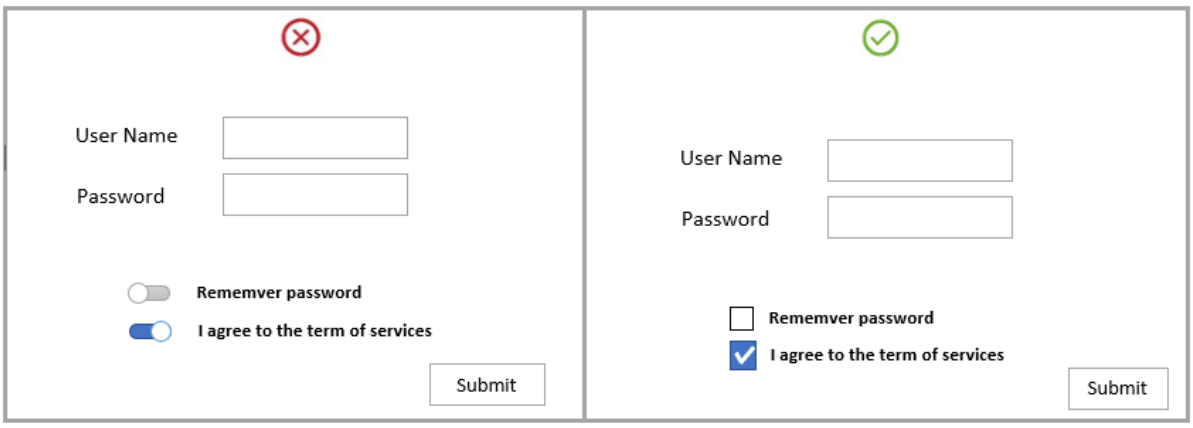


Figure 2.1-8 A single option with a yes/no answer is suitable with a checkbox

While if there is a single option and we want to either turn it "on" or " off" then it is better to use toggle switches (Minhas, 2018).

Figure 2.1-9 The toggle switch is preferred with a single on/off option

From developer's perspective, it is very important to focus on the context while choosing between toggle switches and checkboxes. Thinking about these questions: Does this UI element provide an immediate response? Does the user need to review their setting before applying them? (Haynberg, 2018)

It is very important to choose the right UI element while designing a webpage, mobile application, or any form. This will reduce the ambiguity and confusion while interacting with these elements (Minhas, 2018).

2.2 Stop misusing toggle switches

As I mentioned earlier, sometimes toggle switches are used in the wrong place.

Anthony in this article (Anthony, Stop Misusing Toggle Switches, 2019) mentioned that it is important to be aware of the different types of toggle states and options.

In addition to the toggle switches, there are toggle buttons. As we know toggle switches are used for the system state while toggle buttons are used for the contextual state which affects

the current screen (Anthony, Stop Misusing Toggle Switches, 2019).

Contextual States Vs. System States

Since toggle switches and toggle buttons both control states, it is easy for designers and developers to mix them up. There is a basic difference between them, toggle switches are used for system state which affects the whole application while toggle buttons are used for contextual state which affects just the currently focused screen (Anthony, Stop Misusing Toggle Switches, 2019).

Using toggle switch for search filter is a mistake, the effect of the search filter is only applied to the context of search not to the whole system. In this case, it is better to use checkboxes (Anthony, Stop Misusing Toggle Switches, 2019).

2.3 Web form guidelines

According to this study (Bargas-Avila, et al., 2010), they offered a detailed and organized overview for guidelines that can be applied while designing an online webform.

As we know people visit websites to achieve a specific task like surfing, purchase something, etc., and that requires sometimes filling and submitting an online web form (Bargas-Avila, et al., 2010).

Online webforms are used by most websites as the primary communication point for users and website owners. It is important to ensure a safe and comfortable UI to enable the user to achieve the task successfully, and that requires a proper UI design (Bargas-Avila, et al., 2010). Unusable web forms can lead the user to abort completion filling a form, and this may cause profit loss to a company if the user should fill a form to buy an item. Redesign inefficient online forms can enhance the completion rate in the range of 10%-40% (Bargas-Avila, et al., 2010).

Many areas of online forms have been investigated in the last decade, the areas are classified into several topics as the following (Bargas-Avila, et al., 2010):

- Form content
- Form layout
- Input types
- Error handling
- Form submission (Bargas-Avila, et al., 2010).

As a result, twenty guidelines have been found to achieve usable web form. These guidelines highlighted the importance of certain aspects while designing a web form (Bargas-Avila, et al., 2010).

I will list only five guidelines related to input types that referenced from (Bargas-Avila, et al., 2010) as below:

"Guide line8: Use checkboxes, radio buttons, or drop-down menus to restrict the number of options and for entries that can easily be mistyped. Also, use them if it is not clear to users in advance what kind of answer is expected from them.**"** (Bargas-Avila, et al., 2010)**.**

"Guideline9: Use checkboxes instead of list boxes for multiple selection items.**"** (Bargas-Avila, et al., 2010)**.**

"Guideline 10: For up to four options, use radio buttons; when more than four options are required, use a drop-down menu to save screen real estate.**"** (Bargas-Avila, et al., 2010)**.**

"Guideline 11: Order options in an intuitive sequence (e.g., weekdays in the sequence Monday, Tuesday, etc.). If no meaningful sequence is possible, order them alphabetically.**"** (Bargas-Avila, et al., 2010)**.**

"Guideline 12: For date entries use a drop-down menu when it is crucial to avoid format errors. Use only one input field and place the format requirements with symbols (MM, YYYY) left or inside the text box to achieve faster completion time.**"** (Bargas-Avila, et al., 2010).

As a result, the effective design will allow smooth interaction between the user and the website (Bargas-Avila, et al., 2010).

2.4 Checkboxes vs Radio buttons

In an article done by Jacob (Nielsen, Checkboxes vs. Radio Buttons, 2004), he experienced some issues with checkboxes on a major website's registration page. Below we can see a screenshot of the website's registration page:

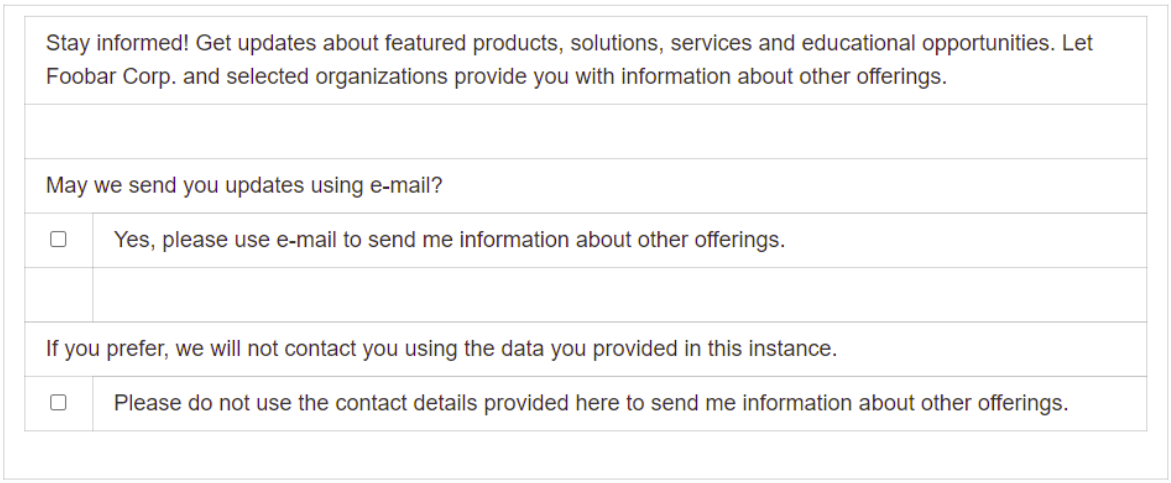


Figure 2.4-1 A major website's registration page which contains two checkboxes with at least two design mistakes

He highlighted the issues that related to the figure above into two mistakes as the following (Nielsen, Checkboxes vs. Radio Buttons, 2004):

Mistake1: The focus point in this article is when the checkboxes are used in a place where radio buttons must be used instead. We can see from the example above that these two options are mutually exclusive which means it is better to use the radio button to make it more understandable that the user should choose one of them.

Mistake2: Presenting these two questions in the first place with a big and long box. An alternative is to use a single checkbox with a short and clear question as he wrote here" **"Yes, send me information about other featured products, solutions, services, and educational opportunities."** (Nielsen, Checkboxes vs. Radio Buttons, 2004)**.**

He mentioned below when to use radio buttons and checkboxes:

- **Radio buttons:** are used when the user must select only one option from a list of options, and when the user selects one the other radio buttons options will be deselected.
- **Checkboxes:** the user can select zero or all the options. They are independent so when the user selects one the status for the other will remain.
- **Single checkbox:** it is one option by which the user can select it to activate it or deselect to deactivate it (Nielsen, Checkboxes vs. Radio Buttons, 2004).

He also mentioned some additional guidelines for these two controls as below:

- **“Use standard visual representations”**

  The design for the checkbox will be an empty small square if it is not selected, and with the sign of x or check mark if it is selected. For radio buttons, it will be a small empty circle if it is empty and with color when the user selects it (Nielsen, Checkboxes vs. Radio Buttons, 2004).
- **“Visually present groups of choices as groups”** (Nielsen, Checkboxes vs. Radio Buttons, 2004)**.**
- **“Layout your lists vertically”**

  It is better to put each choice per line, and if it is mandatory to put several options per line then keeping distance between these options (Nielsen, Checkboxes vs. Radio Buttons, 2004).
- **“Use positive and active wording”**

  This guideline for checkboxes and avoid using negative words like **“do not send me notification”,** because the user would have to check the checkbox to prevent something from happening. An alternative solution is to use two radio buttons, one will represent the option is "on" and the other for "off" option (Nielsen, Checkboxes vs. Radio Buttons, 2004).
- **“If possible, use radio buttons rather than drop-down menus”**

  Because radio buttons keep all options visible and allow users to compare them easily, they have a lower cognitive load. Users who have trouble making precise mouse movements will find radio buttons to be more user-friendly.

  Due to space constraints, you may have to break this rule from time to time but try to keep your options visible as much as possible (Nielsen, Checkboxes vs. Radio Buttons, 2004).
- **“Always offer a default selection for radio button lists”**

  Radio buttons must always have one option selected, so they should not be displayed without one, while checkboxes frequently have no options selected by default (Nielsen, Checkboxes vs. Radio Buttons, 2004).
- **“Because radio buttons require exactly one choice, make sure that the options are both comprehensive and clearly distinct”**

  For example, old people are unable to complete a form that allowed them to choose

their occupation because "retired" was not a choice. If being detailed is difficult, add an "Other" button alongside a type-in area (Nielsen, Checkboxes vs. Radio Buttons, 2004).

- **“Let users select an option by clicking on either the button/box itself or its label”**
  This can be achieved in HTML by coding each label with <label> elements. It is discovered that generous click zones that stretch a few pixels beyond the visibly clickable region eliminate user errors even further (Nielsen, Checkboxes vs. Radio Buttons, 2004).
- **“Use checkboxes and radio buttons only to change settings, not as action buttons”** (Nielsen, Checkboxes vs. Radio Buttons, 2004)**.**

2.5 Toggle-Switch Guidelines by Nielsen Norman Group

To prevent interface confusion and ensure clarification, Joyce in this article (Joyce, 2018) mentioned the importance of following the guidelines below:

- **Immediate Results**
  The effect of toggle switches UI should be immediately after the user toggles them on or off without the need to click on save or submit. She explained that we should make every effort to align the system with reality like the physical light switches. We should consider using alternative UI elements if this guideline is not feasible (Joyce, 2018).
- **Concise, Nonneutral Labels**
  Toggle switches’ labels should be short and clear. There are several principles of Tog’s Principles of Interaction Design, one of them **is “Menu and button labels should have the keyword(s) first, forming unique labels.”** (Tognazzini, 2014)**.**
  Joyce gave an example of this guideline: write **“Email notifications”**, and do not write **“Do you want to receive email notifications from us?”.**
  In an article done by Jakob Nielsen, emphasized that on the web users do not read much on a regular basis Scanning text is a very popular behavior among people with a higher degree of literacy. Users have time to read at most 28 percent of the words on an average Web page during an average visit (Nielsen, How Little Do Users Read?, 2008).
  As a result, put keywords in the front of the labels and get rid of any phrases that are

not necessary (Joyce, 2018).

The labels for toggle switches should not be neutral and vague, these labels should express what the control will do when the toggle switch is on (Joyce, 2018).

- **Standard Visual Design**

  To prevent misunderstanding, make toggle switches appear like sliders and use visual cues (e.g., motion and color). So, the location for the switch must be changed after the user toggles it "on" or "off", and the color is an important aspect (Joyce, 2018).

  Joyce recommended sticking to "on" and "off" labels that describe the state of the toggle switch, and include "on" to the right, and "off" to the left of the toggle switch (Joyce, 2018).

  She attached a screenshot to a toggle switch which is used in windows10 as below:

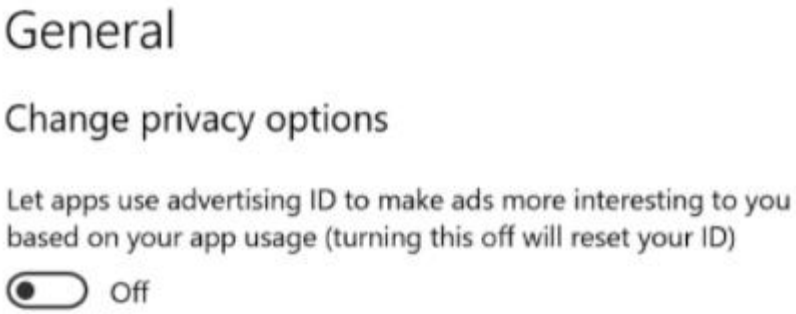


Figure 2.5-1 A screenshot to a toggle switch which is used in windows10

She explained that providing only one label which describes the current state of the toggle switch is not clear and it might be understood as a toggle label (Joyce, 2018).

There are two factors regarding contrast and cultural differences. With low-contrast colors, it will be difficult for some people to differentiate between "on" and "off", it is recommended to use high-contrast color when the state of the toggle switch is changed (Joyce, 2018).

Regarding cultural differences, be aware of what colors convey, for example, red color in some cases refers to a stop signal and that will confuse people (Joyce, 2018).

To describe the state of toggle switches UI, use only on/off to fit real-world standards, and the position for these two words will be right and left respectively to avoid any confusion. If it is difficult to provide a description for both on/off, then keep just the label for the toggle switch UI (Joyce, 2018).

- **Consistently**

  Inconsistency in UI components may confuse the user and make him waste some time thinking about how to interact with these elements. Do not confuse the user whether a statement with two radio buttons is the same as toggle switches (Joyce, 2018).

3 Method

There are three major objectives of evaluation: determine the scope and accessibility of the system's capabilities, examine the interaction's impact on the users, and see if the system has any issues (Dix, Finlay, Abowd, & Beale, 2005).

3.1 Evaluation techniques

There are two main types of evaluation: **Evaluation through expert analysis**, and **evaluation through user participation** (Dix, Finlay, Abowd, & Beale, 2005)**.**

3.1.1 Evaluation through expert analysis

Expert analysis' main goal is to find any areas that are likely to produce problems because they break known cognitive principles or neglect accepted empirical findings (Dix, Finlay, Abowd, & Beale, 2005).

There are several approaches regarding this type of evaluation (Dix, Finlay, Abowd, & Beale, 2005):

- cognitive walkthrough
- heuristic evaluation
- model-based evaluation
- using previous studies in the evaluation (Dix, Finlay, Abowd, & Beale, 2005).

3.1.2 Evaluation through user participation

3.1.2.1 Styles of evaluation

There are two styles:

- **Field studies:** performed in a natural setting or in the actual world. Rather than altering a component under investigation, it prefers to observe, evaluate, and describe what already exists. Field research participants may or may not be aware that they are being researched (Aziz, 2017).
- **laboratory studies:** This type of study is done in an environment that is particularly suited for research. In this type of research, the researcher manipulates the factor under investigation to see if the modification causes a change in the participants (Aziz, 2017).

3.1.2.2 Empirical methods: experimental evaluation

The evaluator selects a hypothesis to investigate, which can be determined by observing some aspect of participant behavior. There are several experimental conditions that differ only in the values of particular controlled variables. Different conditions can cause changes in behavioral variables (Dix, Finlay, Abowd, & Beale, 2005).

There are several factors that must be taken into consideration in the experiment as below:

- Participants
- Variables
- Hypothesis (Dix, Finlay, Abowd, & Beale, 2005).

3.2 Evaluation study with participants

The study in this project is based on an empirical evaluation of user interface toggle switches. A within-user experimental design was used in this evaluation study.

Eighteen prototypes were developed and tested with twenty participants. Every two prototypes were compared together under a specific case. These prototypes represent different UI elements. Quantitative and qualitative data were collected during the user test and analysed by IBM SPSS statistics.

3.2.1 Participants

The experiment was conducted with twenty participants, twelve males, and eight females. Some of the participants are students at Oslo Metropolitan University, and the others are family members and friends.

The range of their ages was as the following:

- 6 participants from (18 - 30).
- 8 participants from (31 - 40)
- 6 participants from (41 - 50)

The test was carried out with the participants individually and remotely by video call through either Microsoft Teams or Zoom.

The following procedures were followed to conduct the experiment session with each participant:

- Greeting the participants and provide them with brief information about the purpose of this study, and about the experiment's details.
- Get Consent form. (Please see consent form under Appendix A)
- Asking the participants some personal questions as below:
    - Their age ranges.
    - Operating system of their PC.
    - Operating system of their current mobile phone.
- Sharing the Axure link for the prototypes so they could freely interact with the prototypes.
- Asking the participants to share their screens so I can see their interaction through the experiment.
- Their responses and answers were recorded manually in word documents. (Please see participants' responses under Appendix B)
- When the participants completed the task, I asked them to stop sharing their screens.
- I shared with the participants my screen to conduct a Likert-type scale questionnaire which consisted of 13 questions and ranging from (1-5). Their responses were manually recorded. (Please see Participants' answers for Likert-type scale questionnaire under Appendix C)

Fourteen participants use windows10 as the operating system for their pcs, while six participants use mac. Regarding their mobile phones, half of the participants use iOS and the other half use Android.

The participants Carried out a task related to these prototypes. During the test, the participants were asked some questions related to some prototypes as we will see later. The total time spent with each participant was about 50 – 55 minutes.

3.2.2 Ethical consideration

In this study, a consent form was introduced to protect the ethical elements. The ethical considerations made in this study, which are referenced from (Consent Form: Remote Usability Test (Adult) | Usability.gov, 2020), are listed below. (Please see the consent form under Appendix A for more details).

- Identifying information such as name, email address, or IP address is not collected in this research.

- Participation in this study is voluntary, they may raise any concerns they might have.
- Participants' responses will remain anonymous.
- No one will know whether they participated in the study

3.2.3 Apparatus and Materials

The following systems and materials were used to perform and analyze the evaluation study:

- Lenovo laptop Intel Core i5 processor with windows10.
- Axure RP9 to create the prototypes.
- Google Chrome Version 90.0.4430.212.
- Microsoft Teams to implement the experiment.
- Zoom to implement the experiment.
- Likert-type scale questionnaire.
- IBM SPSS Statistics 27 to analyze the results.

3.3 Research design and process

The experiment was implemented in three stages, which included the following:

- Introduction
- Actual experiment
- Likert-type scale questionnaire

As I mentioned before, during the introduction, the participants have got information about the purpose of this test and general information about UI elements.

Eighteen prototypes were developed by using Axure RP9. These prototypes were distributed into nine cases, and each case consists of two related prototypes. As mentioned before, the experiment was carried out within-group, there were twenty participants who were exposed to all prototypes. Each prototype is about a user interface, and the participants were asked to interact with each user interface by implementing a specific task and answering some questions.

3.4 Variables

Independent variable

There are 18 prototypes that represent the **independent variables**. These prototypes contain either toggle switches, checkboxes, or radio buttons. (Please click on this link to interact with

the prototypes https://j4qmw4.axshare.com)

These prototypes are distributed into 9 cases, each case consists of two related prototypes. The participants can see only one prototype at a time, and all these cases are independent.

Task description

There was a **task** for each case which consisted of the following:

- Participants viewing first Prototype, and then being asked: **'What is the current state of the UI element?'** This process was then repeated for second prototype.
- Once the above was completed for both prototypes, participants were then asked: **'Which prototype do you prefer? why?'**

All participant responses were carefully recorded. For some prototypes, the participants were asked some other questions in order to understand their perception of these UI elements, as we will see later.

Dependent variable

- **Success rate**: It represents the ability of the participant to know the initial state of the UI element for each prototype before interacting with it, as mentioned in the task description above.
- **Subjective preference:** It represents which prototype the participant prefers under each case, as mentioned in the task description above.

The hypothesis for success rate was set as the following:

H0: There is no significant difference in terms of success rate between first and second prototype for each case.

H1: There is a significant difference in terms of success rate between first and second prototype for each case.

I will mention in detail all these cases as below:

3.5 Cases

Case1

This case consists of two prototypes, the UI element at each prototype is a toggle switch. The color of on-state is blue, while it is grey for off-state. The toggle switch in prototype1a is

designed without an immediate response. The participant should press the save button to show the result. It was designed this way to examine how people react when there is no immediate response with UI toggle switches.

The toggle switch in the second prototype is designed with immediate response. Below we can see these two prototypes.

