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Investigating the Impact of Progress Indicator Design on User Perception of Delay

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Abstract. Mobile applications have become an increasingly popular medium for Internet usage. Progress bars and progress circles including animations or ribbed patterns are often shown on the mobile app in order to keep users informed of loading processes. However, which shape is appropriate for mobile apps design to reduce users' perception of delay is still unknown. This paper aims to investigate the effect of different progress indicator shapes and whether that of having a ribbed design influences the perception of delay in mobile app design. The findings of this study show that the progress circle without having a ribbed pattern can reduce the user's perception of delay. Additionally, the progress bar indicator should include ribbed patterns since it can reduce the perception of delay when compared to those with no pattern. The contributions of this paper include increased insight into the progress indicators design on mobile devices, and user 's time perception as well as design implications for human computer interaction and user experience.

Keywords: Time Perception, User Interface, Progress Indicator, Mobile Application Design

1. Introduction

A progress indicator is a toolkit for managing time perception and user experience while using products such as applications and service interfaces. While waiting for the computer to process or for a download to complete before presenting a new page or a new action from the application, a website should inform the users how long they should be expecting to wait. In terms of human centred design, a progress indicator should display useful information to users (Myers, 1985). For example, the progress indicator should show what task is currently being processed and how much time this task is estimated to take. This information can help users to calculate the length of time left until task completion. Then, they can decide whether they could wait until this task ends or quit this task as this may be taking too long for them to wait. Additionally, the user will know how long is left until completion and can plan their time around this accordingly. The progress indicator should inform the user about a start and an end point and a remaining time. Therefore, the progress indicator should provide informative feedback to users. The users will know what is happening with the application or how long they need to wait until completion. If products provide informative feedback, it can minimize user tension and users will have a positive experience.

Presenting the progress indicator for Internet's users can reduce user's time perception. Previous studies on progress indicators explored how to reduce user perception of delay with different types of progress indicators. The different designs of progress indicator shapes have been investigated in a web browser environment and in software applications – a large screen size. For example, there is no evidence on the effect of the length or thickness of progress indicator shapes on perception of delay (Ohtsubo and Yoshida, 2014a). For progress indicator shapes, a full ring indicator can increase user experience and decrease perception of delay more than a bar indicator (Li *et al.*, 2021). Users perceive less delayed time with an animated progress indicator than with a general progress bar indicator (Hohenstein *et al.*, 2016). Displaying a progress indicator while playing a game can reduce perceived waiting time more than with watching a game story (Li *et al.*, 2020). This implies that the animated progress indicator seems to be an appropriate choice if it is displayed on a large screen size.

However, statistics show that 92 percent of Internet users access the Internet using a mobile device (Howarth, 2023) . There are some differences between websites and mobile applications. For example, mobile users need more interactive and more intuitive interfaces than being one-way communication(Kim *et al.*, 2019). Another example is that the screen size of a mobile device has a different aspect ratio and smaller size than that of a personal computer or notebook. Most mobile devices screens have a screen size of equal to or less than 6.9 inches (Hansen, 2022). This might create a barrier to the experience of usage when compared with the size of a desktop screen. Furthermore, the screen size might impact the progress indicator design and the user's time perception. To bridge the above-mentioned knowledge gaps on mobile devices, designers and developers need to be considerate about the design in the mobile environment. For example, Shakir (2017) argues that users may feel annoyance to see an animated progress indicator. They may blame that indicator for making an app delayed. While others state that a progress indicator should always be animated and visibly moving so that users do not presume the app has frozen (Chang and Ungar, 1993; Harrison *et al.*, 2007; Psannis *et al.*, 2023). However, there is little research on the effect of displaying different progress indicator patterns on the perception of delay on mobile devices.

For this problem, consequently, this paper explores the perception of delay on mobile devices with different displayed progress indicator patterns. Due to the limitation of mobile screen size, we focus on a simple design that is a progress indicator shape and having a ribbed pattern. Our research question is (1) *which design is appropriate to present in a mobile context?* and (2) *which design impacts the perception of delay?* We aim to gain more knowledge about the perception of delay and the user experience design in mobile applications in terms of Human-Computer Interaction (HCI). To ensure that the mobile users have the best experience of an interactive application.

2. Literature Review

2.1. Perception of Delay for Displaying a Progress Indicator

With regards to HCI, the relationship between user behaviour and their perception has been widely explored. For example, the perception of useability and having a positive emotional experience affect the user's intention to return to use a mobile internet banking application again (Yoon and Joung, 2020), and, in another example, an employer's perception of using social media like LinkedIn for employee recruitment (Hosain and Liu, 2020). However, this paper focus on user perception and response time as this issue could be a fundamental element of human awareness and interaction design principle.