Prototype1a_Case1 is shown below:

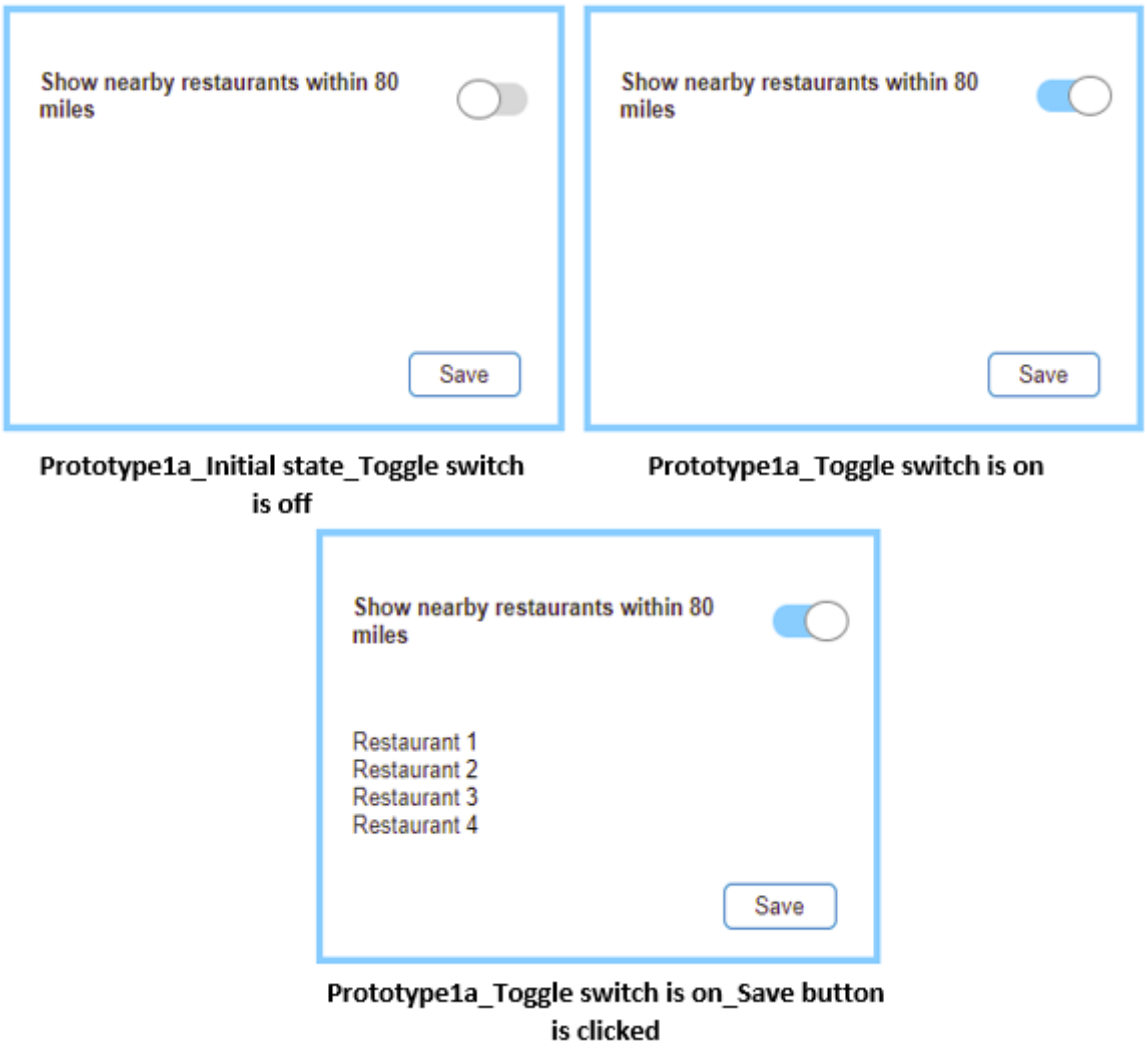


Figure 3.5-1 Prototype1a_Case1

Prototype1b_Case1 is shown below:

Prototype1b_Initial state_Toggle switch is off

Prototype1b_Toggle switch is on

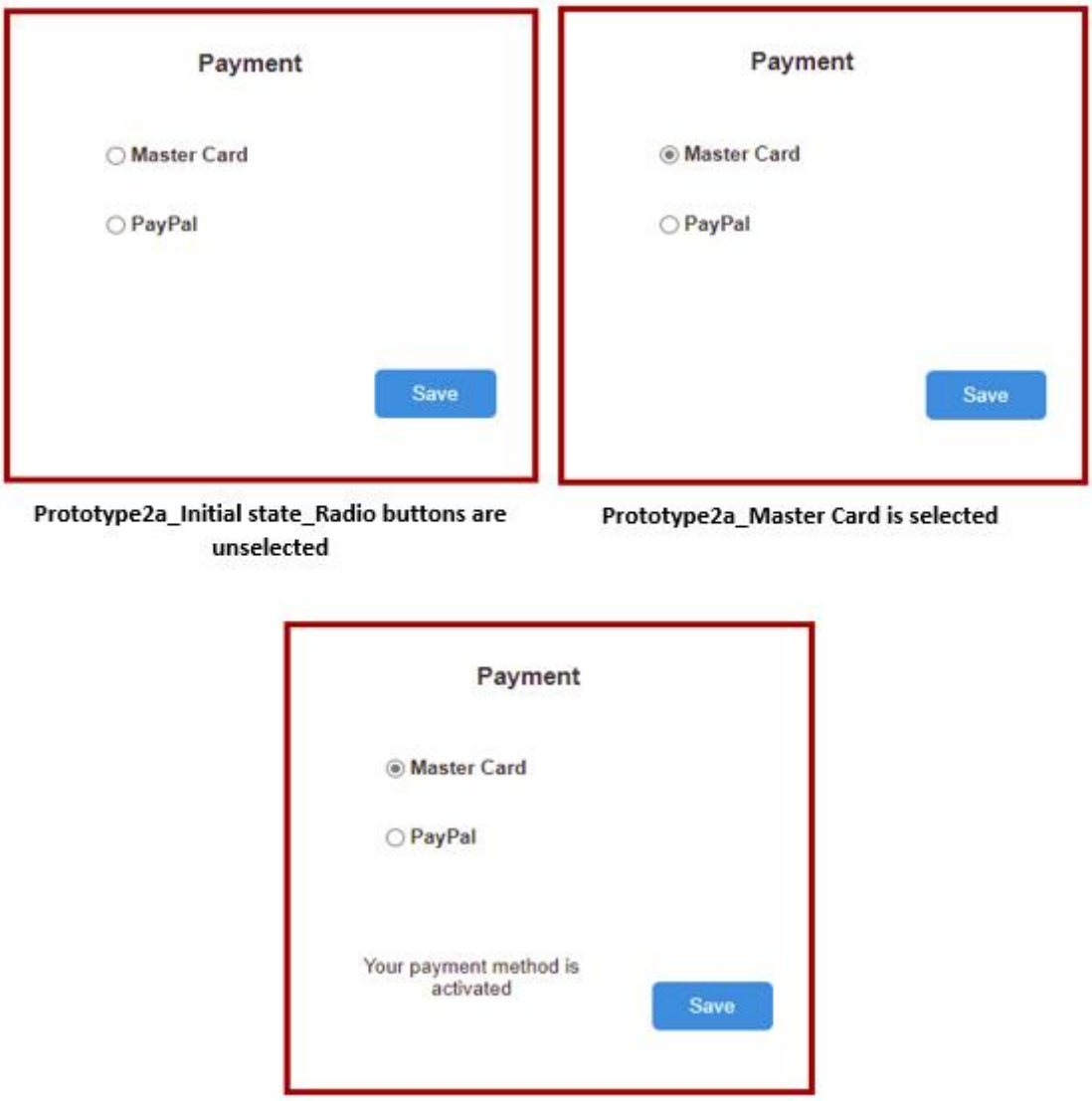
Figure 3.5-2 Prototype1b_Case1

In addition to the task that was mentioned earlier (Please see the task description under variable section), and before interacting with each prototype, the participants were asked this question for both prototypes: **'Do you expect to see the result immediately after the toggle on this switch?'**

Case2

UI element for prototype2a is designed with two radio buttons, and the initial state for these UI elements is not selected. There is no immediate response, it is required to click on the save button to show the result. UI element in prototype2b is a toggle switch. The initial state for the toggle switch is pointed to Master card selection.

Prototype2a_Case2 is shown below:



Prototype2a_Initial state_Radio buttons are unselected

Prototype2a_Master Card is selected

Prototype2a_Master Card is selected - save button is clicked

Figure 3.5-3 Prototype2a_Case2

Prototype2b_Case2 is shown below:

Prototype2b_Initial state – Master Card is selected

Prototype2b_PayPal is selected

Figure 3.5-4 Prototype2b_Case2

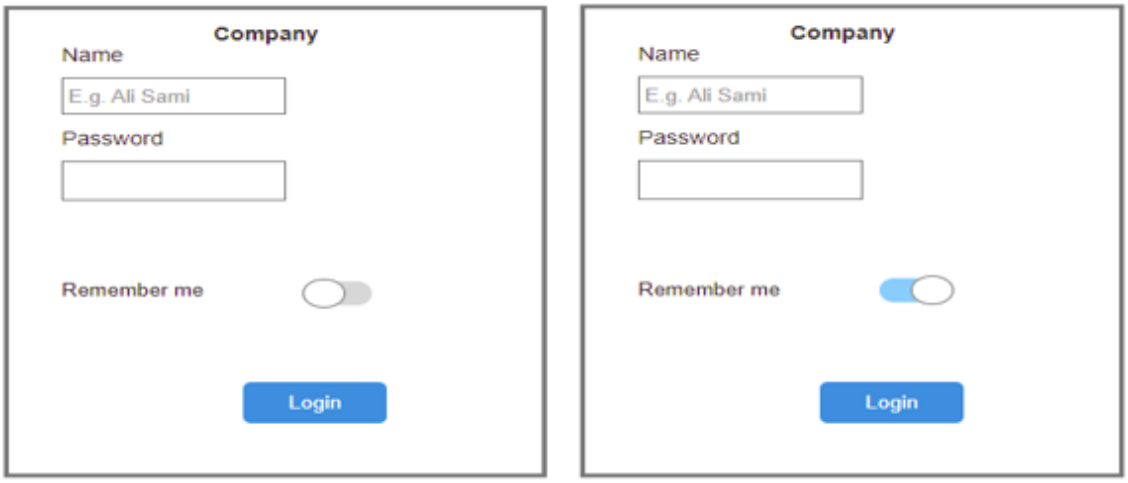
In addition to the task, in prototype2a the participants were asked: **'Do you expect to see the result immediately after choosing one option?'**

In prototype2b the participants were asked: **'What is your opinion about this UI toggle switch? Are you comfortable while using it?'**

Case3

In this case, there is a webform that contains a UI element. In prototype3a, the UI element is a toggle switch with blue color for on-state and grey color for off-state. The initial state for this UI element is off. UI element in prototype3b is a single checkbox with selected initial state.

Prototype3a_Case3 is shown below:

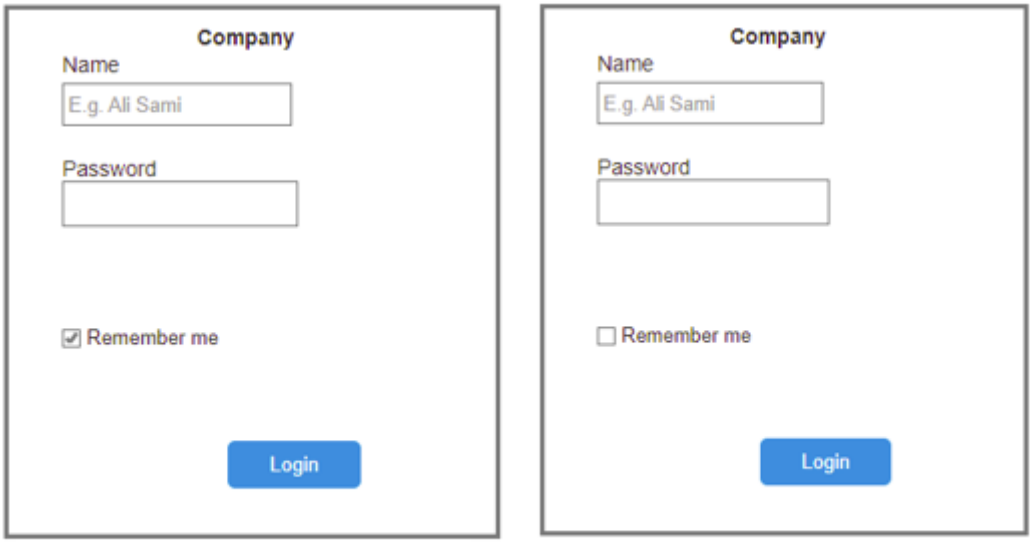


Prototype3a_Initial state_Toggle switch is off

Prototype3a_Toggle switch is on

Figure 3.5-5 Prototype3a_Case3

Prototype3b_Case3 is shown below:



Prototype3b_Initial state_Checkbox is selected

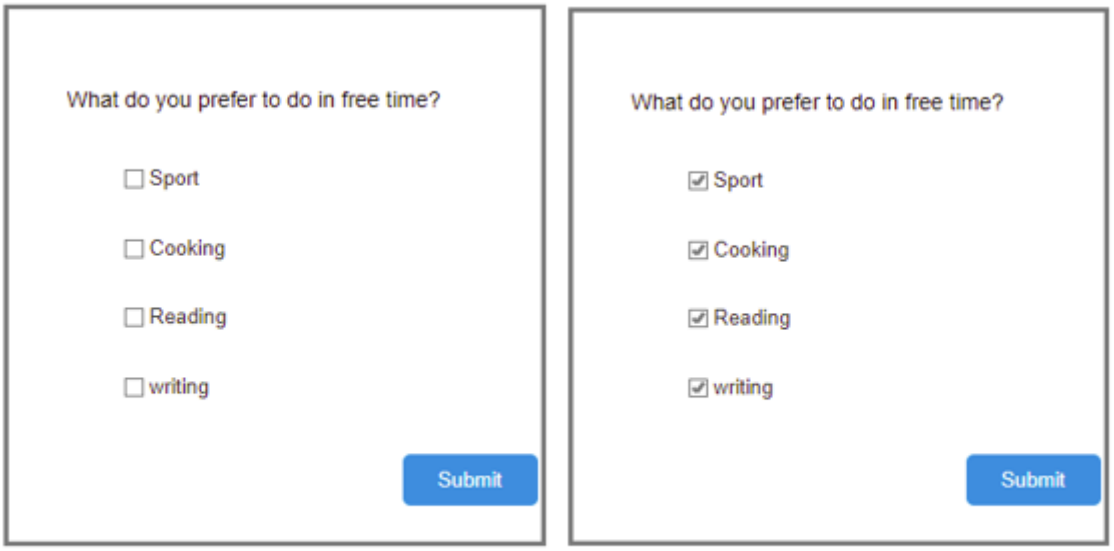
Prototype3b_Checkbox is unselected

Figure 3.5-6 Prototype3b_Case3

Case4

We can see from the figure below that there are several related choices to choose from. In prototype4a, these choices are designed with unselected checkboxes as an initial state. In prototype4b these options are toggle switches with green on-state and grey off-state. The initial state for these toggle switches is off.

Prototype4a_Case4 is shown below:

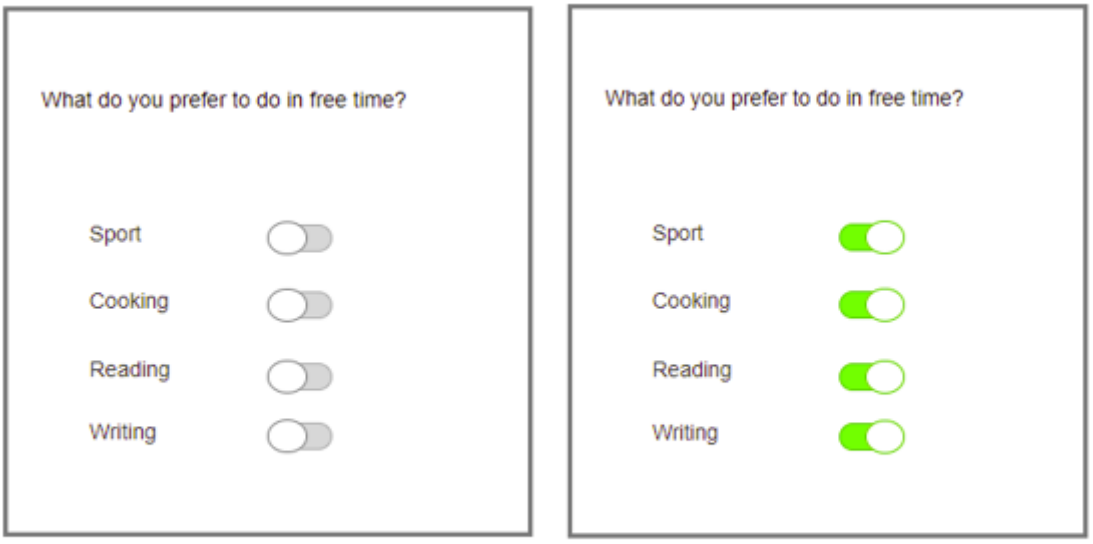


Prototype4a_Initial state – Checkboxes are unselected

Prototype4a_Checkboxes are selected

Figure 3.5-7 Prototype4a_Case4

Prototype4b_Case4 is shown below:



Prototype4b_Initial state_Toggle switches are off

Prototype4b_Toggle switches are on

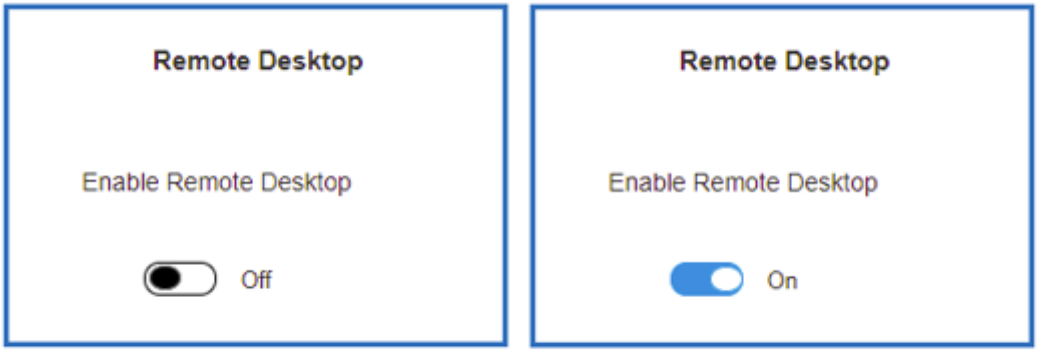
Figure 3.5-8 Prototype4b_Case4

Case5

In prototype5a, I used Microsoft's design to represent the toggle switch. There is only one state label that represents the current state of the toggle switch. This state label is changing

with the current state of the toggle switch. In prototype5b, I provided two (on, off) state labels, we can see both prototypes below:

Prototype5a_Case5 is shown below:



Prototype5a_Initial state – Toggle switch is off

Prototype5a_Toggle switch is on

Figure 3.5-9 Prototype5a_Case5

Prototype5b_Case5 is shown below:

Prototype5b_Initial state_Toggle switch is off

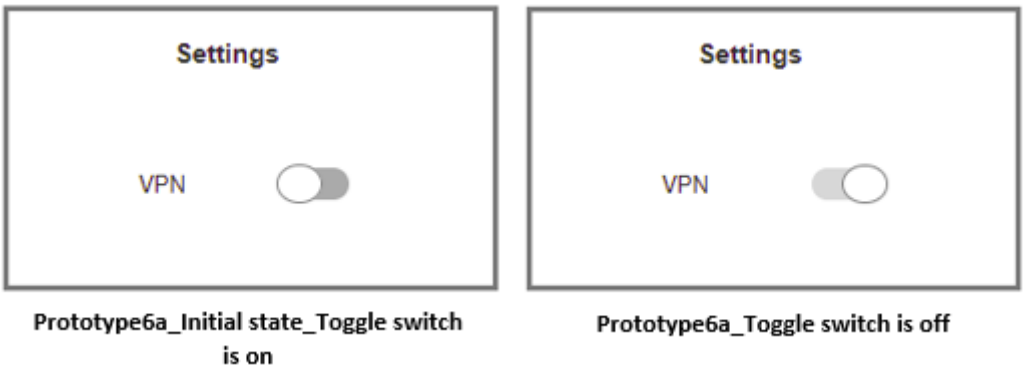
Prototype5b_Toggle switch is on

Figure 3.5-10 Prototype5b_Case5

Case6

In prototype6a, I changed the direction of on-state of the toggle switch to the left, and the color for on-state is dark grey. There is no color to indicate the on state, and the off-state is light grey. In prototype6b, the toggle switch is the same as prototype6a but with two state-labels to indicate the (on, off) state.

Prototype6a_Case6 is shown below:

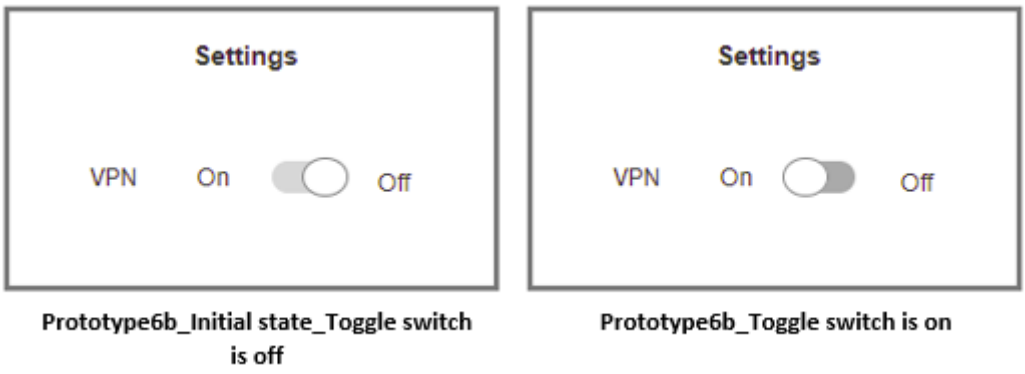


Prototype6a_Initial state_Toggle switch is on

Prototype6a_Toggle switch is off

Figure 3.5-11 Prototype6a_Case6

Prototype6b_Case6 is shown below:



Prototype6b_Initial state_Toggle switch is off

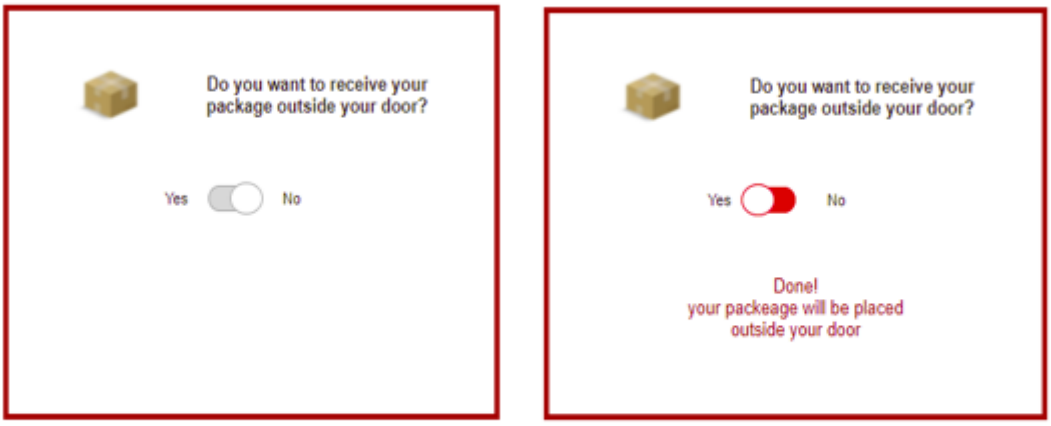
Prototype6b_Toggle switch is on

Figure 3.5-12 Prototype6b_Case6

Case7

It is clear from the figure below that the UI element in prototype7a is a toggle switch. The toggle switch is provided with (yes, no) instead of (1,0) as a state label. The color for on-state is red and the direction for it is to the left. The color for off-state is grey. The UI element in prototype7b is a single checkbox with a save button.