Time perception is elusive to understand and explain. Time perception is a psychological phenomenon of how the brain experiences a period of time based on memorability and intention(Li, 2020). For user interaction with applications, short-term memory (STM), will be used for user responses and user perceptions (Konstantinou and Lavie, 2020). For example, when we read online news, we rely on STM to maintain the position of that news before we decide our next move in regard to other encountered topics. However, we sometimes experience failures of STM when the online news website cannot be loaded. Due to this issue, we might leave the website, or we might keep waiting for the website. Therefore, STM will be affected by a waiting timeframe. This is called a response time on website and application performance.

Ideally, the response time should be as fast as possible to keep users in a website and an application. Nielsen(2009) states that the duration of the waiting time is also of concern for application design. They state that users do not need any feedback for a waiting time between 0.1 and 1.0 second but if the wait is between 1.0 second- and 10-seconds applications should present feedback information in order to keep the user's attention. Other studies argued that the waiting time for displaying information on websites should be approximately 2 seconds (Fui, Nah and Fui-Hoon Nah, 2007; Galitz, 2007). For example, Galletta et al., (2004) experimented for user performance, attitudes, and behavioural intent through a variety of delayed responses (i.e., 0, 2, 4, 6, 8, 10 and 12) on a context of website loading. They found that user performance and user's attention will be decreased if the delayed time extends to 4 seconds and user's attitude will be reduced if the delay time hits 8 seconds or longer.

Therefore, people could wait for having information presented for between 2 and 10 seconds. This implies that if applications do not present feedback information, user's STM will be negatively impacted. If STM is negatively impacted, the users are more likely to leave the application or the website.

2.2. Design of Progress Indicators

A progress indicator is used to acknowledge information to users, such as for how long a task has been processing, and how long a user should expect to wait until the completion of a task. For decades, researchers have been investigating the effect of progress indicator designs on user's perception of delay and the overall user experience. These studies aim to reduce users time perception and increase user experience and user satisfaction. There are many different designs of progress indicators such as: a progress bar, a progress ring and half ring, an animated progress indictor, a progress indicator with a ribbed pattern and variations of all the aforementioned.

Harrison et al, (2010) compared user' perception of delay and user satisfaction on a progress bar indicator and a ribbed progress bar indicator. This experiment was run in the laboratory and progress indicators were presented on a Mac OSX environment. They found that their participants slightly preferred a ribbed progress indicator to a non-ribbed progress bar. Furthermore, the ribbed progress bar can reduce user' time perception. On the contrary, Kurusathianpong and Tangmanee (2018) state that there is no evidence for the ribbed progress indicator compared to the progress bar indicator without having a ribbed pattern in the context of a website loading. In this study, they also explored the effect of different progress bar indicators in regard to the length of the indicator and whether having a ribbed pattern effected the perception of delay. They found the length of the progress bar indicator has a significant effect on use perception. The short bar indicator is a better design in the context of website

loading time. They argue that their participants may focus on the waiting time rather than on the design of the progress indicator. As mentioned above, the shape of the progress bar, especially in a line bar has a significant effect on user's perception while a ribbed progress bar indicator is considered to be less effective from a design perspective.

The exploration of differing shapes of progress indicators might reveal different preferences. Bar types and circles – otherwise known as a full ring - types are a commonly utilised shape for a progress indicator. For example, Li et al, (2021) comparing the effect of presenting different shapes of progress indicators: a bar type and a circle type on user experience, and the physiological reaction. Their experiment was run in a psychological laboratory as a control environment. Rather than using a questionnaire or an interview method for collecting data, they conducted a wearable device to detect user's reaction when the progress indicator was presented. Galvanic skin response and heart rate were used to evaluate the results. This method is different from other studies even though the same research objective was stated. The results show that the participants, in particular women, are more likely to prefer a progress circle indicator to a progress bar indicator. The circle shape is less effective on user experience and has a lower physiological reaction even during a long waiting time. However, another study's example from Kim et al.(2017) investigated the effect of differing design of progress indicators: durations, shapes, embellishments, and progress function on waiting time perception. This experiment was run in the context of an online video website, and they used a questionnaire to collect participant's data. Surprisingly, a progress bar indicator has a slightly significant effect on user time perception more than a progress circle indicator while using the embellishment design did not show any effect on time perception. Noted, there is no confirmation that a ribbed design is a subset of embellishment. This study argues that the shape and embellishment might be less critical for concern in design. However, we have seen that a progress circle indicator used in online video websites.