Prototype7a_Case7 is shown below:

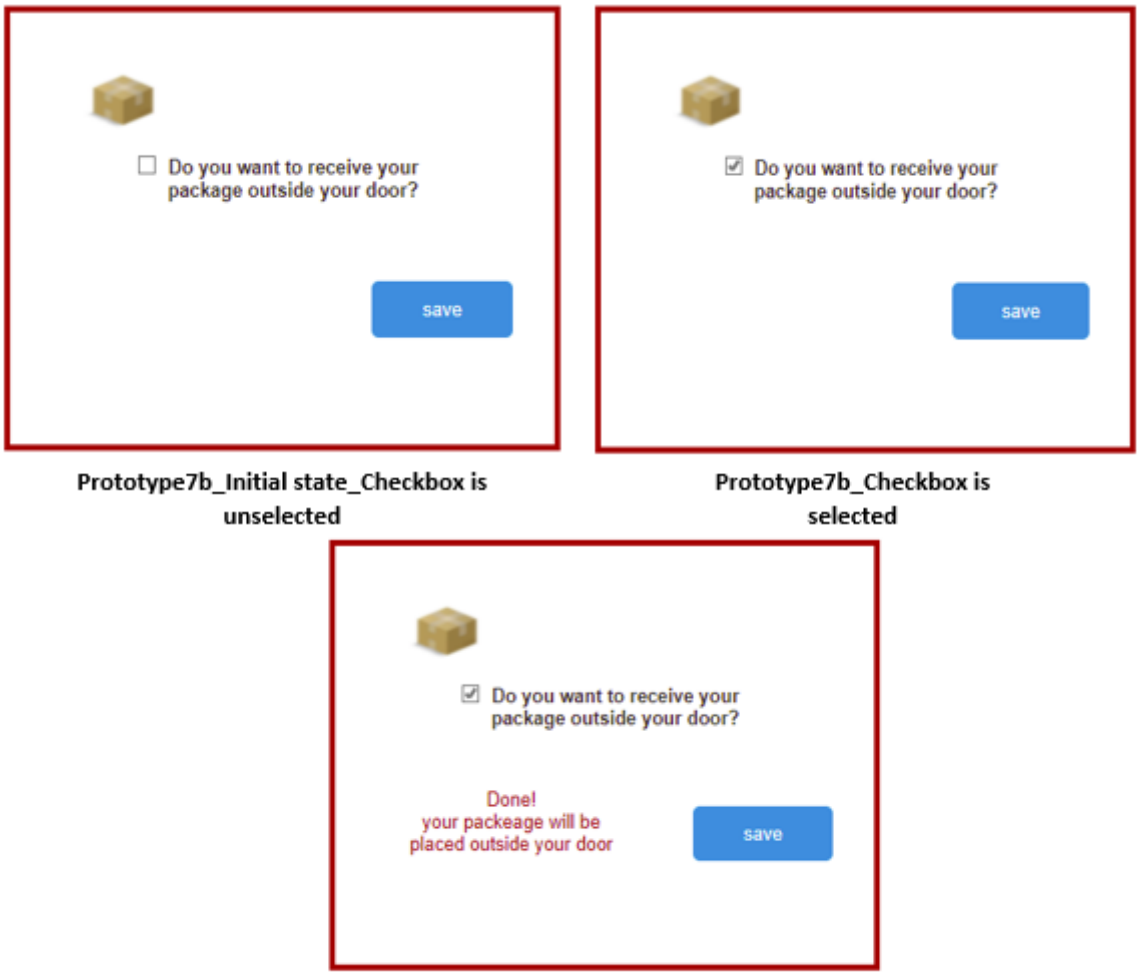


Prototype7a_Initial state_Toggle switch is off

Prototype7a_Toggle switch is on

Figure 3.5-13 Prototype7a_Case7

Prototype7b_Case7 is shown below:



Prototype7b_Initial state_Checkbox is unselected

Prototype7b_Checkbox is selected

Prototype7b_Checkbox is selected_Save button is clicked

Figure 3.5-14 Prototype7b_Case7

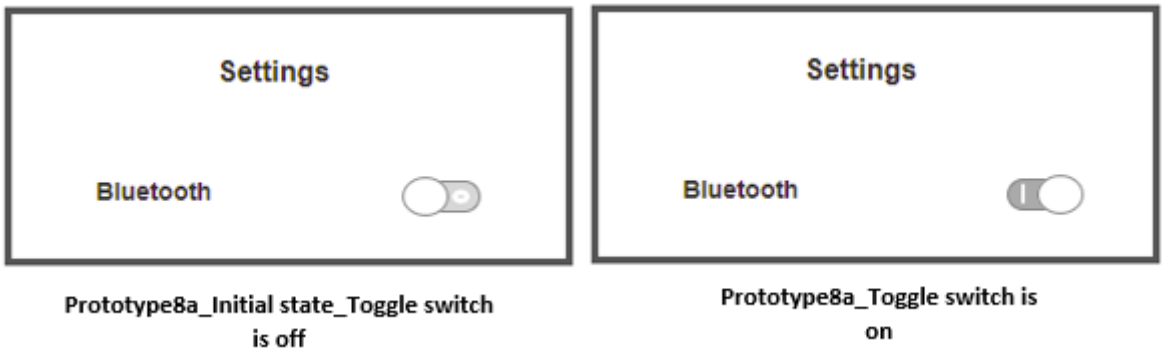
In prototype7a, the participants were asked these two questions:

- **‘Are you comfortable with (Yes, No) labels instead of (On, Off) labels?’**
- **‘Are you comfortable with the red color for the on-state of the toggle switch?’**

Case8

Again, I did not use any color to indicate the on-state, but I kept its direction to the right. I used these (1, 0) in prototype8a which represent on, and off respectively. In prototype8b, I used both (on, off) labels.

Prototype8a_Case8 is shown below:

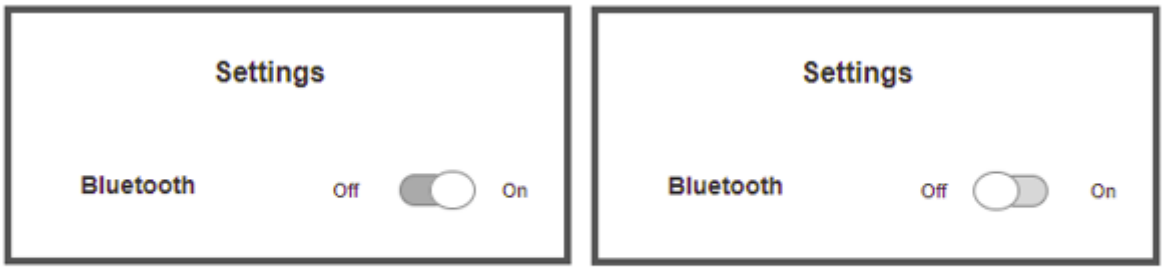


Prototype8a_Initial state_Toggle switch is off

Prototype8a_Toggle switch is on

Figure 3.5-15 Prototype8a_Case8

Prototype8b_Case8 is shown below:



Prototype8b_Initial state_Toggle switch is on

Prototype8b_Toggle switch is off

Figure 3.5-16 Prototype8b_Case8

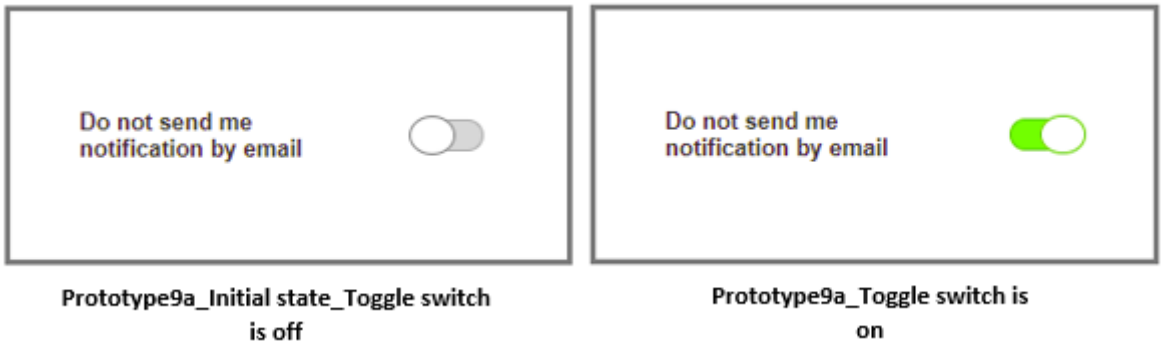
In prototype8a, the participants were asked: **‘Are you comfortable with (1, 0) labels instead of (on, off) labels?’**

Case9

Prototype9a is designed with a single toggle switch. The color for on-state is green and it is in the right direction. The color for off-state is grey. A long sentence with a negative word was used to describe the action for the toggle switch as a toggle label. The design is the same in

prototype9b with a short and clear toggle label.

Prototype9a_Case9 is shown below:

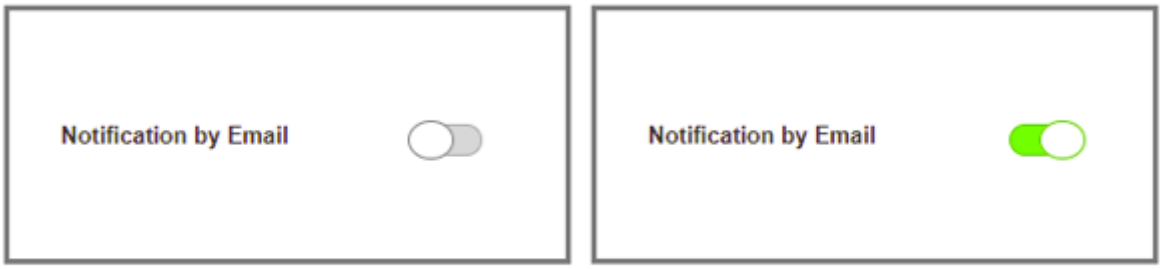


Prototype9a_Initial state_Toggle switch is off

Prototype9a_Toggle switch is on

Figure 3.5-17 Prototype9a_Case9

Prototype9b_Case9 is shown below:



Prototype9b_Initial state – Toggle switch is off

Prototype9b_Toggle switch is on

Figure 3.5-18 Prototype9b_Case9

In addition to the main task, I asked the participants to enable notification by email for both prototypes to see if they are able to understand the toggle label immediately.

3.6 Subjective opinions Likert-type scale questionnaire

As I mentioned before, when the test was completed with each participant, a Likert-type scale questionnaire was conducted. It consisted of thirteen questions and ranging from 1 – 5 (1= Strongly Disagree, 2= Disagree, 3= Neutral, 4= Agree, 5= Strongly Agree).

We can see below the thirteen questions of the questionnaire:

Q1: UI Toggle switches must have an immediate response and there is no need for confirming button.

Q2: It is important to provide two state labels (on, off) for the UI toggle switches.

Q3: It is important to provide state labels (1,0) to indicate the current state of the UI toggle

switches.

Q4: The position for on-state of the UI toggle switches should always be on the right side.

Q5: The color of the on-state of the UI toggle switches should always be green.

Q6: The color of the on-state of the UI toggle switches should always be blue.

Q7: Avoid using red color to indicate the on-state of the UI toggle switches.

Q8: The color of the off-state of the UI toggle switches should always be grey.

Q9: The color of the on-state of the UI toggle switches should follow the color of the theme of the application.

Q10: It is important to provide short, clear, and concise toggle labels which describe the action of the UI toggle switches.

Q11: Use checkboxes or radio buttons instead of toggle switches when the answer is Yes/No and not on/off.

Q12: Use checkboxes instead of toggle switches when there are several related choices to choose from.

Q13: That the initial state of the UI elements should always be off or unselected.

3.7 Qualitative and quantitative data

When all tests with all participants were completed, quantitative and qualitative data were collected and analysed.

Quantitative data represents Success rate (please see section Variables). Qualitative data represents subjective preference (please see section Variables), and subjective opinions Likert-type scale questionnaire rating from 1 to 5 (1= Strongly Disagree, 2= Disagree, 3= Neutral, 4= Agree, 5= Strongly Agree).

Test for Normal distribution

It is very important to test whether the data collected are normally distributed or not to choose the appropriate data analysis method. There are two main methods for normality test: Graphical procedures, and statistical assessment of normal distribution (Mayers, 2013).

There are several methods under statistical assessment of normal distribution, the most

common method is **Kolmogorov–Smirnov (KS) and Shapiro–Wilk (SW) tests.** These two methods can be implemented through SPSS (Mayers, 2013).

The KS test, according to popular opinion, should be used in samples larger than 50, whereas the SW test is preferable for samples less than that (Mayers, 2013).

I used KS/SW tests across single variables to test whether the data collected for success rate are normally distributed or not.

The results showed that the data collected for success rate are not normally distributed (Please see the result of tests of normality under Appendix D)

3.8 Wilcoxon signed-rank test

The Wilcoxon signed-rank test was used to measure the significant difference between two conditions (two prototypes).

The Wilcoxon signed-rank test compares two conditions of a single independent variable to see whether there are any changes in scores of a non-parametric dependent variable. This test is the non-parametric equivalent of the related t-test, and all participants experienced all conditions (Mayers, 2013).

4 Results and analysis

Once the experiment was completed successfully with twenty participants, data were collected and analysed.

Initially, all raw data were handled in word files, which were subsequently analyzed using a statistical program IBM SPSS Statistics 27. (Please see Appendix B for participants' responses)

The data collected for **success rate** was analysed by Wilcoxon Signed Ranks Test using IBM SPSS, while the data collected regarding **subjective preference** was analysed by descriptive statistics frequency using IBM SPSS. Finally, results for subjective opinions Likert-type scale questionnaire were analysed by descriptive statistics using IBM SPSS.

Below we can see the results for each case in detail.

4.1 Case1

The results for success rate for both prototypes are listed below:

- 90% for prototype1a
- 100% for prototype1b

As I mentioned before, data collected for success rate was analysed by Wilcoxon Signed Ranks Test using IBM SPSS. A Wilcoxon signed-rank test showed that there is no significant difference to know the initial state of the UI toggle switch between prototype1a and prototype1b: W = .00; Z = -1.414; P = .157; effect size (r = .316). (Please see Wilcoxon signed-rank test tables for more details from Appendix E).

In addition to the task, the participants were asked to answer this question for both prototypes as I mentioned earlier in the method section:

'Do you expect to see the result immediately after the toggle on this switch?'

The results showed that **85%** of the Participants' responses failed regarding prototype1a, they expected to see an immediate response, and this toggle switch was designed without an immediate response.

The same question was asked for prototype1b, and all the participants answered correctly.

The result for subjective preference variable is shown below:

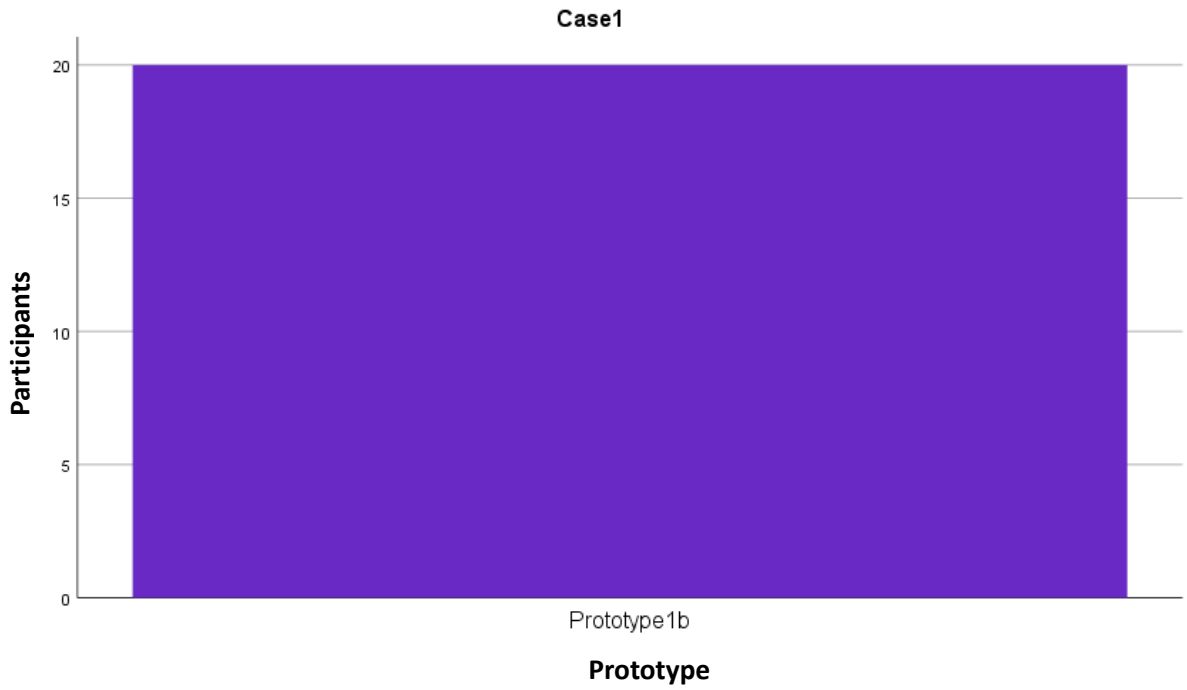


Figure 4.1-1 Subjective preferences graph_Case1

All participants chose prototype1b because they prefer to see the result immediately without the need to click any further button.

4.2 Case2

The results for Success rates for prototype2a and prototype2b are shown below:

- 100% for prototype2a
- 90% for prototype2b

A Wilcoxon signed-rank test showed that there is no significant difference to know the initial state of UI element between prototype2a and prototype2b: W = .00; Z = -1.414; P = .157; effect size (r = .316). (Please see Wilcoxon signed-rank test tables for more details from Appendix E).

In prootype2a, the participants were asked if they expect to see the result immediately. As we saw in the method part these UI elements were radio buttons. 80% of them answered that they do not expect to see any result immediately after choosing one radio button option.

In prototype2b, the participants were asked this question: **'What is your opinion about this toggle switch UI? Are you comfortable while using it?'**

85% of the participants answered that they are not comfortable while using the toggle switch in this scenario. Some of them mentioned that they do not feel safe to see one option is selected by default with payment case.

Regarding subjective preference variable, nineteen out of twenty participants chose prototype2a and only one chose prototype2b as shown in the graph below:

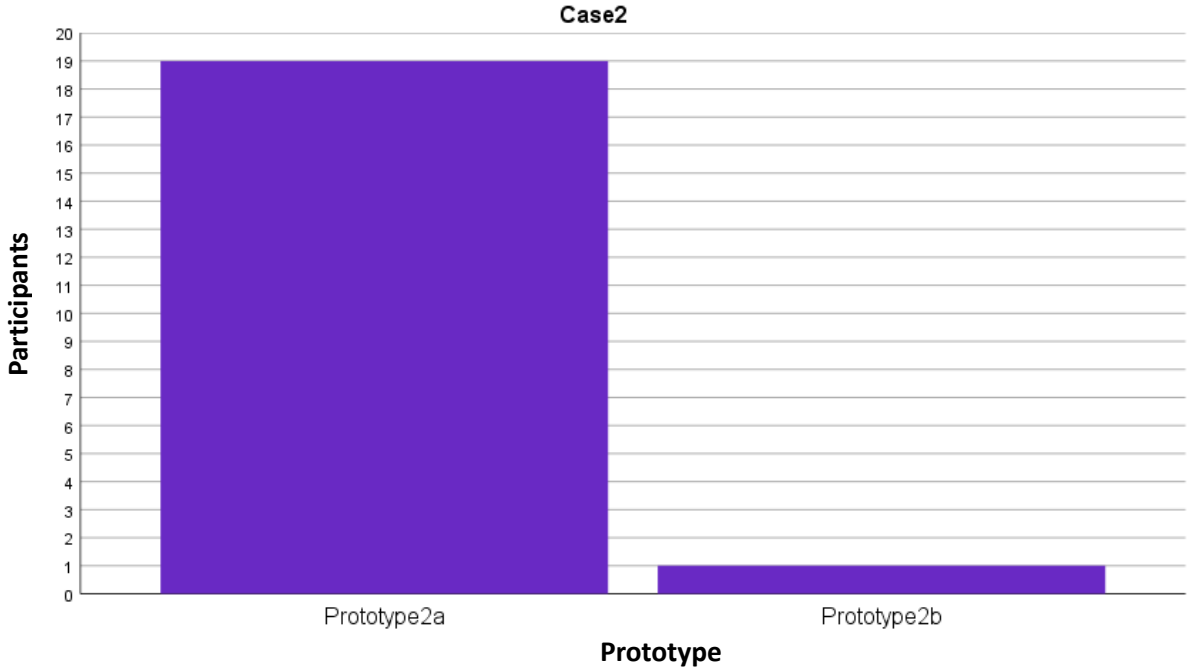


Figure 4.2-1 Subjective preferences graph_Case2

The participants are not familiar and not comfortable with this type of toggle switch in prototype2b. They do not want to see one option is selected by default.