Previous studies have explored the design of progress indicators in the context of web browsers that were on a larger screen, between 15 and 34 inches, such as the screens used for personal computers and notebooks. However, recently mobile devices are the most popular device for browsing the Internet (Howarth, 2023). Mobile devices typically have a screen size between 4.7 and 13 inches. Therefore, we hypothesized that the design of progress indictors in the context of mobile devices might be different from the context of the larger screen. Chen and Li (2020) explored the effect of different visual progress indicators and different periods of waiting time on user time perception. They conducted this using three designs of progress indicators: a bar shape, a pie shape, and a logo and three periods of waiting time: 2s, 5s and 10s. This experiment was run in a lab and participants were asked to use a provided mobile device that was the iOS 4.7 inches screen (iPhone 6s) for browsing an online news application. There were 30 participants who were under 35 years old. The results show that most participants prefer the cartoon indicator to the bar type and the pie type. The cartoon indicator can reduce user's time perception, especially while the wait time is 10 seconds or greater whilst the cartoon indicator has no effect when the wait time is 2 seconds. Unexpectedly, there is no evidence on the effect of presenting the cartoon indicator on user experience. However, they state that a complex design on the progress indicator might distract user attention from the waiting time.

Meanwhile, research has shown that providing more pieces of information while waiting leads to an increase user perception of passed time(Drnevich and Croson, 2013). This can imply that a complex design could make users feel like the wait is longer. Wang et al, (2021) studied that designs of progress indicators can impact the user experience and time perception. There were four indicator designs: null, circle, logo, and a combination between a logo and a slogan. This experiment was run in a psychological lab and used a mobile emulator on a personal computer, representing an iPhone X. They found that a combination between a logo and a slogan is appropriate for an initial loading page and participants have a positive emotional experience to this design. The circle type of a progress indicator can make users perceive a shorter waiting time in comparison to having no progress indicator. However, the combination types would be inappropriate in other loading pages, especially in the application itself.

This implies that a picture and a short text information should not be a part of the progress indicator that will be used in mobile application.

It seems that certain designs of progress indicators should be matched with specific environments such as websites, online streaming websites, desktop devices and mobile devices. Therefore, displaying different progress indicator types on mobile applications should be investigated in greater depth and detail. Thus, in this study, we aim to focus on the context of mobile interface design and how to develop an appropriate progress indicator to reduce user's perception of delay in order to improve user experience on mobile devices.

3. Method

3.1. Research objectives and hypotheses

This paper aims to explore appropriate designs for progress indicators for mobile apps. When it refers to mobile apps, mobile users have different needs and expectations than desktop users. The mobile users are often use mobile apps and sites on the go. Hence, they have shorter attentions, and they also use smaller screens and touch interfaces. For mobile app design, intuitively, the a few strategies for designing mobile apps are to make an app easy to access information or functions that they are looking for as well as the interface should be readable(Weichbroth, 2020).

We will compare the effect of four different types of progress indicator - Bar, Circle, with a ribbed pattern and Combinations of the aforementioned - on user's perception delay while watching clips on the YouTube mobile application. Therefore, the hypothesis of this experiment was about the differing effects of displaying four different progress indicator patterns on the perception of delay.

3.2. Experiment design

For this experiment we designed progress indicators with simplicity and readability in mind. Rectangular shapes and not having ribbed patterns on the progress indicator are considered appropriate because they have a simple design. Also, this is consistent with research that a progress bar indicator is a more appropriate design than a progress circle indicator and an embellishment indicator in the context of online video websites (Park and Kim, 2017). Nevertheless, exploring current designs of progress indicators on mobile apps, we found that a circle with a ribbed pattern is often used for representing a loading page in online video websites and a progress bar indicator are often displayed for task loading status in mobile apps such as the Duolingo app (Nushi and Eqbali, 2016), HealthyTogether (Chen and Pu, 2014). Therefore, a progress shape indicator and having ribbed pattern are interested in this study.

The aim of this paper is comparing different independent variables to find which one is suitable in a specific situation. The between – subject study design is used for minimizing participant's learning effect bias. An individual independent variable was assigned to each participant as a balance to randomise the display to each participant.