4.3 Case3

The results for success rates are listed below:

- 95% for prototype3a
- 100% for prototype3b

A Wilcoxon signed-rank test showed that there is no significant difference to know the initial state of UI element between prototype3a and prototype3b: W = .00; Z = -1.000; P = .317; effect size (r = .223). (Please see Wilcoxon signed-rank test tables for more details from Appendix E).

Regarding subjective preference variable, sixteen out of twenty participants chose prototype3b, while only four chose prototype3a as shown below:

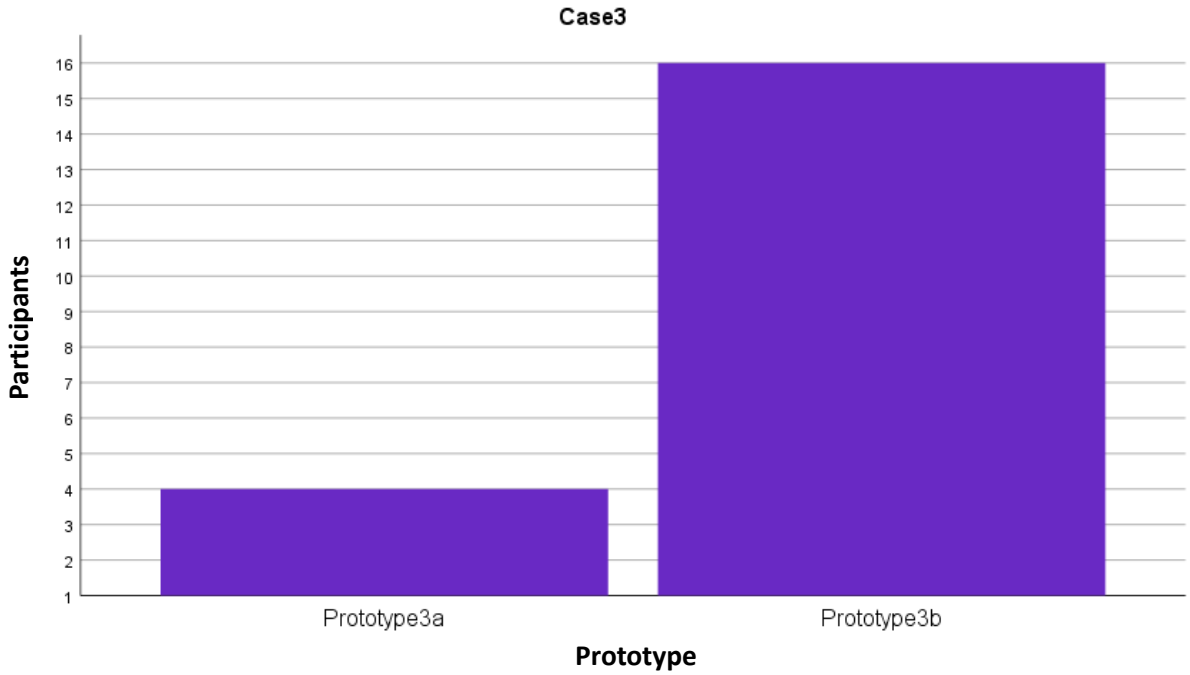


Figure 4.3-1 Subjective preferences graph_Case3

Most of the participants said that they are more familiar to have a checkbox in this scenario, but many of them mentioned that they do not like to see selected UI elements as an initial state.

4.4 Case4

The results for success rates are listed below:

- 100% for prototype4a
- 95% for prototype4b

A Wilcoxon signed-rank test showed that there is no significant difference to know the initial state of UI element between prototype4a and prototype4b: W = .00; Z = -1.000; P = .317; effect size (r = .223). (Please see Wilcoxon signed-rank test tables for more details from Appendix E).

In terms of subjective preference variable, we can see the result as below:

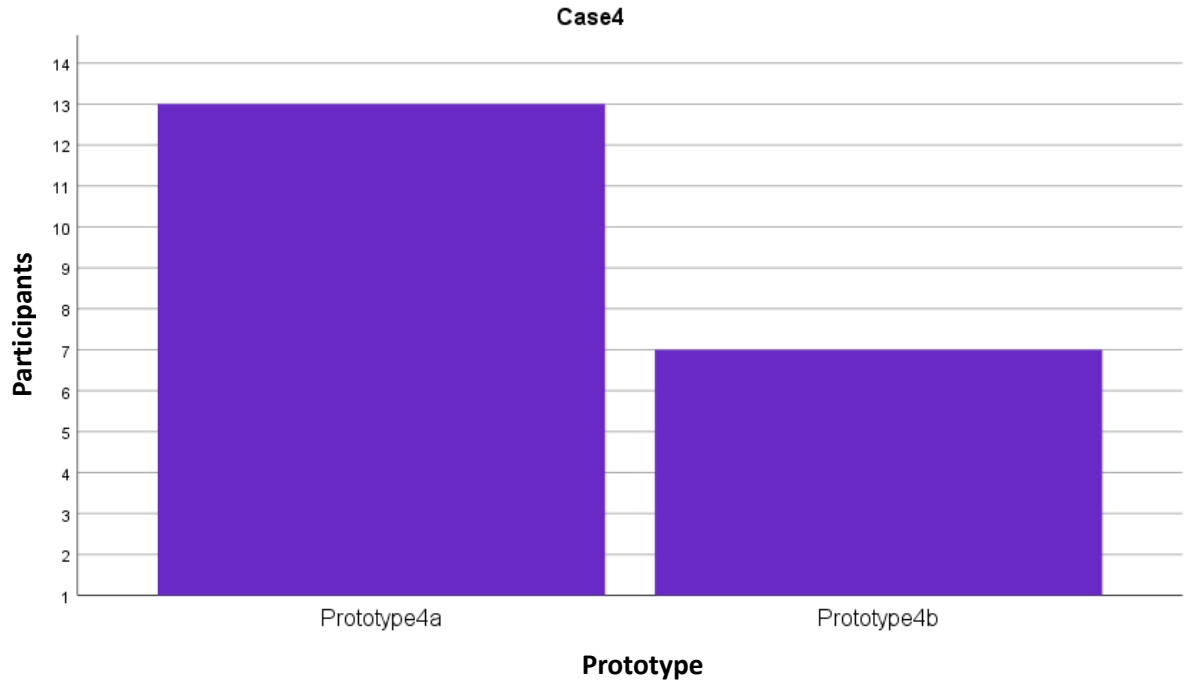


Figure 4.4-1 Subjective preferences graph_Case4

Thirteen out of twenty participants chose prototype4a. They were more familiar with checkboxes when there are several related choices to choose from. Some of them explained that it is better to review their choices before submitting.

The rest chose prototype4b, they said that it was easy to use toggle switches with these choices, and toggle switches are more attractive.

4.5 Case5

The results for success rates are shown below:

- 65% for prototype5a
- 100% for prototype5b

A Wilcoxon signed-rank test showed that there is a significant difference to know the initial state of UI element between prototype5a and prototype5b: W = .00; Z = -2.646; P = .008; with a strong effect size (r = .591). Therefore, Prototype 5b fostered a significantly more correct state of the UI interpretations from the participants. (Please see Wilcoxon signed-rank test tables for more details from Appendix E).

The graph below shows the result for the subjective preference variable:

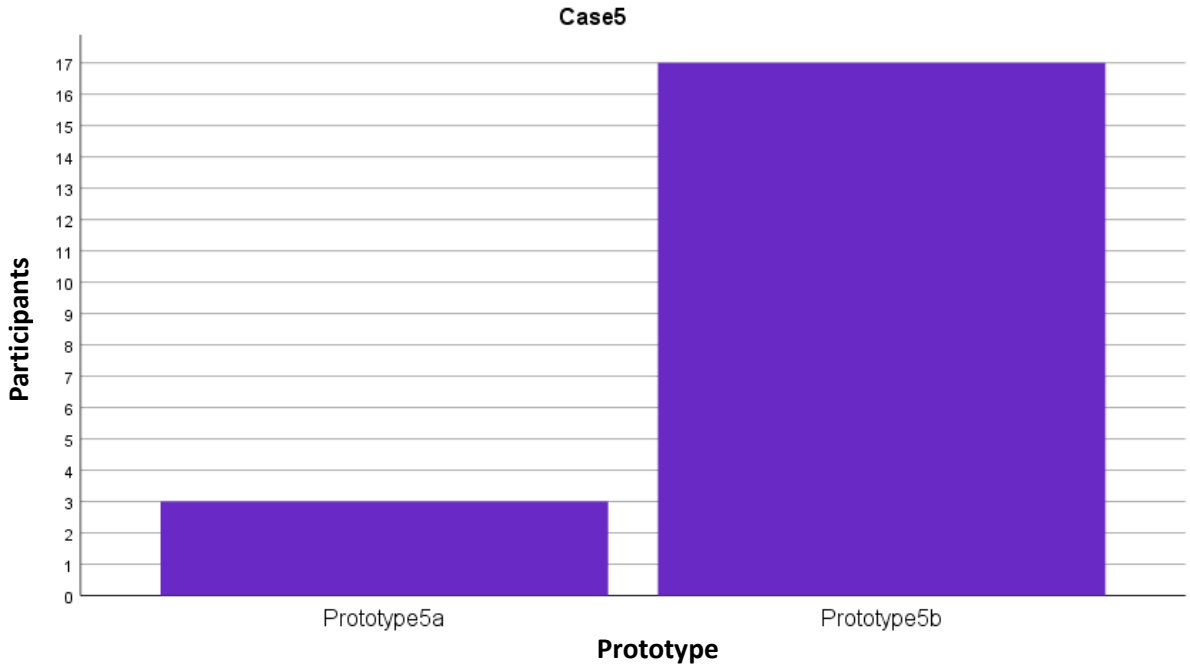


Figure 4.5-1 Subjective preferences graph_Case5

It is clear from the graph above most of the participants preferred prototype5b, and only three out of twenty chose prototype5a.

The participants who chose prototype5b explained that the toggle switch in this prototype is more understandable and informative with two state labels that indicate "on" and "off" status. Some of them felt confused with prototype5a. Few of the participants preferred prototype5a because they want to see only one state label that represents the current state.

4.6 Case6

The results for success rates are shown below:

- 10% for prototype6a
- 95% for prototype6b

A Wilcoxon signed-rank test showed that there is a significant difference to know the initial state of UI element between prototype6a and prototype6b: W = .00; Z = -4.123; P = .000; with a strong effect size (r = .921). As a result, Prototype6b significantly enabled participants to make considerably more accurate UI predictions. (Please see Wilcoxon signed-rank test tables for more details from Appendix E).

Below, we can see the graph that shows the result for the subjective preference variable:

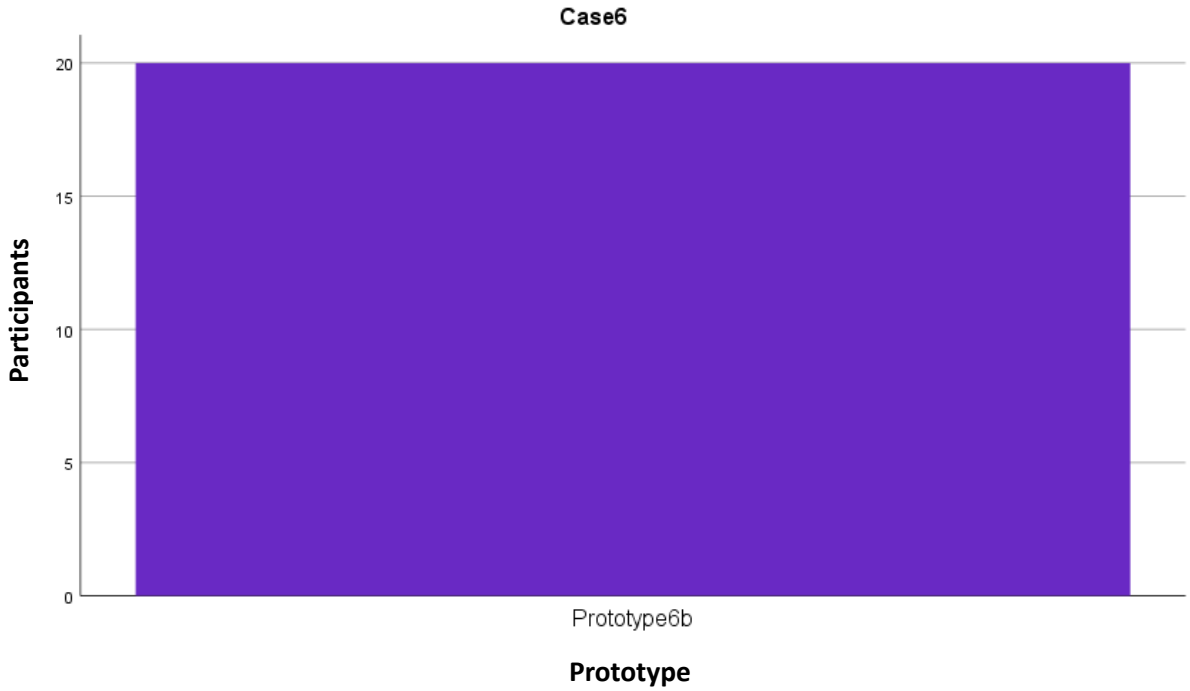


Figure 4.6-1 Subjective preferences graph_Case6

It is obvious that all the participants preferred prototype6b. It was difficult to predict the initial state for the toggle switch in prototype6a because the on-state color was grey, and the position for on-state was not to the right direction. They preferred prototype6b because the toggle switch was provided with state labels which make it easy to know the initial state immediately.

4.7 Case7

Success rates for both prototypes are shown below:

- 65% for prototype7a
- 100% for prototype7b

A Wilcoxon signed-rank test showed that there is a significant difference to know the initial state of UI element between prototype7a and prototype7b: W = .00; Z = -2.646; P = .008; with a strong effect size (r = .591). Therefore, Prototype7b allowed participants significantly to make far more precise UI predictions. (Please see Wilcoxon signed-rank test tables for more details from Appendix E).

Regarding prototype7a, the participants were asked these two questions in addition to the task:

- **'Are you comfortable with (Yes, No) labels instead of (On, Off) labels?'**
- **'Are you comfortable with the red color for the on-state of the toggle switch?'**

For the first question, 55% of the participant answered that they are not familiar and not comfortable to see toggle switch with (Yes, No) instead of (on, off).

For the second question, 85% of the participants answered that they are not comfortable seeing on-state with red color because red color refers to danger or stop sign.

The result for subjective preference variable is shown in the graph below:

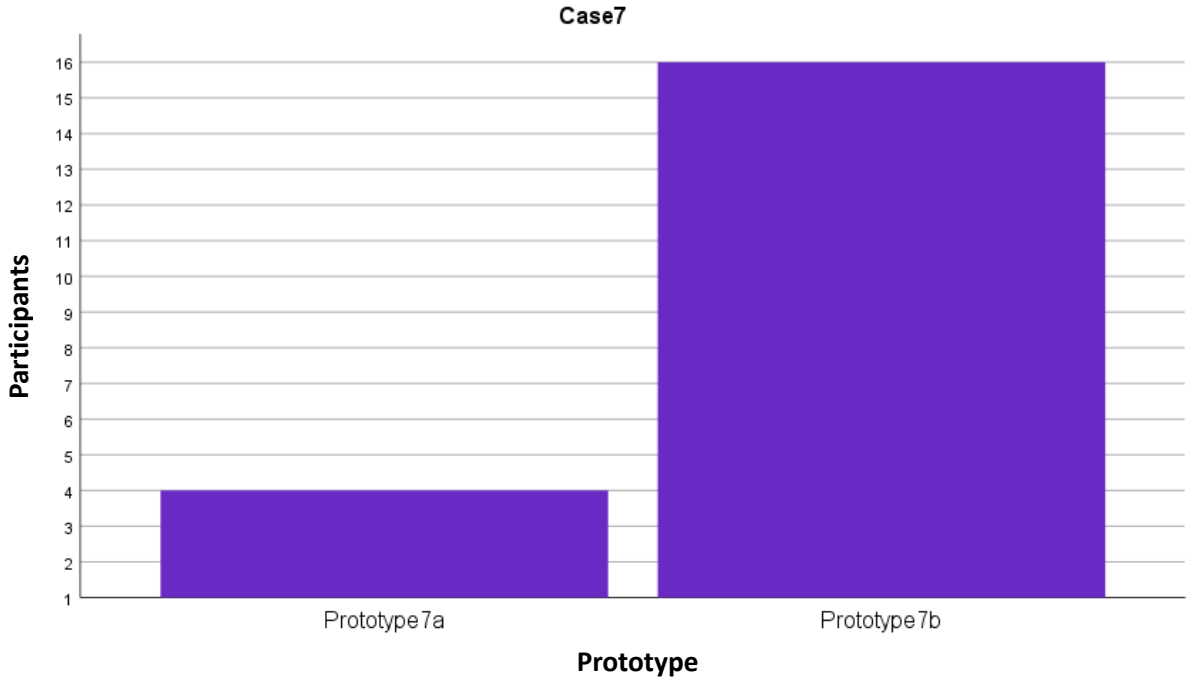


Figure 4.7-1 Subjective preferences graph_Case7

Sixteen out of twenty participants chose prototype7b, the reasons for their choices were diverse. Some of them mentioned that checkboxes suit better than toggle switches with a question when the answer is (yes, no). The other said that they do not feel safe to have an immediate response in this scenario. Some of the participants are not familiar to have (yes, no) labels with toggle switches and this made them confused. Only four participants chose prototype7a because they felt it is more intuitive with the toggle switch and more understandable as compared with the checkbox in this scenario.

4.8 Case8

Success rate results are shown below:

- 75% for prototype8a
- 100% for prototype8b

A Wilcoxon signed-rank test showed that there is a significant difference to know the initial state of UI element between prototype8a and prototype8b: W = .00; Z = -2.236; P = .025; effect

size (r = .499). As a result, participants were able to generate significantly more exact UI predictions using Prototype8b. (Please see Wilcoxon signed-rank test tables for more details from Appendix E).

As I mentioned in the method part, prototype8a was provided with (1,0) labels instead of (on, off), and this feature is provided with iOS for accessibilities features. In this prototype8a, the participants were asked: **'Are you comfortable with (1, 0) labels instead of (on, off) labels?'**

60% of the participants answered that they are comfortable but not familiar, only one participant uses this feature on her mobile phone. Some of them said it is more useful to use (1,0) labels instead of (on, off) labels in the mobile applications. The rest mentioned that they are not comfortable while seeing (1,0) labels.

The result for subjective preference variable is shown in the graph below:

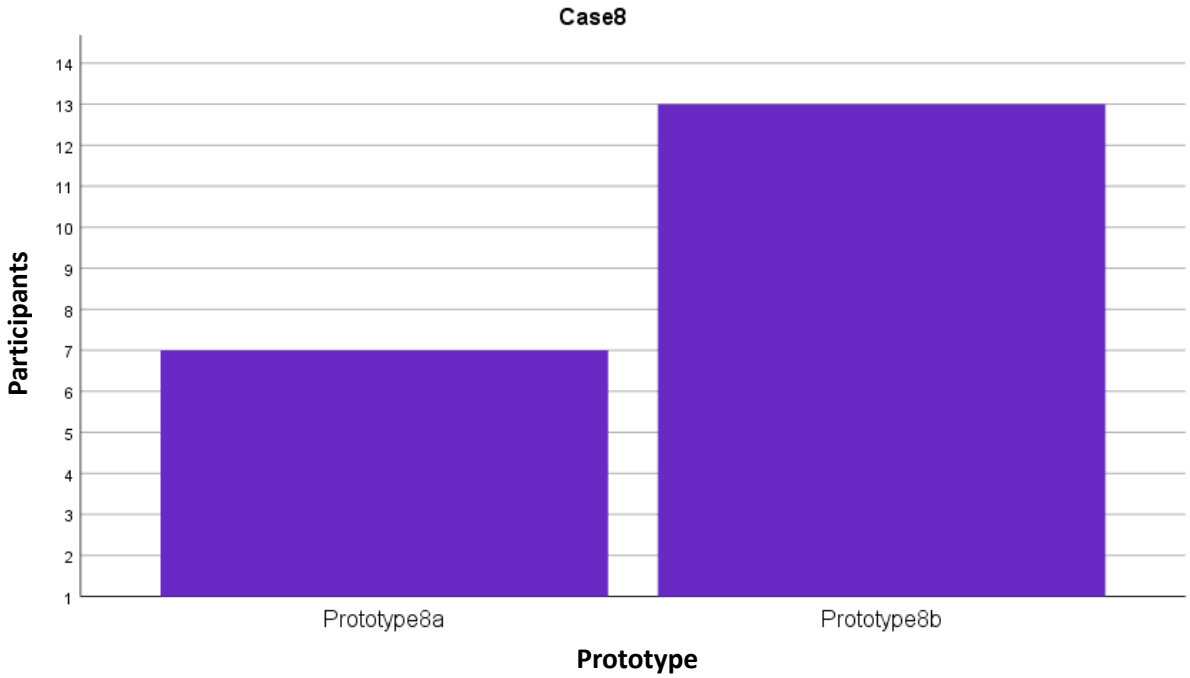


Figure 4.8-1 Subjective preferences graph_Case8

Thirteen out of twenty participants preferred prototype8b because they feel the toggle switch in this prototype is easier and more understandable because of (on, off) labels, and they are not familiar with the (0, 1) labels.

The rest who preferred prototype8a mentioned that using (0, 1) labels reduces the noise in smart devices' display.

4.9 Case9

For the last case, the results for success rate are shown below:

- 95% for prototype9a
- 100% for prototype9b

A Wilcoxon signed-rank test showed that there is no significant difference to know the initial state of UI element between prototype9a and prototype9b: W = .00; Z = -1.000; P = .317; effect size (r = .223). (Please see Wilcoxon signed-rank test tables for more details from Appendix E).

In addition to the task, the participants were asked to enable the notification by email for both prototypes as it was described in the method part.

All participants, except two, failed to enable the notification in the first prototype while all of them succeed in the second prototype.

And finally, the result for the subjective preference variable is shown in the graph below:

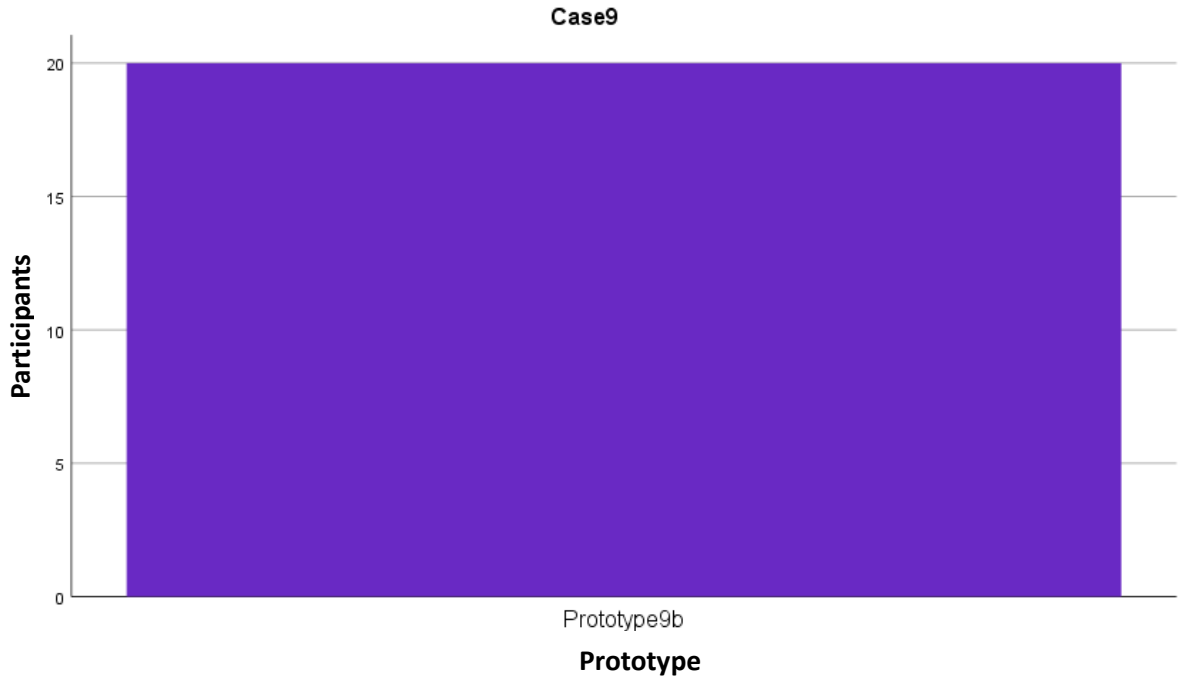


Figure 4.9-1 Subjective preferences graph_Case9

All the participants preferred prototype9b because the toggle label that describes the action is short and clear. Some of them do not like to see negative words in the toggle label.

4.10 Subjective opinions Likert-type scale questionnaire

As I mentioned in the method part, subjective opinions Likert-type scale questionnaire ranging from 1 to 5 (1= Strongly Disagree, 2= Disagree, 3= Neutral, 4= Agree, 5= Strongly Agree), was

conducted at the end of the experiment. It consisted of 13 questions. (Please see participants' responses tables from Appendix C)

The data collected from this questionnaire was analysed with Descriptive Statistics by IBM SPSS Statistics. The results are shown below:

Descriptive Statistics					
Questions	**N**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Q1: UI Toggle switches must have an immediate response and there is no need for confirming button.	20	4	5	4.70	.470
Q2: It is important to provide two state labels (on, off) for the UI toggle switches.	20	1	5	3.90	1.119
Q3: It is important to provide state labels (1,0) to indicate the current state of the UI toggle switches.	20	1	5	2.75	1.293
Q4: The position for on-state of the UI toggle switches should always be on the right side.	20	1	5	4.20	1.196
Q5: The color of the on-state of the UI toggle switches should always be green.	20	1	5	4.05	1.191

Q6: The color of the on-state of the UI toggle switches should always be blue.	20	1	5	3.10	1.119
Q7: Avoid using red color to indicate the on-state of the UI toggle switches.	20	1	5	4.15	1.348
Q8: The color of the off-state of the UI toggle switches should always be grey.	20	1	5	3.80	1.322
Q9: The color of the on-state of the UI toggle switches should follow the color of the theme of the application.	20	1	5	2.80	1.399
Q10: It is important to provide short, clear, and concise toggle labels which describe the action of the UI toggle switches.	20	4	5	4.95	.224
Q11: Use checkboxes or radio buttons instead of toggle switches when the answer is Yes/No and not on/off.	20	1	5	4.10	1.210
Q12: Use checkboxes instead of toggle switches when there are several related choices to choose from.	20	2	5	3.70	1.174

Q13: That the initial state of the UI elements should always be off or unselected.	20	3	5	4.60	.754
Valid N (listwise)	20				

Table 4.10-1 Descriptive Statistics of Likert-type scale questionnaire

In **question1**, as shown in the table above, the mean is equal to 4.70 which means the majority of the participants strongly agree to provide an immediate response with the UI toggle switch. Low Std. Deviation = .470 shows the data is consistent and is clustered closely around the mean.

Regarding the **question2**, the mean is 3.90 which indicates that most participants agree to provide two state labels (on, off) to indicate the current state of the UI toggle switches. We can see that Std. Deviation= 1.119 which is low, and it indicates that the data is consistent and clustered closely around the mean.

The mean in **question3** is 2.75 which means that most of the participants reported neutrality by providing state labels (1,0) to indicate the current state of the UI toggle switches. The Std. Deviation is equal to 1.293, which means the data are consistent and more reliable.

For **question4**, the mean is equal to 4.20 and the std. Deviation is equal to 1.196 which is low. These values indicate that most participants strongly agree that the position for on-state of UI toggle switches should always be on the right side. The data collected are consistent.

In **question5**, the mean is equal to 4.05, and the std. Deviation is equal to 1.191. We concluded that most participants agree that the color of the on-state of UI toggle switches should always be green. The data are consistent and more reliable.

The mean in **question6** = 3.10, and std. Deviation= 1.119, we understand that most of the participants reported neutrality to have blue color for on-state of UI toggle switches.

In **question7,** the mean= 4.15, most of the participants agree to the fact that the red color is not suitable for on-state of UI toggle switches. The value of std. Deviation= 1.348 indicates that the data are consistent and clustered closely around the mean.

In **question8,** the mean= 3.80, which means most of the participants agree that the off-state color of UI toggle switches should be grey. The Low value of std. Deviation= 1.322 indicates

that the data are consistent and clustered closely around the mean.

Regarding **question9,** mean= 2.80, and that means most of the participants are neutral regarding the color of on-state UI toggle switches should match the color of the application. The Std. Deviation= 1.399, and that indicates the data are consistent.

In **question10,** mean = 4.95, which means most of the participants strongly agree to provide clear and concise toggle labels that describe the action of UI toggle switches. The Low value of Std. Deviation= .224 indicates that the data are consistent and clustered closely around the mean.

For **question11,** the mean= 4.10, which means most of the participants agree to use checkboxes or radio buttons instead of toggle switches when the answer is Yes/No and not on/off. The value of std. Deviation= 1.210 indicates that the data are consistent and clustered closely around the mean.

For **question12,** the mean= 3.70, which means that most of the participants agree to use checkboxes instead of toggle switches when there are several related choices to choose from. The value of std. Deviation= 1.174, which means the data are consistent and clustered closely around the mean.

Finally, the mean value for the **question13** is equal to 4.60, which means that most of the participants strongly agree that the initial state of the UI elements should always be off or unselected by default. The Low value of std. Deviation which is equal to .754 indicates that the data are consistent and clustered closely around the mean.

5 Discussion

In this chapter, I will discuss the findings that were concluded from the summary of the analysis result, compare these findings with the previous work. I will also discuss the limitation that I have faced during the project.

5.1 Summary of analysis result and comparison with previous work

As we saw in the result chapter that data collected during the experiment were analysed statistically by IBM SPSS 27 program. The experiment has been done with twenty participants who tested eighteen prototypes. Every two prototypes were compared together. These prototypes represent independent variables, and two dependent variables were measured:

- **Success rate**
- **Subjective preference**

hypotheses were set during the method chapter as below:

H0: There is no significant difference in terms of success rate between first and second prototype for each case.

H1: There is a significant difference in terms of success rate between first and second prototype for each case.

At the end of the test, a Likert-type scale questionnaire was conducted.

As I mentioned before, success rate represents the ability of the participant to know the initial state of the UI element before interacting with it.

The results for success rates showed that there is no significant difference between the two prototypes for the following cases: 1, 2, 3, 4, and 9. According to those results, H0 is accepted, and H1 is rejected. The participants found it easy to know the initial state of these UI elements.

On the other hand, the results for success rates showed that there is a significant difference between the two prototypes for these cases: 5, 6, 7, and 8. According to those results, H0 is rejected, and H1 is accepted.

Where to use UI toggle switch?

As we saw in the introduction chapter, there is a set of rules and guidelines that developers and designers should follow while designing UI elements.

I will discuss below the findings that I have found during the experiment and compare them with the previous work. These findings give us a clear brief of some guidelines of UI toggle switches.

Immediate response

In **case1**, the participants were asked to answer whether they expect to see an immediate result after the toggle on this switch. As we know prototype1a was designed without immediate response, while prototype1b was designed with immediate response. The result showed that 85% of the participants expected to see an immediate response with toggle switch UI in prototype1a.

The results showed that all the participants preferred prototype1b, so they are familiar and expected to see an immediate response with UI toggle switches. They do not expect to click on further button like next or submit. Microsoft guidelines supported these results. They mentioned that if the user must take further action for the modification to take effect, it is better to use a checkbox (Guidelines for toggle switch controls - Windows apps | Microsoft Docs, 2021).

The result for **question1** in the Likert-type scale questionnaire also supported the participants' preferences. It showed that most of the participants strongly agree with providing an immediate response with UI toggle switches.

While reviewing the literature review chapter, Immediate response was categorized by Joyce (Joyce, 2018) as one guideline for the UI toggle switch. She mentioned an example where the toggle switch was designed without immediate response, and this can lead to confusion.

Minhas compared between checkboxes and toggle switches in this article (Minhas, 2018)

She said that when an option or setting demands a quick response without the need for confirmation, such as save or submit, a toggle switch is preferable.

On the other hand, avoid using UI toggle switches that provide immediate response in payment situations. It is better to choose another UI elements like radio buttons or checkboxes instead.

In **case2**, the result showed that nineteen out of twenty participants preferred **prototype2a**. (Please see Figure 3.5-3 Prototype2a_Case2). They do not feel safe to have one option is selected

by default especially with payment issues as we saw in prototype2b, and they prefer to have a further step for confirmation, they are not comfortable with immediate response.

Standard Visual Design

To know the initial state of the UI toggle switch immediately and without any effort is an important issue. State labels, the color of the (on, off) state, and the position of on-state are important factors that can have a big impact on the ability of the user to predict the initial state easily and without any doubt.

In **case5**, 35% failed to know the initial state of the UI toggle switch for prototype5a. The toggle switch in this prototype was the same design as Microsoft Windows10. (Please see Figure 3.5-9 Prototype5a_Case5).

Some of the participants felt confused to see only one changeable state label which represents the current state of the toggle switch. They preferred to see two state labels (on, off) as shown in Figure *3.5-10* Prototype5b_Case5.

Providing two state labels (on, off) will reduce the confusion and will make it easy to predict the initial state immediately.

The results showed that the design should be **simple and intuitive use** which is one of the seven principles of universal design as I mentioned in the introduction chapter.

As we saw in the literature review, Joyce in this article (Joyce, 2018) mentioned that providing only one label which represents the current state of the toggle switch can confuse the user, and it can be taken for a toggle switch label.

Regarding the **case6**, 90% of the participants failed to know the initial state of the UI toggle switch in prototype6a (Please see Figure *3.5-11* Prototype6a_Case6). The color of the on-state of this element was designed with grey color and it was to the left position.

People with a color vision deficiency may not recognize the colors, it will be difficult for them to differentiate between (on, off) without labels. We cannot rely only on color to refer to on-state for the UI toggle switch.

The results above foster the necessity to achieve another 7 UD principle which is **perceptible information**. For the redundant representation of essential data, use multiple modalities (pictorial, verbal, tactile) (The 7 Principles | Centre for Excellence in Universal Design, u.d.).

The result from the Likert-type scale questionnaire indicates that most participants agree to provide state labels (on, off), but some of them mentioned that adding these labels may distort the appearance especially in mobile applications where there is not enough space.

As we saw in the introduction chapter, Apple's guidelines recommended avoiding using state labels for UI toggle switches. They provided optional features under accessibility which is called on/off Labels. This feature show (1, 0) as a state label for toggle switches (Switches - Controls - iOS - Human Interface Guidelines - Apple Developer, u.d.).

In **prototype8a** under **case8**, I used (1, 0) instead of (on, off) as state labels as shown in Figure *3.5-15* Prototype8a_Case8.

The results showed that 25% of the participants failed to know the initial state in the prototype mentioned above, they were not familiar and not comfortable with the (1, 0) state labels.

Most of the participants are not aware of it and did not use it before. They preferred to see (on, off) state labels instead of (1, 0). A few of the participants feel fine with (1, 0). In my opinion, I feel (1, 0) state labels are more suitable with mobile applications despite people are not familiar with and not comfortable with them. (1, 0) state labels can reduce the noise, especially with a small display.

Another important issue is the position of the on-state. People are familiar to see on-state to the right. Likert-type scale questionnaire indicates that most participants strongly agree that the position for on-state of UI toggle switches should always be in the right position.

Using (yes, no) instead (on, off) as state labels can confuse the user. In **prototype7a**, 35% failed to know the initial state of the UI toggle switch (Please see Figure 3.5-13 Prototype7a_Case7). This UI toggle switch was designed with (yes, no) instead of (on, off) as state labels.

Some of the participants were not familiar with (yes, no) state labels. Most of them preferred the other prototype which was designed with a single checkbox.

In the posten.no webpage, we can see the same design as prototype7a. The toggle switch was provided with (yes, no) instead of (on, off) state labels, and the direction of ''yes'' was to the left.

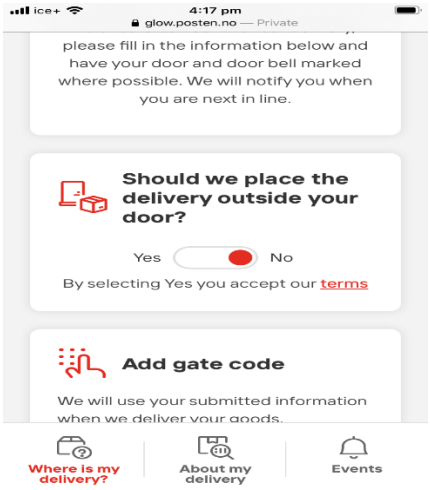


Figure 5.1-1 A screenshot from posten.no website which contains a toggle switch with (yes, no) state labels

Minhas mentioned that if there is doubt about the ''on'' and ''off'' state of a toggle switch, it is better to use checkboxes (Minhas, 2018).

As we saw in the result chapter for Likert-type scale questionnaire, most of the participants agree to use checkboxes or radio buttons instead of toggle switches when the answer is (Yes, No) and not (on, off). (Please see Table 4.10-1 Descriptive Statistics of Likert-type scale questionnaire).

In addition to that, the participants were not familiar to see the red color for the on-state of the toggle switch. The results showed that most of the participants agree to avoid using red color for on-state of UI toggle switches because it refers to danger or stops signs. (Please see Table 4.10-1 Descriptive Statistics of Likert-type scale questionnaire).

Joyce in this article (Joyce, 2018) mentioned that it is very important to take into consideration while designing UI toggle switches two things: contrast and cultural differences. She explained that the red color can be a sign of stop for some people.

Single option

Minhas in this article (Minhas, 2018) mentioned that it is better to use a single checkbox and not toggle switch when there is only one option that can be selected or deselected.

In **Case3**, there was a single option for both prototypes. it was a toggle switch in prototype3a, while it was a single checkbox in the other prototype as shown in Figure 3.5-5 Prototype3a_Case3 and Figure 3.5-6 Prototype3b_Case3.

The results showed that sixteen out of twenty participants preferred prototype3b. They mentioned that they are not familiar to see toggle switch on a webform.

Related choices

In **Case4**, UI element was checkboxes in prototype4a, and it was toggle switches in the other prototype as shown in Figure 3.5-7 Prototype4a_Case4 and Figure 3.5-8 Prototype4b_Case4. These UI elements represented several related choices to choose from.

Thirteen out of twenty participants preferred prototype4a. They were more comfortable seeing checkboxes with related options.

Minhas recommended in her article to use checkboxes where there are several related choices (Minhas, 2018). Also, Microsoft mentioned in their guidelines that when the user needs to pick several options that are related to a single same setting, choose checkboxes (Guidelines for toggle switch controls - Windows apps | Microsoft Docs, 2021).

Concise, Nonneutral Labels

The results showed that most of the participants strongly agree to provide clear and concise toggle labels which describe the action of the toggle switches UI.

As we saw in the result chapter for the case9, the participants were asked to enable notification by email for both prototypes. 90% of the participants failed to enable the notification in prototype9a. They were confused with the toggle label. They explained that they do not want to see negative words in the toggle label.

By reviewing the literature review chapter, we see that Joyce also said that toggle switch labeling should be simple, short, and direct (Joyce, 2018). Jacob also supported the result, he mentioned that it is important to use positive and active wording for example avoid using **"do not send me notification"** as a label for the UI element (Nielsen, Checkboxes vs. Radio Buttons, 2004).

Default value of the UI element

There is an important issue that developers and designers must take it into consideration while designing UI elements, the initial state of any UI elements should always be off or unselected by default.

The results from Likert-type scale questionnaire showed that most of participants strongly

agree that the initial state of the UI elements should always be off or unselected (Please see Table 4.10-1 Descriptive Statistics of Likert-type scale questionnaire)

The whole results showed that the design of UI elements should be **Equitable Use,** which is principle one of the 7 principles of the UD that makes sure the design is accessible to everyone (The 7 Principles | Centre for Excellence in Universal Design, u.d.).

5.2 Limitation of the study

There were some limitations to this study. I intended to include a more diverse user group. If the elderly and people with disabilities were included in this evaluation study, the findings could be more significant, but due to the COVID-19 pandemic situation, it was difficult to communicate and find a diverse groups of people.

The result would be more significant if there were more than twenty participants in this experiment.

It was also difficult to conduct the experiment physically during the pandemic. As I mentioned before, the experiment was done remotely through Microsoft teams and zoom.

There were no previous peer review papers regarding UI toggle switches, and that limited the scope of comparison with other studies, but we can consider lack of resources as a challenge that faced me during this project. This study may open the door for future work regarding UI toggle switches and other elements.

6 Conclusion

This evaluation study investigated whether the existing UI toggle switches that are found in webpages and mobile applications are accessible and usable.

In the beginning, it was difficult to find related papers that investigated UI toggle switches. This limitation took some time and effort to find and choose the best method to implement this evaluation study.

There were some helpful articles for people who made investigations about UI elements. The big limitation with their work was that they did not include participants in their study. As I mentioned earlier, include participants is a crucial thing while designing or developing any system or product. In addition to this limitation, there were not many articles regarding the visual design of UI toggle switches. They did not discuss whether the user finds it easy to know the initial state of the toggle switches. These elements are simple but if they are not following any standard design, this may confuse people. UI toggle switches became more popular in web and mobile applications. Non-standard UI toggle switches were found in the field of web design (Toggle Switch – Accessible UI Components List, 2016).

The study went through several stages:

- Explore the existing UI toggle switches and other elements like radio buttons, checkboxes.
- The problems with UI toggle switches were investigated using different literature.
- Those problems were generalized, and eighteen prototypes that represent different UI elements were designed. These prototypes were distributed into nine cases and were tested with twenty participants.
- At the end of the test, a Likert-type scale questionnaire ranging from (1-5) and consisted of thirteen questions was conducted to have more understanding of participants' perceptions towards UI toggle switches.
- Data collected were statistically analysed with IBM SPSS.

These eighteen prototypes, as we saw in the method chapter, contained either toggle switches, checkboxes, or radio buttons. These components were designed in different ways and every two prototypes were compared together.

The participants were asked to accomplish a task as described in the method chapter (Please

see Variables section about task description).

Two dependent variables were measured:

- **Success rate:** It represents the ability of the participant to know the initial state of the UI elements before interacting with them.
- **Subjective preference:** This preference was made between every two prototypes under each case.

Data collected were statistically analysed with IBM SPSS Statistics. The results showed that there is no significant difference in success rate between the two prototypes for the following cases: 1, 2, 3, 4, and 9. While there is a significant difference between the two prototypes for these cases: 5, 6, 7, and 8.

As we saw in the introduction and literature review chapters, there are some rules and guidelines that are followed by some companies, but these guidelines are not followed by all developers and designers.

See below for a **summary of the recommendations** that I concluded from this research study:

- Provide immediate response with UI toggle switches.
- Avoid using red color for on-state of the UI toggle switches.
- Use green or blue color to indicate the on-state of the UI toggle switches.
- On-state of the UI toggle switches should always be on the right direction.
- It is recommended to have a grey color for off-state of the UI toggle switches.
- UI Toggle switches' labels should be clear, concise, and do not contain any negative words.
- Use checkboxes or radio buttons instead of toggle switches UI when the answer is Yes/No and not on/off.
- Use radio buttons instead of toggle switches when there is a need to switch between two separate options.
- When there are several related options to choose from, it is better to use checkboxes rather than toggle switches.
- The initial state of any UI element should be off or unselected by default.
- Provide two state labels (on, off) for the UI toggle switches, it can help people with disabilities and reduce the confusion about the initial state of UI toggle switches.

Despite these UI toggle switches are simple elements and interacting with them are not so complicated, but if they are using in the wrong place, and if they are not universally designed then this can lead to confusion.

Developers and designers must be aware of people with disabilities while designing because simple things like the appearance of UI elements can make a big difference.

If we go back to the first research question: '**Are the existing user interface toggle switches universally designed?'** the answer is: not all the existing UI toggle switches are universally designed. For example, without providing state labels, it will be difficult for some people to know whether the toggle switch is on or off. We cannot rely only on colors.

For the second question: **'Is there any guidelines that are followed by all designers and developers which lead to accessible and usable user interface toggle switches?'**

We concluded from previous work and from the analysis results that there are no standard guidelines that can be followed by all developers and designers while designing UI toggle switches. Some developers follow their own guidelines, but others are not following any guidelines.

And for the last question: **'How can we achieve accessible and usable UI toggle switches?'** We can achieve usable and accessible toggle switches by following the recommendations mentioned above, this can reduce the confusion about UI toggle switches.