For the control environment, the duration of displaying progress indicators in this experiment was 10 seconds as per Nielsen (2009) and Chen and Li (2020). Ten seconds of waiting time is suitable to display the progress indicator because if less than 10 seconds participants may not look at the progress indicator and if longer than 10 seconds the participant might lose focus and leave the experiment. Additionally, an individual progress indicator was run on a white background and a blue colour was assigned on each progress indicator. The same length was used for all progress indicators.

In this experiment, the independent variable was a progressive pattern, including *a shape (bar, circle) and a ribbed display (having ribbed and having not ribbed)*. Four types of progressive information (2 * 2) were therefore created in this experiment (see Fig. 1). The dependent variable was *perception of delay*. We conducted a set of questions on the user's perception of delay. These questions were developed from previous studies, for example, how long did you have to wait for the YouTube content to load? how fast did you perceive the website displayed the content? how much satisfaction did you feel for the waiting time for displaying the content? and how much benefit did you acquire after wating

for the contents? (Shakir, 2017; Wang *et al.*, 2021)These questions were used to calculate the user's perception of delay.

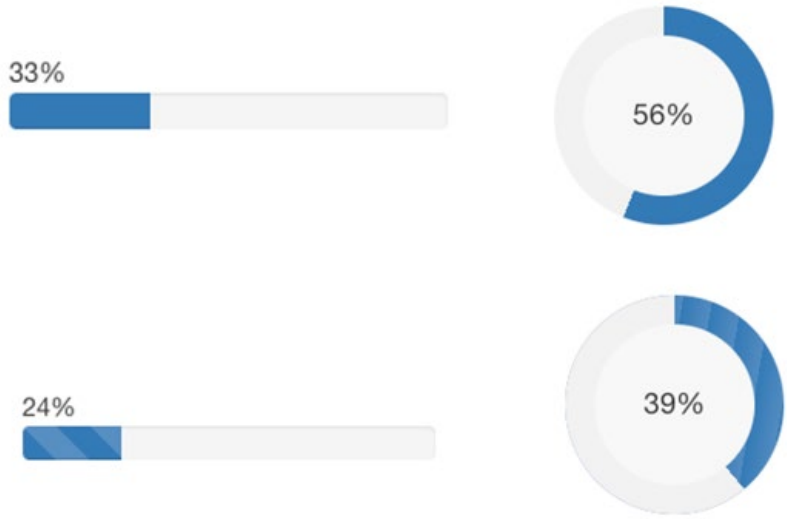

Fig. 1: There are four types of a progress indicator: a progress bar on the top left, a progress circle on the top right, a ribbed progress bar on the bottom left and a ribbed progress circle on the bottom right.

Before starting the experiment, we minimised the possible effect from other variables such as the colour of the progressive indicator, and the length of the progressive indicator. The colour of the progressive pattern was blue, while the colour of the progressive pattern with a ribbed pattern was blue and light blue. Both colour patterns were suggested from the Bootstrap custom progress bar feature that is commonly used by designers or developers (Bootstrap, no date). Therefore, we presume that participants are familiar with these progressive indictors, and it does not distract the participant's focus. For controlling the speed of the indicator, the length of progressive indicators for both patterns used the same length.

3.3. Participants

In total, 240 participants took part in this study. They were recruited by word of mouth, and through advertised posts on Facebook groups and through emails. 139 of the participants used their personal computer or tablet for this experiment while 101 participants used a mobile device for this experiment. However, this study focused on mobile devices because the mobile device is the most popular device type for watching YouTube. Therefore, only the 101 participants using a mobile device were used for analysis in this study. Of these, 60 identified as females, 40 as males and 1 who do not identify with any gender. On average, they were 20 years old (M = 20.61, SD = 3.93). The participants reported they were, on average, at an entry level of programming language (M = 1.37, SD = 1.83). Their online learning experience was, on average, 11 hours weekly (M = 10.58, SD = 9.45).

3.4. Procedure

There were three main tasks: (1) waiting for a YouTube clip with a progress indicator, (2) watching a clip, and (3) completing the user's perception of delay questionnaire. We combined an online experiment task and an online questionnaire on the Gorilla platform which is a psychological experiment builder (https://gorilla.sc/). Participants in this experiment were asked to use their own mobile devices with their default browsers. Therefore, the experience was broadly the same regardless of the operating system of the mobile device.