It would be better to have more than twenty users participate in the experiment, and the result would be more significant and interesting if there were a more diverse group of participants. But because of the COVID-19 pandemic situation, it was difficult to communicate with many people and to conduct the experiments physically as well.

6.1 Future work

Following the advice might be a major element in the researcher's decision to pursue additional study into toggle switch assessment:

- It is necessary to involve participants when assessing any system in terms of universal design. It is very important to include a more diverse user group in order to obtain a more accurate result in terms of usability and accessibility. It was tough in this study to interact and locate a varied group of people owing to the COVID-19 pandemic

condition.

- It is strongly recommended to include as many participants as possible (more than 20 participants) since this will result in more reliable results. Due to the COVID-19 pandemic condition, it was difficult to find more than 20 participants.
- Incorporating linguistic preferences into prototype design can help an experiment recruit a wider range of participants.

6.2 Journey throughout the research study

When I think back on my time working on this research project, I realize how much I liked every minute of it. It was interesting to explore UI elements such as toggle switches, radio buttons, and checkboxes and how people interact with them. In the beginning, it was difficult to think of the best approach to implement this research, because UI toggle switches are simple elements, and there was less research done regarding UI elements, and no peer-reviewed papers were found regarding toggle switches.

In the beginning, I began by looking for several papers and articles on general UI elements and attempting to sketch up the problems related to toggle switches. An article from Nielsen Normal group which was recommended by my supervisor was very helpful for my investigation towards UI toggle switches. Later I came up with a structured plan to implement this study. Eighteen prototypes were designed and tested with twenty participants. Data were collected and analysed, and the results were presented and interpreted.

Finally, I am very grateful to my supervisor who was patient and cooperated with me. He gave me his valuable time and rich knowledge through regular meetings and fast responses. His recommendations and suggestions were a very important part to accomplish this study.

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8 Appendices

8.1 Appendix A

8.1.1 Consent Form

Consent form

Please read and sign this form.

You are invited to participate in a usability and universal design investigation into User Interface Toggle Switches for the master thesis project. This is a research project being conducted by Alyaa Aljasim, a student at Oslo Metropolitan University. It should take approximately 50 minutes to complete.

During this usability test, I agree to participate in an online session using my computer. During the session, I will be asked to answer questions, and complete a task, and asked to complete a questionnaire about the experience.

We do not collect identifying information such as your name, email address, or IP address. Therefore, your responses will remain anonymous. No one will be able to identify you or your answers, and no one will know whether you participated in the study.

I understand that participation is voluntary, and I agree to immediately raise any concerns I might have.

Please sign below to indicate that you have read and understood the information on this form and that any questions you might have about the session have been answered.

Date: _____

Please sign or print your name: _____

Thank you!

We appreciate your participation.

8.2 Appendix B

8.2.1 Participants' responses and answers during the test

Candidate: 1

Age range: 31 - 40

Gender: Male

OS of the PC: win10

OS of the Phone: Android

Case1

Prototype1a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes
Prototype1b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes
Which prototype do you prefer? Why?	Prototype1b. It provides immediate response without further step.

Case2

Prototype2a	Participant's responses
What is the current state of the UI element?	Radio buttons are not selected (success)
Do you expect to see the result immediately after choosing one option?	No, with the radio button it is not expected to see the result immediately.
Prototype2b	Participant's responses
What is the current state of the UI element?	Master card is selected (success)
What is your opinion about this UI toggle switch? Are you comfortable while using it?	I am not so comfortable with it. It is not familiar.
Which prototype do you prefer? Why?	Prototype2a, if there are two options and you need to select only one, then it is better to use radio buttons.

Case3

Prototype3a	Participant's responses

What is the current state of the UI element?	Toggle switch is off (success)
Prototype3b	Participant's responses
What is the current state of the UI element?	Checkbox is selected (success)
Which prototype do you prefer? Why?	Prototype3a, I am familiar with it.

Case4

Prototype4a	Participant's responses
What is the current state of the UI element?	Checkboxes are not selected (success)
Prototype4b	Participant's responses
What is the current state of the UI element?	Toggle switches are off (success)
Which prototype do you prefer? Why?	Prototype4b, because it is more visible and has better represented with toggle switches.

Case5

Prototype5a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype5b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype5b, because it is more understandable with two labels (on, off).

Case6

Prototype6a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (fail)
Prototype6b	Participant's responses
What is the current state of the UI element?	Toggle switch is on (fail)
Which prototype do you prefer? Why?	Prototype6b, because of (on, off) labels. In general, I did not like both because the position of on-state is not to the right position

Case7

Prototype7a	Participant's responses
What is the current state of the UI element?	Toggle switch is on (fail)

Are you comfortable with (Yes, No) labels instead of (On, Off) labels?	Yes, I feel in this scenario (yes, no) is better than (on, off).
Are you comfortable with the red color for the on-state of the toggle switch?	Yes, red color is ok
Prototype7b	Participant's responses
What is the current state of the UI element?	Checkbox is unselected (success)
Which prototype do you prefer? Why?	Prototype7b, because it is easy to interact with it.

Case8

Prototype8a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Are you comfortable with (1, 0) labels instead of (on, off) labels?	No, I am confused about (1,0) labels
Prototype8b	Participant's responses
What is the current state of the UI element?	Toggle switch is on (success)
Which prototype do you prefer? Why?	Prototype8b, because it is more understandable and obvious.

Case9

Prototype9a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	Fail
Prototype9b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	Success
Which prototype do you prefer? Why?	Prototype9b, because the toggle label for prototype9a is confusing.

Candidate:2

Age range: 31 - 40

Gender: Female

OS of the PC: mac

OS of the Phone: iOS Apple

Case1

Prototype1a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes
Prototype1b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	yes
Which prototype do you prefer? Why?	Prototype1b, it provides immediate response.

Case2

Prototype2a	Participant's responses
What is the current state of the UI element?	Radio buttons are unselected (success)
Do you expect to see the result immediately after choosing one option?	No, I expect to click save to see the result, but for some websites I can expect to see an immediate response.
Prototype2b	
What is the current state of the UI element?	Master card is selected(success)
What is your opinion about this UI toggle switch? Are you comfortable while using it?	I am unfamiliar with it. I do not want to see toggle switches with anything related to payment. It is risky to have an immediate response.
Which prototype do you prefer? Why?	Prototype2a, because it is safer.

Case3

Prototype3a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype3b	Participant's responses
What is the current state of the UI element?	Checkbox is selected (success)
Which prototype do you prefer? Why?	Prototype3b, I am more familiar with it.

Case4

Prototype4a	Participant's responses
What is the current state of the UI element?	Checkboxes are unselected (success)
Prototype4b	Participant's responses

What is the current state of the UI element?	Toggle switches are off (success)
Which prototype do you prefer? Why?	Prototype4b, because it is easier.

Case5

Prototype5a	
What is the current state of the UI element?	Toggle switch is off (success)
Prototype5b	
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype5b, it is more informative with two labels instead of one.

Case6

Prototype6a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (fail)
Prototype6b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype6b, it is more informative with labels.

Case7

Prototype7a	Participant's responses
What is the current state of the UI element?	Toggle switch is No (success)
Are you comfortable with (Yes, No) labels instead of (On, Off) labels?	I am not familiar with (yes, no) but they are fine.
Are you comfortable with the red color for the on-state of the toggle switch?	I am not comfortable with the red color.
Prototype7b	Participant's responses
What is the current state of the UI element?	Check box is unselected (success)
Which prototype do you prefer? Why?	Prototype7a, it is easy to use.

Case8

Prototype8a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Are you comfortable with (1, 0) labels instead of (on, off) labels?	I am not comfortable with (1, 0) labels.
Prototype8b	Participant's responses
What is the current state of the UI element?	Toggle switch is on (success)

Which prototype do you prefer? Why?	Prototype8b, it provides labels

Case9

Prototype9a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	Fail
Prototype9b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	success
Which prototype do you prefer? Why?	Prototype9b, because the toggle label is clear while in prototype1 it is not clear with negative words.

Candidate: 3

Age range: 31 – 40

Gender: Male

OS of the PC: Mac

OS of the Phone: Android

Case1

Prototype1a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes
Prototype1b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes
Which prototype do you prefer? Why?	Prototype1b, because it is more predictable with immediate response.

Case2

Prototype2a	Participant's responses
What is the current state of the UI element?	Radio buttons are unselected (success)
Do you expect to see the result immediately after choosing one option?	No, there is a need to have further steps to see the result.
Prototype2b	Participant's responses
What is the current state of the UI element?	Master card is selected (success)

What is your opinion about this UI toggle switch? Are you comfortable while using it?	I am not familiar with it.
Which prototype do you prefer? Why?	Prototype2a, because I am not familiar with the toggle switch in prototype2b, and I do not feel secure with having an immediate response to something related to payment.

Case3

Prototype3a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype3b	Participant's responses
What is the current state of the UI element?	Checkbox is selected (success)
Which prototype do you prefer? Why?	Prototype3b, it is more convenient with a checkbox.

Case4

Prototype4a	Participant's responses
What is the current state of the UI element?	Checkboxes are unselected (success)
Prototype4b	Participant's responses
What is the current state of the UI element?	Toggle switches are off (success)
Which prototype do you prefer? Why?	Prototype4b, I feel it is good for selected.

Case5

Prototype5a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype5b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype5b, because of (on, off) labels which make it clearer.

Case6

Prototype6a	Participant's responses
What is the current state of the UI element?	Toggle switch is on (success)
Prototype6b	
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype6b, because of the labels (on, off).

Case7

Prototype7a	Participant's responses

What is the current state of the UI element?	Toggle switch is off (success)
Are you comfortable with (Yes, No) labels instead of (On, Off) labels?	I am not so comfortable.
Are you comfortable with the red color for the on-state of the toggle switch?	I am not comfortable with the red color because it refers to stop.
Prototype7b	Participant's responses
What is the current state of the UI element?	Checkbox is unselected (success)
Which prototype do you prefer? Why?	Prototype7b, because it suits better with the question.

Case8

Prototype8a	Participant's responses
What is the current state of the UI element?	Toggle switch is on (fail)
Are you comfortable with (1, 0) labels instead of (on, off) labels?	No
Prototype8b	Participant's responses
What is the current state of the UI element?	Toggle switch is on (success)
Which prototype do you prefer? Why?	Prototype8b, I prefer to see (on, off) labels instead of (1, 0) labels.

Case9

Prototype9a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	Fail
Prototype9b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	success
Which prototype do you prefer? Why?	Prototype9b, because it is easy to understand the action for the toggle switch.

Candidate: 4

Age range: 18 - 30

Gender: Male

OS of the PC: win10

OS of the Phone: iOS

Case1

Prototype1a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)

Do you expect to see the result immediately after the toggle on this switch?	Yes
Prototype1b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes
Which prototype do you prefer? Why?	Prototype1b, it provides immediate response. There is no need to click save button.

Case2

Prototype2a	Participant's responses
What is the current state of the UI element?	Radio buttons are unselected (success)
Do you expect to see the result immediately after choosing one option?	No, I do not expect to see any immediate result after choosing the radio button.
Prototype2b	Participant's responses
What is the current state of the UI element?	It is master card (success)
What is your opinion about this UI toggle switch? Are you comfortable while using it?	I am not comfortable, it is confusing.
Which prototype do you prefer? Why?	Prototype2a, because I am familiar with it.

Case3

Prototype3a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype3b	Participant's responses
What is the current state of the UI element?	Checkbox is selected (success)
Which prototype do you prefer? Why?	Prototype3b, because it is more familiar, but I prefer the initial state for a checkbox to be unselected by default.

Case4

Prototype4a	Participant's responses
What is the current state of the UI element?	Checkboxes are not selected (success)
Prototype4b	Participant's responses
What is the current state of the UI element?	Toggle switches are off (success)

Which prototype do you prefer? Why?	Prototype4a, I am familiar to see checkboxes if there are several related choices.

Case5

Prototype5a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype5b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype5b, it is descriptive with labels.

Case6

Prototype6a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (fail)
Prototype6b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype6b, I can understand the status of the toggle switches with labels.

Case7

Prototype7a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Are you comfortable with (Yes, No) labels instead of (On, Off) labels?	Yes
Are you comfortable with the red color for the on-state of the toggle switch?	No, I prefer to see green for on-state and maybe red for off.
Prototype7b	Participant's responses
What is the current state of the UI element?	Checkbox is unselected (success)
Which prototype do you prefer? Why?	Prototype7a, more understandable.

Case8

Prototype8a	Participant's responses
What is the current state of the UI element?	Toggle switch is on (fail)
Are you comfortable with (1, 0) labels instead of (on, off) labels?	I am not comfortable with (1,0) labels.
Prototype8b	Participant's responses

What is the current state of the UI element?	Toggle switch is on (success)
Which prototype do you prefer? Why?	Prototype8b, because of the labels.

Case9

Prototype9a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	Fail
Prototype9b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	success
Which prototype do you prefer? Why?	Prototype9b, because prototype9a is badly designed.

Candidate: 5

Age range: 31 – 40

Gender: Male

OS of the PC: win10

OS of the Phone: Android

Case1

Prototype1a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes
Prototype1b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	yes
Which prototype do you prefer? Why?	Prototype1b, I prefer to see immediate response without the need to push extra keys.

Case2

Prototype2a	Participant's responses
What is the current state of the UI element?	Radio buttons are unselected (success)

Do you expect to see the result immediately after choosing one option?	No, I am familiar with when there are radio buttons then I expect to see an extra step.
Prototype2b	Participant's responses
What is the current state of the UI element?	Master card is selected (success)
What is your opinion about this UI toggle switch? Are you comfortable while using it?	I am not so comfortable,
Which prototype do you prefer? Why?	Prototype2a, because prototype2b is forcing me to choose between them and the initial state is master card which is selected by default.

Case3

Prototype3a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype3b	Participant's responses
What is the current state of the UI element?	Checkbox is selected (success)
Which prototype do you prefer? Why?	Prototype3a, it is more convenient and nicer.

Case4

Prototype4a	Participant's responses
What is the current state of the UI element?	Checkboxes are unselected (success)
Prototype4b	Participant's responses
What is the current state of the UI element?	Toggle switches are off (success)
Which prototype do you prefer? Why?	Prototype4b, because the response is fast, immediate, and accurate.

Case5

Prototype5a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype5b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype5a, because there is no need for extra help and information regarding labels.

Case6

Prototype6a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (fail)
Prototype6b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype6b, in prototype6a there are no labels, no colors and the direction for on-state is not to the right. In prototype6b there are labels to know whether it is on or off.

Case7

Prototype7a	Participant's responses
What is the current state of the UI element?	Toggle switch is on (fail)
Are you comfortable with (Yes, No) labels instead of (On, Off) labels?	I am not comfortable.
Are you comfortable with the red color for the on-state of the toggle switch?	I am not comfortable. Red color refers to something wrong.
Prototype7b	Participant's responses
What is the current state of the UI element?	Check box is unselected (success)
Which prototype do you prefer? Why?	Prototype7b, it looks simple and normal. It is better to use the check box in this scenario because the answer for the question is either (yes or no) and not (on or off).

Case8

Prototype8a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Are you comfortable with (1, 0) labels instead of (on, off) labels?	I am not comfortable, it is confusing
Prototype8b	Participant's responses
What is the current state of the UI element?	Toggle switch is on (success)
Which prototype do you prefer? Why?	Prototype8b, I prefer (on, off) labels instead of (0,1) labels.

Case9

Prototype9a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)

Enable notification by email	Fail
Prototype9b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	success
Which prototype do you prefer? Why?	Prototype9b, the toggle label is simple and clear.

Candidate: 6

Age range: 31 – 40

Gender: Female

OS of the PC: win10

OS of the Phone: Android

Case1

Prototype1a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes
Prototype1b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes
Which prototype do you prefer? Why?	Prototype1b, because it provides immediate response.

Case2

Prototype2a	Participant's responses
What is the current state of the UI element?	Radio buttons are unselected (success)
Do you expect to see the result immediately after choosing one option?	No, I expect to see a further step.
Prototype2b	Participant's responses
What is the current state of the UI element?	Master card is selected (success)
What is your opinion about this UI toggle switch? Are you comfortable while using it?	I am not comfortable. I do not feel safe.
Which prototype do you prefer? Why?	Prototype2a, because the response is not fast, and more careful.

Case3

Prototype3a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype3b	Participant's responses
What is the current state of the UI element?	Checkbox is selected (success)
Which prototype do you prefer? Why?	Prototype3b, it is easy to use, and I am familiar with it.

Case4

Prototype4a	Participant's responses
What is the current state of the UI element?	Checkboxes are unselected (success)
Prototype4b	Participant's responses
What is the current state of the UI element?	Toggle switches are off (success)
Which prototype do you prefer? Why?	Prototype 4a, because there are several related choices in this prototype, and I need to review them before submitting.

Case5

Prototype5a	Participant's responses
What is the current state of the UI element?	Toggle switch is on (fail)
Prototype5b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype5b, because of the two labels

Case6

Prototype6a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (fail)
Prototype6b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype6b, it is clearer because of labels

Case7

Prototype7a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Are you comfortable with (Yes, No) labels instead of (On, Off) labels?	Yes

Are you comfortable with the red color for the on-state of the toggle switch?	I am not comfortable; I feel something wrong with the red color.
Prototype7b	Participant's responses
What is the current state of the UI element?	Toggle switch is unselected (success)
Which prototype do you prefer? Why?	Prototype7b, it is better to have further steps to make sure before activating.

Case8

Prototype8a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Are you comfortable with (1, 0) labels instead of (on, off) labels?	I am not familiar with (1,0) labels.
Prototype8b	Participant's responses
What is the current state of the UI element?	Toggle switch is on (success)
Which prototype do you prefer? Why?	Prototype8b, because of (on, off) labels.

Case9

Prototype9a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	fail
Prototype9b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	success
Which prototype do you prefer? Why?	Prototype9b, it is easy to understand the action for this toggle switch.

Candidate: 7

Age range: 18 – 30

Gender: Female

OS of the PC: win10

OS of the Phone: Android

Case1

Prototype1a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	No, I expect to see the result after clicking the save button.

Prototype1b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes, because I do not see a save button.
Which prototype do you prefer? Why?	Prototype1b, easier to use with less need to click further button. It is better performance.

Case2

Prototype2a	Participant's responses
What is the current state of the UI element?	Radio buttons are unselected (success)
Do you expect to see the result immediately after choosing one option?	No
Prototype2b	Participant's responses
What is the current state of the UI element?	Master card is selected (success)
What is your opinion about this UI toggle switch? Are you comfortable while using it?	It is confused because master card is selected by default.
Which prototype do you prefer? Why?	Prototype2a, it is clear to me.

Case3

Prototype3a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype3b	Participant's responses
What is the current state of the UI element?	Checkbox is selected (success)
Which prototype do you prefer? Why?	Prototype3b, I feel the checkbox is more relative to the text (remember me).

Case4

Prototype4a	Participant's responses
What is the current state of the UI element?	Checkboxes are unselected (success)
Prototype4b	Participant's responses
What is the current state of the UI element?	Toggle switches are off (success)
Which prototype do you prefer? Why?	Prototype4b, easy and more attractive.

Case5

Prototype5a	Participant's responses
What is the current state of the UI element?	Toggle switch is on (fail)
Prototype5b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)

Which prototype do you prefer? Why?	Prototype5b, it is mor clear with two labels.

Case6

Prototype6a	
What is the current state of the UI element?	Toggle switch is off (fail)
Prototype6b	
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype6b, it is clearer with (on, off) labels especially with no color for on-state.

Case7

Prototype7a	
What is the current state of the UI element?	Toggle switch is off (success)
Are you comfortable with (Yes, No) labels instead of (On, Off) labels?	No, it is Confusing.
Are you comfortable with the red color for the on-state of the toggle switch?	I am not comfortable. When I see red color, I consider something is wrong or danger.
Prototype7b	
What is the current state of the UI element?	Checkbox is unselected (success)
Which prototype do you prefer? Why?	Prototype7b, because checkbox took less space, and it is relative to the question.

Case8

Prototype8a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Are you comfortable with (1, 0) labels instead of (on, off) labels?	Yes, but I am not so familiar with it. It can preserve space.
Prototype8b	Participant's responses
What is the current state of the UI element?	Toggle switch is on (success)
Which prototype do you prefer? Why?	Prototype8b, more understandable.

Case9

Prototype9a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	Success
Prototype9b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	success
Which prototype do you prefer? Why?	Prototype9b, because the toggle label for prototype9a is confusing.

Candidate: 8

Age range: 31 – 40

Gender: Female

OS of the PC: mac

OS of the Phone: iOS

Case1

Prototype1a	Participant's responses
What is the current state of the UI element?	Off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes
Prototype1b	Participant's responses
What is the current state of the UI element?	Off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes
Which prototype do you prefer? Why?	Prototype1b. It provides immediate response.

Case2

Prototype2a	Participant's responses
What is the current state of the UI element?	Radio buttons are not selected (success)
Do you expect to see the result immediately after choosing one option?	Yes. I expect to see an input field to enter the information about the card.
Prototype2b	Participant's responses
What is the current state of the UI element?	Master card is selected (success)
What is your opinion about this UI toggle switch? Are you comfortable while using it?	I am not comfortable; it is not so clear.
Which prototype do you prefer? Why?	Prototype2a, because it is easy to use.

Case3

Prototype3a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype3b	Participant's responses
What is the current state of the UI element?	Checkbox is selected (success)
Which prototype do you prefer? Why?	Prototype3b. I am familiar with it.

Case4

Prototype4a	Participant's responses
What is the current state of the UI element?	Checkboxes are not selected (success)
Prototype4b	Participant's responses
What is the current state of the UI element?	Toggle switches are off (success)

Which prototype do you prefer? Why?	Prototype4a, because I am more familiar with checkboxes if there are multiple choices to choose from.

Case5

Prototype5a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype5b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype5b, because it provides two state labels.

Case6

Prototype6a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (fail)
Prototype6b	Participant's responses
What is the current state of the UI element?	Toggle switch is on (success)
Which prototype do you prefer? Why?	Prototype6b, easy to understand with state labels.