A Likert scale was used to evaluate participant's perception. The Likert scales included twenty-one response scales: – 10 for the most negative experience, 0 for a neutral experience and 10 for the most positive experience. Rather than giving a definition for each point, we used the positive and negative number representing the valence of emotional experience. Also, the Likert scales contains multiple items which is more reliable than a single item (Albaum, 2018).

After signing the online consent form, each participant waited for the YouTube clip while being presented with a progressive indicator. The waiting time was set at 10 seconds. Then the participants were presented the YouTube clip as called the five common mistakes of User Experience (UX) design. They were asked to watch this clip with a duration of around 6 minutes. The clip was chosen because its content is a common basic user experience presented with good examples. It is easy to understand and thus reduce subject's bias. Next the questionnaire was presented on the screen. In total, the participants took around 10 minutes to complete this study.

3.5. Statistical Processing

This study, R programming was used to handle collected data and being a statistical tool for analysis data. Cronbach's Alpha was used which is a measure of internal consistency or reliability that is how correlation between a set of survey items are as a group. The Cronbach's Alpha quantifies the level of alpha on a standardized 0 to 1 scale. A high value of alpha indicates that the response values for each participant across a set of items are consistent.

Analysis of Variance (ANOVA) is a statistical formular to compare variance across the means of different groups. This formular helps us to understand there are significant different between the means of independent variables in this study.

4. Results

The participants had a moderately positive perception, on average, at 3.74. The skew of the perception of delay was found to be 0.19 and the kurtosis of the perception of delay was -0.70, indicating that the distribution was a symmetrical distribution (see in Table 1). Additionally, the Cronbach's alpha coefficient for the perception questions is 0.80, suggesting these questions have a high internal consistency.

Table 1: Descriptive data of user's perceived delay classified by progress indicator types.

Pattern	N	Mean	SD	Skewness	Kurtosis
Bar	39	3.86	3.49	0.21	- 0.75
Circle	62	3.66	3.30	0.18	- 0.66
Total	**101**	**3.74**	**3.36**	**0.19**	**- 0.70**
Have ribbed	50	3.98	3.36	- 0.06	- 0.62
Have no ribbed	51	3.50	3.37	0.48	- 0.57
Total	**101**	**3.74**	**3.36**	**0.19**	**- 0.70**

To test user's perception of delay for different progress indicator patterns, an analysis of variance (ANOVA) was performed (see in Table 2). The result shows that the interaction between the progress indicator shapes and the progress indicator with a ribbed pattern has a significant effect as $F(1, 97) = 4.65, p = .032$.

Fig. 2 shows that the lines for having ribbed display and having no ribbed display on the progress indicator do intersect, which indicates that there is likely an interaction effect between patterns and whether ribbed is used. If the progress indicator provides a bar shape with a ribbed pattern the perception of delay will be lower. Nevertheless, the circle progress indicator without a ribbed pattern will have the lowest perceived delay when it is shown on mobile applications.

Table 2: The effect of mean of perception of delay on different indicator types.

Sources	Sum of Squares	df	Mean Square	F	Sig
Shape	0.78	1	0.78	0.71	0.79
Ribbed	0.53	1	0.53	0.05	0.83
Shape * Ribbed	51.32	1	51.32	4.67	0.03
Error	1070.55	97	11.04		
Total	2539.63	100			

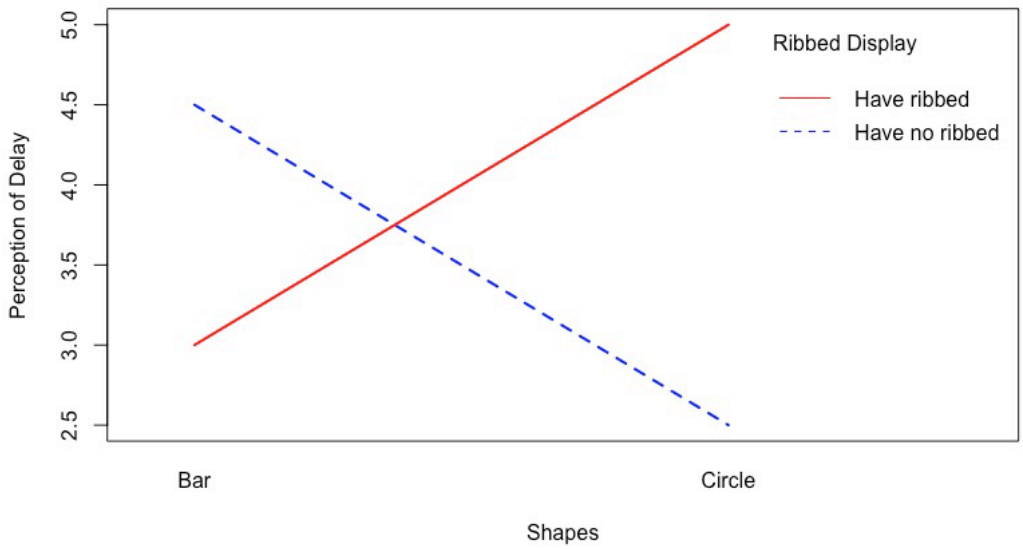

Fig. 2: The interaction plot between progress indicator patterns and the average value of perception of delay.