Case7

Prototype7a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Are you comfortable with (Yes, No) labels instead of (On, Off) labels?	I am familiar more with (on, off) labels.
Are you comfortable with the red color for the on-state of the toggle switch?	I am not comfortable with red color; I am not familiar with red color for on-status.
Prototype7b	Participant's responses
What is the current state of the UI element?	Checkbox is unselected.
Which prototype do you prefer? Why?	Prototype7b, because it is clearer.

Case8

Prototype8a	Participant's responses
What is the current state of the UI element?	Toggle switch is on (fail)
Are you comfortable with (1, 0) labels instead of (on, off) labels?	I am not comfortable and not familiar with (1, 0) labels.
Prototype8b	Participant's responses
What is the current state of the UI element?	Toggle switch is on (success)
Which prototype do you prefer? Why?	Prototype8b, it is easier because of state labels.

Case9

Prototype9a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success).
Enable notification by email	Fail
Prototype9b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	Success
Which prototype do you prefer? Why?	Prototype9b, because the toggle label is concise and clear.

Candidate: 9

Age range: 18 - 30
Gender: Male
OS of the PC: win10
OS of the Phone: Android

Case1

Prototype1a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	yes
Prototype1b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	yes
Which prototype do you prefer? Why?	Prototype1b, I do not want to click further step to get the result.

Case2

Prototype2a	Participant's responses
What is the current state of the UI element?	Radio buttons are unselected (success)
Do you expect to see the result immediately after choosing one option?	No
Prototype2b	Participant's responses
What is the current state of the UI element?	Master card is selected
What is your opinion about this UI toggle switch? Are you comfortable while using it?	I am comfortable, but I have not seen this design before.
Which prototype do you prefer? Why?	Prototype2b, less user interaction.

Case3

Prototype3a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype3b	Participant's responses
What is the current state of the UI element?	Checkbox is selected (success)
Which prototype do you prefer? Why?	Prototype3a, easy to use, I can see the toggle switch clearly.

Case4

Prototype4a	Participant's responses
What is the current state of the UI element?	Checkboxes are unselected (success)
Prototype4b	Participant's responses
What is the current state of the UI element?	Toggle switches are off (success)
Which prototype do you prefer? Why?	Prototype4b, easier to check it and move on.

Case5

Prototype5a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype5b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype5a, I prefer to see one label which represents the current state, I do not like to see multiple areas.

Case6

Prototype6a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (fail)
Prototype6b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype6b, it is easy to recognize on, and off status especially with no color which indicates the on state.

Case7

Prototype7a	Participant's responses
What is the current state of the UI element?	Toggle switch is No (success)
Are you comfortable with (Yes, No) labels instead of (On, Off) labels?	Yes, they are fine.
Are you comfortable with red color for the toggle switch?	Yes

Prototype7b	Participant's responses
What is the current state of the UI element?	Checkbox is unselected (success)
Which prototype do you prefer? Why?	Prototype7a, I do not feel that checkbox is suitable for the question.

Case8

Prototype8a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Are you comfortable with (1, 0) labels instead of (on, off) labels?	Yes, I like to see (1,0) and not (on, off) labels in mobile application.
Prototype8b	Participant's responses
What is the current state of the UI element?	Toggle switch is on (success)
Which prototype do you prefer? Why?	Prototype8a, I prefer to see (1,0) labels.

Case9

Prototype9a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	Success
Prototype9b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	success
Which prototype do you prefer? Why?	Prototype9b, the toggle label is short and understandable.

Candidate: 10

Age range: 41 - 50
Gender: Male
OS of the PC: win10
OS of the Phone: iPhone

Case1

Prototype1a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes
Prototype1b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	yes

Which prototype do you prefer? Why?	Prototype1b, because it provides immediate response.

Case2

Prototype2a	Participant's responses
What is the current state of the UI element?	Radio buttons are unselected (success)
Do you expect to see the result immediately after choosing one option?	Yes
Prototype2b	Participant's responses
What is the current state of the UI element?	Master card is selected (success)
What is your opinion about this UI toggle switch? Are you comfortable while using it?	I am not comfortable.
Which prototype do you prefer? Why?	Prototype1a, I feel more secure.

Case3

Prototype3a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype3b	Participant's responses
What is the current state of the UI element?	Checkbox is selected (success)
Which prototype do you prefer? Why?	Prototype3b, the status of checkbox is clearer.

Case4

Prototype4a	Participant's responses
What is the current state of the UI element?	Checkboxes are unselected (success)
Prototype4b	Participant's responses
What is the current state of the UI element?	Toggle switches are off (success)
Which prototype do you prefer? Why?	Prototype4a, easy and clear. I am more familiar with it.

Case5

Prototype5a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype5b	Participant's responses
What is the current state of the UI element?	Toggle switch is off is off (success)
Which prototype do you prefer? Why?	Prototype5b, it is clearer with labels

Case6

Prototype6a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (fail)

Prototype6b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype6b, clearer because of the labels. It was difficult to differentiate between (on, and off) without state-labels.

Case7

Prototype7a	Participant's responses
What is the current state of the UI element?	Toggle switch is on (fail)
Are you comfortable with (Yes, No) labels instead of (On, Off) labels?	It is fine.
Are you comfortable with the red color for the on-state of the toggle switch?	No, it refers to close.
Prototype7b	Participant's responses
What is the current state of the UI element?	Checkbox is unselected (success)
Which prototype do you prefer? Why?	Prototype7b, better and safer.

Case8

Prototype8a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Are you comfortable with (1, 0) labels instead of (on, off) labels?	No, I feel they are not necessary
Prototype8b	Participant's responses
What is the current state of the UI element?	Toggle switch is on (success)
Which prototype do you prefer? Why?	Prototype8b, I prefer to see (on, off) labels. More understandable.

Case9

Prototype9a	
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	Fail
Prototype9b	
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	success
Which prototype do you prefer? Why?	Prototype9b, the toggle label is easy to understand.

Candidate: 11

Age range: 18 - 30

Gender: Male

OS of the PC: win10

OS of the Phone: iOS

Case1

Prototype1a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes
Prototype1b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes
Which prototype do you prefer? Why?	Prototype1b, it is faster with immediate response.

Case2

Prototype2a	Participant's responses
What is the current state of the UI element?	Radio buttons are unselected (success)
Do you expect to see the result immediately after choosing one option?	Yes
Prototype2b	Participant's responses
What is the current state of the UI element?	Master card is selected (success)
What is your opinion about this UI toggle switch? Are you comfortable while using it?	I am not comfortable, because one of them is already selected by default.
Which prototype do you prefer? Why?	Prototype2a, easy to understand and no option is selected by default.

Case3

Prototype3a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype3b	Participant's responses
What is the current state of the UI element?	Checkbox is selected (success)
Which prototype do you prefer? Why?	Prototype3b, I am more familiar with it.

Case4

Prototype4a	Participant's responses
What is the current state of the UI element?	Checkboxes are unselected (success)
Prototype4b	Participant's responses
What is the current state of the UI element?	Toggle switches are off (success)
Which prototype do you prefer? Why?	Prototype4a, I am more familiar to see checkboxes when there are several choices.

Case5

Prototype5a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype5b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype5a, I am more familiar, and the label is more pleasing. I do not like to see both (on, off) labels.

Case6

Prototype6a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (fail)
Prototype6b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype6b, clearer, and it is confusing to see grey color for on status.

Case7

Prototype7a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Are you comfortable with (Yes, No) labels instead of (On, Off) labels?	Yes
Are you comfortable with the red color for the on-state of the toggle switch?	No, the red color refers to a wrong sign.
Prototype7b	Participant's responses
What is the current state of the UI element?	Checkbox is unselected (success)
Which prototype do you prefer? Why?	Prototype7b, I do not like to see red color for on-state.

Case8

Prototype8a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Are you comfortable with (1, 0) labels instead of (on, off) labels?	They are comfortable but not familiar.
Prototype8b	Participant's responses
What is the current state of the UI element?	Toggle switch is on (success)
Which prototype do you prefer? Why?	Prototype 8a, I do not like to see (on, off) labels.

Case9

Prototype9a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	Fail
Prototype9b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	Success
Which prototype do you prefer? Why?	Prototype9b, less effort to understand the action for this toggle switch.

Candidate: 12

Age range: 18 - 30

Gender: Male

OS of the PC: mac

OS of the Phone: iOS

Case1

Prototype1a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes
Prototype1b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	yes
Which prototype do you prefer? Why?	Prototype1b, I prefer to see immediate response here, but I prefer to click further step for more secure in another scenario.

Case2

Prototype2a	Participant's responses
What is the current state of the UI element?	Radio buttons are unselected (success)
Do you expect to see the result immediately after choosing one option?	Yes
Prototype2b	Participant's responses
What is the current state of the UI element?	Master card is selected (success)
What is your opinion about this UI toggle switch? Are you comfortable while using it?	I feel it is a crucial step that may create a problem.
Which prototype do you prefer? Why?	Prototype2a, it keeps my attention better.

Case3

Prototype3a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype3b	Participant's responses
What is the current state of the UI element?	Checkbox is selected (success)
Which prototype do you prefer? Why?	Prototype3b, I feel toggle switch in prototype3a is misleading in this scenario.

Case4

Prototype4a	Participant's responses
What is the current state of the UI element?	Checkboxes are unselected (success)
Prototype4b	Participant's responses
What is the current state of the UI element?	Toggle switches are off (success)
Which prototype do you prefer? Why?	Prototype4b, I like the appearance for toggle switches. More attractive.

Case5

Prototype5a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype5b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype5b, it indicates the status more directly with (on, off) labels.

Case6

Prototype6a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (fail)
Prototype6b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype6b, more understandable with labels, especially there is no color to indicate the on state.

Case7

Prototype7a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Are you comfortable with (Yes, No) labels instead of (On, Off) labels?	It is fine.
Are you comfortable with the red color for the on-state of the toggle switch?	Red color is fine.
Prototype7b	Participant's responses

What is the current state of the UI element?	Checkbox is unselected (success)
Which prototype do you prefer? Why?	Prototype7a, it is more intuitive. Because the action is a question, so I prefer to see (yes, no) answer.

Case8

Prototype8a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Are you comfortable with (1, 0) labels instead of (on, off) labels?	It is ok, I am not familiar to see (1,0) labels with toggle switches.
Prototype8b	Participant's responses
What is the current state of the UI element?	Toggle switch is on (success)
Which prototype do you prefer? Why?	Prototype8a, I feel it is too much with labels. I prefer minimal presentation.

Case9

Prototype9a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	Fail
Prototype9b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	Success
Which prototype do you prefer? Why?	Prototype9b, it is more intuitive, and it avoids double noise confusion.

Candidate: 13

Age range: 41 - 50

Gender: Female

OS of the PC: Win10

OS of the Phone: iOS

Case1

Prototype1a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes
Prototype1b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes

Which prototype do you prefer? Why?	Prototype1b, because there is an immediate response for this toggle switch.

Case2

Prototype2a	Participant's responses
What is the current state of the UI element?	Radio buttons are unselected (success)
Do you expect to see the result immediately after choosing one option?	No
Prototype2b	Participant's responses
What is the current state of the UI element?	Master card is selected (success)
What is your opinion about this UI toggle switch? Are you comfortable while using it?	I do not expect to see one payment method is activated by default. I am not comfortable while using the toggle switch this way.
Which prototype do you prefer? Why?	Prototype2a. Clearer and no option is selected by default. It is more secure to use radio buttons, especially with payment cases. It is better to have further step for confirming.

Case3

Prototype3a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype3b	Participant's responses
What is the current state of the UI element?	Checkbox is selected (success)
Which prototype do you prefer? Why?	Prototype3b, I do not want to save my password before clicking the login button, because the toggle switch provides an immediate response.

Case4

Prototype4a	Participant's responses
What is the current state of the UI element?	Checkboxes are unselected (success)
Prototype4b	Participant's responses
What is the current state of the UI element?	Toggle switches are off (success)
Which prototype do you prefer? Why?	Prototype4a, I prefer to see checkboxes over toggle switches if there are several related choices. It is easier and faster for me.

Case5

Prototype5a	Participant's responses
What is the current state of the UI element?	Toggle switch is on (fail)
Prototype5b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype5b, I prefer to see two (on, off) labels on both sides. It is more understandable.

Case6

Prototype6a	
What is the current state of the UI element?	Toggle switch is off (fail)
Prototype6b	
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype6b, it is more understandable, especially there is no color to indicate the on status.

Case7

Prototype7a	Participant's responses
What is the current state of the UI element?	Toggle switch is on (fail)
Are you comfortable with (Yes, No) labels instead of (On, Off) labels?	No, I am not familiar with (yes, no). I thought from the beginning No is on.
Are you comfortable with the red color for the on-state of the toggle switch?	No, red color indicates danger.
Prototype7b	Participant's responses
What is the current state of the UI element?	checkbox is unselected (success)
Which prototype do you prefer? Why?	Prototype7b, I feel it is better to have a checkbox in this scenario. I feel it is better to have toggles switch when the action is on, off and not Yes, No.

Case8

Prototype8a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Are you comfortable with (1, 0) labels instead of (on, off) labels?	Yes, I use this feature in my mobile phone.
Prototype8b	Participant's responses
What is the current state of the UI element?	Toggle switch is on (success)

Which prototype do you prefer? Why?	Prototype8a, I prefer to see (1,0) in the mobile applications. Because there is not enough space and I feel it is prettier.

Case9

Prototype9a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	Fail
Prototype9b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	Success
Which prototype do you prefer? Why?	Prototype9b, the description is short and clear.

Candidate: 14

Age range: 31 – 40

Gender: Male

OS of the PC: Win10

OS of the Phone: Android

Case1

Prototype1a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes
Prototype1b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes
Which prototype do you prefer? Why?	Prototype1b, immediate response, there is no need for save button.

Case2

Prototype2a	Participant's responses
What is the current state of the UI element?	Radio buttons are unselected (success)
Do you expect to see the result immediately after choosing one option?	No
Prototype2b	Participant's responses
What is the current state of the UI element?	Master card is selected (success)
What is your opinion about this UI toggle switch? Are you comfortable while using it?	It is a strange design; I do not like it because there is already a selected option.

Which prototype do you prefer? Why?	Prototype2a, more secure and no option is selected by default.

Case3

Prototype3a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype3b	Participant's responses
What is the current state of the UI element?	Checkbox is selected (success)
Which prototype do you prefer? Why?	Prototype3b, I am more familiar with it.

Case4

Prototype4a	Participant's responses
What is the current state of the UI element?	Checkboxes are unselected (success)
Prototype4b	Participant's responses
What is the current state of the UI element?	Toggle switches are off (success)
Which prototype do you prefer? Why?	Prototype4a, I do not feel comfortable using toggle switches with many related selections.

Case5

Prototype5a	Participant's responses
What is the current state of the UI element?	Toggle switch is on (fail)
Prototype5b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype5b, the first one is confusing.

Case6

Prototype6a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (fail)
Prototype6b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype6b, the first prototype is confusing because the color of on-state was grey, and it was located to the left.

Case7

Prototype7a	Participant's responses
What is the current state of the UI element?	Toggle switch is on (fail)
Are you comfortable with (Yes, No) labels instead of (On, Off) labels?	No

Are you comfortable with the red color for the on-state of the toggle switch?	No, it refers to a stop indication.
Prototype7b	Participant's responses
What is the current state of the UI element?	Checkbox is unselected (success)
Which prototype do you prefer? Why?	Prototype7b, I am not familiar with prototype7a.

Case8

Prototype8a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Are you comfortable with (1, 0) labels instead of (on, off) labels?	I am not familiar, but I like it.
Prototype8b	Participant's responses
What is the current state of the UI element?	Toggle switch is on (success)
Which prototype do you prefer? Why?	Prototype8a, more practical especially in smart devices.

Case9

Prototype9a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	Fail
Prototype9b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	Success
Which prototype do you prefer? Why?	Prototype9b, I did not understand immediately how to enable notification in prototype9a, I am not familiar to see negative words in the toggle label.

Candidate: 15

Age range: 18 - 30

Gender: Male

OS of the PC: mac

OS of the Phone: iOS

Case1

Prototype1a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	No
Prototype1b	Participant's responses

What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after toggle on this switch?	Yes
Which prototype do you prefer? Why?	Prototype1b, I can see the results immediately without clicking any further step.

Case2

Prototype2a	Participant's responses
What is the current state of the UI element?	Radio buttons are unselected (success)
Do you expect to see the result immediately after choosing one option?	No
Prototype2b	Participant's responses
What is the current state of the UI element?	Master card is selected (success)
What is your opinion about this UI toggle switch? Are you comfortable while using it?	It looks attractive but I do not feel secure.
Which prototype do you prefer? Why?	Prototype2a, I am familiar with it. It is safer to have further step for activation.

Case3

Prototype3a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype3b	Participant's responses
What is the current state of the UI element?	Checkbox is selected (success)
Which prototype do you prefer? Why?	Prototype3b, I do not like to see toggle switches in this scenario. But I do not prefer to have something selected as an initial state.

Case4

Prototype4a	Participant's responses
What is the current state of the UI element?	Checkboxes are unselected (success)
Prototype4b	Participant's responses
What is the current state of the UI element?	Toggle switches are off (success)
Which prototype do you prefer? Why?	Prototype4a, I am familiar with it, but the toggle switches look fine also.

Case5

Prototype5a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (fail)

Prototype5b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype5b, because it more understandable with labels

Case6

Prototype6a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (fail)
Prototype6b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype6b, it was difficult to predict the current state without state labels, and with grey color for the on-state.

Case7

Prototype7a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Are you comfortable with (Yes, No) labels instead of (On, Off) labels?	No, but it looks fine.
Are you comfortable with the red color for the on-state of the toggle switch?	No, I do not want to see red color for on-state.
Prototype7b	Participant's responses
What is the current state of the UI element?	Checkbox is unselected (success)
Which prototype do you prefer? Why?	Prototype7b, I feel it is more suitable to see a checkbox with (yes, no) answer.

Case8

Prototype8a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Are you comfortable with (1, 0) labels instead of (on, off) labels?	Yes, I feel it suites for mobile applications.
Prototype8b	Participant's responses
What is the current state of the UI element?	Toggle switch is on (success)
Which prototype do you prefer? Why?	Prototype8a, because (1, 0) labels reduce the noise especially in mobile applications.

Case9

Prototype9a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	Fail

Prototype9b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	Success
Which prototype do you prefer? Why?	Prototype9b, easy to understand.

Candidate: 16

Age range: 41 - 50

Gender: Male

OS of the PC: Win10

OS of the Phone: iOS

Case1

Prototype1a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	No
Prototype1b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes
Which prototype do you prefer? Why?	Prototype1b, it is boring with prototype1 to click further button.

Case2

Prototype2a	Participant's responses
What is the current state of the UI element?	Radio buttons are unselected (success)
Do you expect to see the result immediately after choosing one option?	No
Prototype2b	Participant's responses
What is the current state of the UI element?	Master card is selected
What is your opinion about this UI toggle switch? Are you comfortable while using it?	It is comfortable, nice design
Which prototype do you prefer? Why?	Prototype2a, more secure and need confirmation before activating any selection

Case3

Prototype3a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype3b	Participant's responses
What is the current state of the UI element?	Checkbox is selected (success)

Which prototype do you prefer? Why?	Prototype3a, it is more understandable with toggle switch. I can understand it is activated better than checkbox.

Case4

Prototype4a	Participant's responses
What is the current state of the UI element?	Checkboxes are unselected (success)
Prototype4b	Participant's responses
What is the current state of the UI element?	Toggle switches are off (success)
Which prototype do you prefer? Why?	Prototype4a, there is confirmation before submitting the answer.

Case5

Prototype5a	Participant's responses
What is the current state of the UI element?	Toggle switch is on (fail)
Prototype5b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype5b, clearer with two labels

Case6

Prototype6a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (fail)
Prototype6b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype6b, clearer because of the labels.

Case7

Prototype7a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Are you comfortable with (Yes, No) labels instead of (On, Off) labels?	Yes,
Are you comfortable with the red color for the on-state of the toggle switch?	No, it refers to stop sign.
Prototype7b	Participant's responses
What is the current state of the UI element?	Checkbox is unselected (success)
Which prototype do you prefer? Why?	Prototype7b, I am more familiar with it,

Case8

Prototype8a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)

Are you comfortable with (1, 0) labels instead of (on, off) labels?	It is fine but I am not familiar.
Prototype8b	Participant's responses
What is the current state of the UI element?	Toggle switch is on (success)
Which prototype do you prefer? Why?	Prototype8b, I am familiar to see (on, off) labels.

Case9

Prototype9a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	Fail
Prototype9b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	success
Which prototype do you prefer? Why?	Prototype9b, because toggle label is easy to understand.

Candidate: 17

Age range: 41 - 50

Gender: Male

OS of the PC: Win10

OS of the Phone: Android

Case1

Prototype1a	Participant's responses
What is the current state of the UI element?	Toggle switch is on (fail)
Do you expect to see the result immediately after the toggle on this switch?	Yes
Prototype1b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes
Which prototype do you prefer? Why?	Prototype1b, I prefer to see immediate response.

Case2

Prototype2a	Participant's responses
What is the current state of the UI element?	Radio buttons are unselected (success)
Do you expect to see the result immediately after choosing one option?	No
Prototype2b	Participant's responses

What is the current state of the UI element?	Toggle switch is off (fail)
What is your opinion about this UI toggle switch? Are you comfortable while using it?	I am not comfortable
Which prototype do you prefer? Why?	Prototype2a, I could not understand the initial state of prototype2.

Case3

Prototype3a	Participant's responses
What is the current state of the UI element?	Toggle switch is on (fail)
Prototype3b	Participant's responses
What is the current state of the UI element?	Checkbox is selected (success)
Which prototype do you prefer? Why?	Prototype3b, easy to understand, I do not like to see toggle switch in this scenario. I am not familiar with it.

Case4

Prototype4a	Participant's responses
What is the current state of the UI element?	Checkboxes are unselected (success)
Prototype4b	Participant's responses
What is the current state of the UI element?	Toggle switches are on (fail)
Which prototype do you prefer? Why?	Prototype4a, I do not use toggle switch very often.

Case5

Prototype5a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype5b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype5b, better understanding with labels.

Case6

Prototype6a	Participant's responses
What is the current state of the UI element?	Toggle switch is on (success)
Prototype6b	Participant's responses
What is the current state of the UI element?	Toggle switch is off(success)
Which prototype do you prefer? Why?	Prototype6b, I prefer to see (on, off) labels

Case7

Prototype7a	Participant's responses

What is the current state of the UI element?	Toggle switch is on (fail)
Are you comfortable with (Yes, No) labels instead of (On, Off) labels?	No, but it is fine
Are you comfortable with the red color for the on-state of the toggle switch?	No, it refers to stop or danger
Prototype7b	Participant's responses
What is the current state of the UI element?	checkbox is unselected (success)
Which prototype do you prefer? Why?	Prototype7b, more understandable

Case8

Prototype8a	Participant's responses
What is the current state of the UI element?	Toggle switch is on (fail)
Are you comfortable with (1, 0) labels instead of (on, off) labels?	Yes,
Prototype8b	Participant's responses
What is the current state of the UI element?	Toggle switch is on (success)
Which prototype do you prefer? Why?	Prototype8a, it can be practical to use in mobile applications.

Case9

Prototype9a	Participant's responses
What is the current state of the UI element?	Toggle switch is on (fail)
Enable notification by email	Fail
Prototype9b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	Success
Which prototype do you prefer? Why?	Prototype9b, I could understand how to enable notification. It was ambiguous in prototype9a.

Candidate: 18

Age range: 41 - 50

Gender: Female

OS of the PC: Win10

OS of the Phone: Android

Case1

Prototype1a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes

Prototype1b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes
Which prototype do you prefer? Why?	Prototye1b, I expect to see immediate response. Save button is strange with toggle switch.

Case2

Prototype2a	Participant's responses
What is the current state of the UI element?	Radio buttons are not selected (success)
Do you expect to see the result immediately after choosing one option?	No, after clicking on further button.
Prototype2b	Participant's responses
What is the current state of the UI element?	Master card is selected (Success)
What is your opinion about this UI toggle switch? Are you comfortable while using it?	It is strange, I see this for the first time. Not comfortable
Which prototype do you prefer? Why?	Prototype2a, it is more familiar and comfortable

Case3

Prototype3a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype3b	Participant's responses
What is the current state of the UI element?	Checkbox is selected (success)
Which prototype do you prefer? Why?	Prototype3b, more familiar with it.

Case4

Prototype4a	Participant's responses
What is the current state of the UI element?	Checkboxes are not selected (success)
Prototype4b	Participant's responses
What is the current state of the UI element?	Toggle switches are off (success)
Which prototype do you prefer? Why?	Prototype4a, I am more familiar with it.

Case5

Prototype5a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype5b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype5b, I feel prototype5a is confusing

Case6

Prototype6a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (fail)
Prototype6b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype6b, it is clearer because of the labels.

Case7

Prototype7a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Are you comfortable with (Yes, No) labels instead of (On, Off) labels?	Yes, it is fine
Are you comfortable with the red color for the on-state of the toggle switch?	No
Prototype7b	Participant's responses
What is the current state of the UI element?	checkbox is unselected
Which prototype do you prefer? Why?	Prototype7b, it is more suitable with the question because the answer is Yes or No

Case8

Prototype8a	
What is the current state of the UI element?	Toggle switch is on (fail)
Are you comfortable with (1, 0) labels instead of (on, off) labels?	No, I feel that not everyone understands (1,0) symbols
Prototype8b	
What is the current state of the UI element?	Toggle switch is on
Which prototype do you prefer? Why?	Prototype8b, I prefer (on, off) labels.

Case9

Prototype9a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	Fail
Prototype9b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	Success
Which prototype do you prefer? Why?	Prototype9b, the toggle label of the first prototype is long and with negative word, difficult to understand immediately.

Candidate: 19

Age range: 41 - 50

Gender: Female

OS of the PC: Win10

OS of the Phone: Android

Case1

Prototype1a	Participant's responses
What is the current state of the UI element?	Toggle switch is on (Fail)
Do you expect to see the result immediately after the toggle on this switch?	Yes
Prototype1b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes
Which prototype do you prefer? Why?	Prototype1b, easier to use.

Case2

Prototype2a	Participant's responses
What is the current state of the UI element?	Radio buttons are unselected (success)
Do expect to see the result immediately? why?	No
Prototype2b	Participant's responses
What is the current state of the UI element?	PayPal is selected (fail)
What is your opinion with this toggle switch UI? Are you comfortable while using it?	I am not comfortable
Which prototype do you prefer? Why?	Prototype2a, it is easier to understand

Case3

Prototype3a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype3b	Participant's responses
What is the current state of the UI element?	Checkbox is selected (success)
Which prototype do you prefer? Why?	Prototype3b, I am familiar with it.

Case4

Prototype4a	Participant's responses
What is the current state of the UI element?	Checkboxes are unselected (success)
Prototype4b	Participant's responses
What is the current state of the UI element?	Toggle switches are off (success)
Which prototype do you prefer? Why?	Prototype4a, it is more familiar.

Case5

Prototype5a	Participant's responses
What is the current state of the UI element?	Toggle switch is on (fail)
Prototype5b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype5b, easy to understand with state labels

Case6

Prototype6a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (fail)
Prototype6b	Participant's responses
What is the current state of the UI element?	Toggle switch is off(success)
Which prototype do you prefer? Why?	Prototype6b, l like to see state labels, more understandable especially with no color for on-state.

Case7

Prototype7a	Participant's responses
What is the current state of the UI element?	Toggle switch is on (fail)
Are you comfortable with (Yes, No) labels instead of (On, Off) labels?	No
Are you comfortable with the red color for the on-state of the toggle switch?	No
Prototype7b	Participant's responses
What is the current state of the UI element?	Checkbox is unselected (success)
Which prototype do you prefer? Why?	Prototype7b, because prototype7a is confusing. I thought ''No'' is ''On'' at the beginning.

Case8

Prototype8a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Are you comfortable with (1, 0) labels instead of (on, off) labels?	Yes
Prototype8b	Participant's responses
What is the current state of the UI element?	Toggle switch is on (success)
Which prototype do you prefer? Why?	Prototype8b, I am more familiar with (on, off) labels but it is also fine with (1,0) labels.

Case9

Prototype9a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	Fail
Prototype9b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	success
Which prototype do you prefer? Why?	Prototype9b, because the toggle label is short and understandable.

Candidate: 20

Age range: 31 - 40

Gender: Female

OS of the PC: mac

OS of the Phone: iOS

Case1

Prototype1a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes
Prototype1b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Do you expect to see the result immediately after the toggle on this switch?	Yes
Which prototype do you prefer? Why?	Prototype1b, because the results appear immediately after turning on this toggle switch.

Case2

Prototype2a	Participant's responses
What is the current state of the UI element?	Radio buttons are unselected (success)
Do you expect to see the result immediately after choosing one option?	No
Prototype2b	Participant's responses
What is the current state of the UI element?	Master card is selected (success)
What is your opinion about this UI toggle switch? Are you comfortable while using it?	I am not comfortable,

Which prototype do you prefer? Why?	Prototype2a, because I do not like to see one of these two selections is initially selected by default.

Case3

Prototype3a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype3b	Participant's responses
What is the current state of the UI element?	Checkbox is selected (success)
Which prototype do you prefer? Why?	Prototype3b, I do not feel this toggle switch is suitable in this scenario.

Case4

Prototype4a	Participant's responses
What is the current state of the UI element?	Checkboxes are unselected (success)
Prototype4b	Participant's responses
What is the current state of the UI element?	Toggle switches are off (success)
Which prototype do you prefer? Why?	Prototype4a, checkboxes are more suitable here with many choices.

Case5

Prototype5a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Prototype5b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype5b, more understandable with state labels.

Case6

Prototype6a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (fail)
Prototype6b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Which prototype do you prefer? Why?	Prototype6b, in prototype6a on-state was grey so it was difficult to know the current state without state labels.

Case7

Prototype7a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)

Are you comfortable with (Yes, No) labels instead of (On, Off) labels?	No
Are you comfortable with the red color for the on-state of the toggle switch?	No, I do not like it.
Prototype7b	Participant's responses
What is the current state of the UI element?	Checkbox is unselected (success)
Which prototype do you prefer? Why?	Prototype7b, it is better to use checkbox with this question.

Case8

Prototype8a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Are you comfortable with (1, 0) labels instead of (on, off) labels?	Yes
Prototype8b	Participant's responses
What is the current state of the UI element?	Toggle switch is on (success)
Which prototype do you prefer? Why?	Prototype8a, I feel it is more suitable with mobile application.

Case9

Prototype9a	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	Fail
Prototype9b	Participant's responses
What is the current state of the UI element?	Toggle switch is off (success)
Enable notification by email	Success
Which prototype do you prefer? Why?	Prototype9b, toggle label is clearer than the first one.

8.3 Appendix C

8.3.1 Participants' answers for Likert-type scale questionnaire

Likert-type scale questionnaire consists of thirteen questions and ranging from 1-5 (1= Strongly Disagree, 2= Disagree, 3= Neutral, 4= Agree, 5= Strongly Agree).

The questions of Likert-type scale questionnaire

Questions	Score
Q1: UI Toggle switches must have an immediate response and there is no need for confirming button.	

Q2: It is important to provide two state labels (on, off) for the UI toggle switches.	
Q3: It is important to provide state labels (1,0) to indicate the current state of the UI toggle switches.	
Q4: The position for on-state of the UI toggle switches should always be on the right side.	
Q5: The color of the on-state of the UI toggle switches should always be green.	
Q6: The color of the on-state of the UI toggle switches should always be blue.	
Q7: Avoid using red color to indicate the on-state of the UI toggle switches.	
Q8: The color of the off-state of the UI toggle switches should always be grey.	
Q9: The color of the on-state of the UI toggle switches should follow the color of the theme of the application.	
Q10: It is important to provide short, clear, and concise toggle labels which describe the action of the UI toggle switches.	
Q11: Use checkboxes or radio buttons instead of toggle switches when the answer is Yes/No and not on/off.	
Q12: Use checkboxes instead of toggle switches when there are several related choices to choose from.	
Q13: That the initial state of the UI elements should always be off or unselected.	

Table 8.3-1 The questions of Likert-type scale questionnaire

The answers for Likert-type scale questionnaire for all candidates

Participants	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13
1	4	2	1	5	5	3	4	5	4	5	4	2	5
2	5	4	2	5	5	4	4	5	2	5	2	2	5
3	5	4	1	5	3	5	5	2	4	5	5	2	5
4	5	5	1	1	3	3	5	1	4	5	4	5	5
5	4	1	2	5	3	3	5	4	5	5	5	3	3
6	4	5	2	3	5	2	5	5	2	5	5	5	5
7	4	5	4	4	4	4	3	5	5	5	5	4	3
8	5	5	2	5	5	2	5	3	2	5	4	4	4
9	5	2	4	5	1	1	2	4	4	5	1	2	5
10	4	4	1	4	4	4	1	3	2	4	4	3	4
11	5	3	2	5	5	5	1	2	3	5	3	4	5
12	5	4	3	5	5	5	4	5	1	5	2	2	5
13	5	4	4	5	5	3	5	5	1	5	5	5	5
14	5	4	5	5	5	3	5	5	1	5	5	5	5
15	5	4	4	5	5	2	5	5	2	5	5	4	5

16	4	4	3	3	4	3	5	3	3	5	4	4	5
17	5	5	4	3	3	3	4	3	3	5	5	5	5
18	5	5	2	2	2	2	5	2	5	5	5	5	3
19	5	4	4	4	4	3	5	4	2	5	4	4	5
20	5	4	4	5	5	2	5	5	1	5	5	4	5

Table 8.3-2 The answers for Likert-type scale questionnaire for all candidates

8.4 Appendix D

8.4.1 Tests of Normality (Kolmogorov–Smirnov (KS) and Shapiro–Wilk (SW) tests)

Kolmogorov–Smirnov (KS) and Shapiro–Wilk (SW) test for case1

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Prototype1a_Case1	.527	20	.000	.351	20	.000
Prototype1b_Case1	.	20	.	.	20	.
a. Lilliefors Significance Correction						

Kolmogorov–Smirnov (KS) and Shapiro–Wilk (SW) test for case2

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Prototype2a_Case2	.	20	.	.	20	.
Prototype2b_Case2	.527	20	.000	.351	20	.000
a. Lilliefors Significance Correction						

Kolmogorov–Smirnov (KS) and Shapiro–Wilk (SW) test for case3

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Prototype3a_Case3	.538	20	.000	.236	20	.000

Prototype3b_Case3	.	20	.	.	20	.
a. Lilliefors Significance Correction						

Kolmogorov–Smirnov (KS) and Shapiro–Wilk (SW) test for case4

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Prototype4a_Case4	.	20	.	.	20	.
Prototype4b_Case4	.538	20	.000	.236	20	.000
a. Lilliefors Significance Correction						

Kolmogorov–Smirnov (KS) and Shapiro–Wilk (SW) test for case5

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Prototype5a_Case5	.413	20	.000	.608	20	.000
Prototype5b_Case5	.	20	.	.	20	.
a. Lilliefors Significance Correction						

Kolmogorov–Smirnov (KS) and Shapiro–Wilk (SW) test for case6

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Prototype6a_Case6	.527	20	.000	.351	20	.000
Prototype6b_Case6	.538	20	.000	.236	20	.000
a. Lilliefors Significance Correction						

Kolmogorov–Smirnov (KS) and Shapiro–Wilk (SW) test for case7

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Prototype7a_Case7	.413	20	.000	.608	20	.000

Prototype7b_Case7	.	20	.	.	20	.
a. Lilliefors Significance Correction						

Kolmogorov–Smirnov (KS) and Shapiro–Wilk (SW) test for case8

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Prototype8a_Case8	.463	20	.000	.544	20	.000
Prototype8b_Case8	.	20	.	.	20	.
a. Lilliefors Significance Correction						

Kolmogorov–Smirnov (KS) and Shapiro–Wilk (SW) test for case9

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Prototype9a_Case9	.538	20	.000	.236	20	.000
Prototype9b_Task9	.	20	.	.	20	.
a. Lilliefors Significance Correction						

8.5 Appendix E

8.5.1 Wilcoxon Signed Ranks Test Results

Wilcoxon Signed Ranks test presents following results for within subject effect

Wilcoxon Signed Ranks Test Results for case1

Ranks				
		N	Mean Rank	Sum of Ranks
Prototype1b_Case1 - Prototype1a_Case1	Negative Ranks	2[a]	1.50	3.00
	Positive Ranks	0[b]	.00	.00
	Ties	18[c]		

	Total	20		
a. Prototype1b_Case1 < Prototype1a_Case1				
b. Prototype1b_Case1 > Prototype1a_Case1				
c. Prototype1b_Case1 = Prototype1a_Case1				

Table 8.5-1 Wilcoxon Signed Ranks Test_Ranks_case1

Test Statistics[a]	
	Prototype1b_Case1 - Prototype1a_Case1
Z	-1.414[b]
Asymp. Sig. (2-tailed)	.157
a. Wilcoxon Signed Ranks Test	
b. Based on positive ranks.	

Table 8.5-2 Wilcoxon Signed Ranks Test_Test Statistics _case1

Wilcoxon Signed Ranks Test Results for case2

Ranks				
		N	Mean Rank	Sum of Ranks
Prototype2b_Case2 - Prototype2a_Case2	Negative Ranks	0[a]	.00	.00
	Positive Ranks	2[b]	1.50	3.00
	Ties	18[c]		
	Total	20		
a. Prototype2b_Case2 < Prototype2a_Case2				
b. Prototype2b_Case2 > Prototype2a_Case2				
c. Prototype2b_Case2 = Prototype2a_Case2				

Table 8.5-3 Wilcoxon Signed Ranks Test_Ranks_case2

Test Statistics[a]	
	Prototype2b_Case2 - Prototype2a_Case2
Z	-1.414[b]
Asymp. Sig. (2-tailed)	.157
a. Wilcoxon Signed Ranks Test	

b. Based on negative ranks.

Table 8.5-4 Wilcoxon Signed Ranks Test_Test Statistics _case2

Wilcoxon Signed Ranks Test Results for case3

Ranks				
		N	Mean Rank	Sum of Ranks
Prototype3b_Case3 - Prototype3a_Case3	Negative Ranks	1[a]	1.00	1.00
	Positive Ranks	0[b]	.00	.00
	Ties	19[c]		
	Total	20		
a. Prototype3b_Case3 < Prototype3a_Case3				
b. Prototype3b_Case3 > Prototype3a_Case3				
c. Prototype3b_Case3 = Prototype3a_Case3				

Table 8.5-5 Wilcoxon Signed Ranks Test_Ranks_case3

Test Statistics[a]	
	Prototype3b_Case3 - Prototype3a_Case3
Z	-1.000[b]
Asymp. Sig. (2-tailed)	.317
a. Wilcoxon Signed Ranks Test	
b. Based on positive ranks.	

Table 8.5-6 Wilcoxon Signed Ranks Test_Test Statistics _case3

Wilcoxon Signed Ranks Test Results for case4

Ranks				
		N	Mean Rank	Sum of Ranks
Prototype4b_Case4 - Prototype4a_Case4	Negative Ranks	0[a]	.00	.00
	Positive Ranks	1[b]	1.00	1.00
	Ties	19[c]		
	Total	20		
a. Prototype4b_Case4 < Prototype4a_Case4				
b. Prototype4b_Case4 > Prototype4a_Case4				
c. Prototype4b_Case4 = Prototype4a_Case4				

Table 8.5-7 Wilcoxon Signed Ranks Test_Ranks_case4

Test Statistics[a]	
	Prototype4b_Case4 - Prototype4a_Case4
Z	-1.000[b]
Asymp. Sig. (2-tailed)	.317
a. Wilcoxon Signed Ranks Test	
b. Based on negative ranks.	

Table 8.5-8 Wilcoxon Signed Ranks Test_Test Statistics _case4

Wilcoxon Signed Ranks Test Results for case5

Ranks				
		N	Mean Rank	Sum of Ranks
Prototype5b_Case5 - Prototype5a_Case5	Negative Ranks	7[a]	4.00	28.00
	Positive Ranks	0[b]	.00	.00
	Ties	13[c]		
	Total	20		
a. Prototype5b_Case5 < Prototype5a_Case5				
b. Prototype5b_Case5 > Prototype5a_Case5				
c. Prototype5b_Case5 = Prototype5a_Case5				

Table 8.5-9 Wilcoxon Signed Ranks Test_Ranks_case5

Test Statistics[a]	
	Prototype5b_Case5 - Prototype5a_Case5
Z	-2.646[b]
Asymp. Sig. (2-tailed)	.008
a. Wilcoxon Signed Ranks Test	
b. Based on positive ranks.	

Table 8.5-10 Wilcoxon Signed Ranks Test_Test Statistics _case5

Wilcoxon Signed Ranks Test Results for case6

Ranks			
	N	Mean Rank	Sum of Ranks

Prototype6b_Case6 - Prototype6a_Case6	Negative Ranks	17[a]	9.00	153.00
	Positive Ranks	0[b]	.00	.00
	Ties	3[c]		
	Total	20		
a. Prototype6b_Case6 < Prototype6a_Case6				
b. Prototype6b_Case6 > Prototype6a_Case6				
c. Prototype6b_Case6 = Prototype6a_Case6				

Table 8.5-11 Wilcoxon Signed Ranks Test_Ranks_case6

Test Statistics[a]	
	Prototype6b_Case6 - Prototype6a_Case6
Z	-4.123[b]
Asymp. Sig. (2-tailed)	.000
a. Wilcoxon Signed Ranks Test	
b. Based on positive ranks.	

Table 8.5-12 Wilcoxon Signed Ranks Test_Test Statistics _case6

Wilcoxon Signed Ranks Test Results for case7

Ranks				
		N	Mean Rank	Sum of Ranks
Prototype7b_Case7 - Prototype7a_Case7	Negative Ranks	7[a]	4.00	28.00
	Positive Ranks	0[b]	.00	.00
	Ties	13[c]		
	Total	20		
a. Prototype7b_Case7 < Prototype7a_Case7				
b. Prototype7b_Case7 > Prototype7a_Case7				
c. Prototype7b_Case7 = Prototype7a_Case7				

Table 8.5-13 Wilcoxon Signed Ranks Test_Ranks_case7

Test Statistics[a]	
	Prototype7b_Case7 - Prototype7a_Case7
Z	-2.646[b]

Asymp. Sig. (2-tailed)	.008
a. Wilcoxon Signed Ranks Test	
b. Based on positive ranks.	

Table 8.5-14 Wilcoxon Signed Ranks Test_Test Statistics _case7

Wilcoxon Signed Ranks Test Results for case8

Ranks				
		N	Mean Rank	Sum of Ranks
Prototype8b_Case8 - Prototype8a_Case8	Negative Ranks	5[a]	3.00	15.00
	Positive Ranks	0[b]	.00	.00
	Ties	15[c]		
	Total	20		
a. Prototype8b_Case8 < Prototype8a_Case8				
b. Prototype8b_Case8 > Prototype8a_Case8				
c. Prototype8b_Case8 = Prototype8a_Case8				

Table 8.5-15 Wilcoxon Signed Ranks Test_Ranks_case8

Test Statistics[a]	
	Prototype8b_Case8 - Prototype8a_Case8
Z	-2.236[b]
Asymp. Sig. (2-tailed)	.025
a. Wilcoxon Signed Ranks Test	
b. Based on positive ranks.	

Table 8.5-16 Wilcoxon Signed Ranks Test_Test Statistics _case8

Wilcoxon Signed Ranks Test Results for case9

Ranks				
		N	Mean Rank	Sum of Ranks
Prototype9b_Task9 - Prototype9a_Case9	Negative Ranks	1[a]	1.00	1.00
	Positive Ranks	0[b]	.00	.00
	Ties	19[c]		
	Total	20		
a. Prototype9b_Task9 < Prototype9a_Case9				
b. Prototype9b_Task9 > Prototype9a_Case9				

c. Prototype9b_Task9 = Prototype9a_Case9

Table 8.5-17 Wilcoxon Signed Ranks Test_Ranks_case9

Test Statistics[a]	
	Prototype9b_Task9 - Prototype9a_Case9
Z	-1.000[b]
Asymp. Sig. (2-tailed)	.317
a. Wilcoxon Signed Ranks Test	
b. Based on positive ranks.	

Table 8.5-18 Wilcoxon Signed Ranks Test_Test Statistics _case9