5. Discussion

5.1. Principal Findings

This study explores the effect of presenting different progress indicators on user's perception of delay. The main independent variables in this study are the differing shapes and whether or not there is a ribbed design employed. Additionally, this study also investigates using a mobile device for media consumption such as watching YouTube. In the experiment, participants were asked to watch an informative video called the five common mistakes of user experience (UX). The progress indicator was presented for 10 seconds before the clip was displayed.

Our findings show that the effect of presenting different progress indicators can affect the perception of delay. The results of this study confirm that a progress indicator should still be considered to be implemented in mobile devices when apps or web browsers need a loading time. It helps users perceive a shorter waiting time. There are two main findings in this study.

First, a bar shaped progress indicator with a ribbed pattern can make the user experience feel faster than a bar shape without ribbed patterns when users are browsing a mobile app. This finding is in the

line with prior studies. In the past study of Harrison et al, (2010), they state that a progress bar with a ribbed pattern has a strongly significant effect on user's perception. However, our finding is opposite to the study of Kurusathianpong and Tangmanee (2018). They found that there is no evidence of showing a progress bar indicator with having ribbed pattern on user perception of waiting in the context of a website loading page and in a PC environment. Their studies have two dependent variables: the length of indicators and having ribbed pattern. This could create different outcomes when compared to this study which is constructed differently. Moreover, the ribbed pattern included in a progress bar is a commonly used tactic for showing the products status to users while the products are operating in the background. We can extend this logic to assume that users would also like to see a ribbed pattern loading progress bar inside mobile apps as well. The ribbed pattern used as a minimal graphic display on the progress bar could reduce user' time perception because users like to be reassured that the application is still working.

Secondly, unexpectedly, a progress circle indicator does not need to include a ribbed pattern and users can still perceive less delay. This finding is a surprising differentiation from the progress bar indicator. This finding shows that the perception of delay for using a progress circle indicator without ribbed pattern has less than the average rating of the perception of delay at 3.74. It was also less than the perception of delay for displaying a progress bar indicator with ribbed pattern. Therefore, the progress circle indicator without a ribbed pattern is a better fit for mobile applications. Supported by Li et al. (2021) reported that their participants preferred a ring indicator. Using a spinner - a circle progressive indicator with animated ribbed patterns - might be annoying to some users (Shakir, 2017). Observing, a progress circle indicator is a simple animated icon with the colour bar inside the circle moving continuously to indicate that the application is still working. Having ribbed in the circle seems to not impact the effectiveness either way. Therefore, we can conclude that as users were watching apps on mobile devices, a progress circle indicator without ribbed patterns would be best suited to reduce user's perception of delay.

5.2. Design Implications

One of the essential toolkits for designing product interfaces is a progress indicator. In the theorical design state a progress indicator can reduce a user's perception of delay and increase the positive user experience of using the product. The progress indicator needs to provide informative feedback such as how long a task has been processing, and how long a user could expect to wait until the completion of a task. There are two general shapes of progress indicators: bar shape and circle shape. Previous scholars have discussed which design is suitable for users. However, not every single design process can handle implementing these features for time perception and user experience.

This study confirms that displaying different progress indicator shapes and whether or not having ribbed can affect perception of delay especially while displaying it on a mobile application. This study suggests that a progress circle without a ribbed pattern is a better design to reduce user's time perception for mobile apps. Users might not focus on the ribbed pattern, but they focus on the entire progress of the circle indictor. Additionally, the screen size for a mobile device is limited. The progress circle indicator can fit better on the smaller screen. When the circle indicator is processing, the colour bar inside the circle will move, following the application's background operation. Users might see the circle character as an animation. The users might not need to see the additional animation for the ribbed pattern on the circle indicator. However, if designers and developers want to use a progress bar on mobile apps, the progress bar indictor should have a ribbed pattern. This is a commonly used design for a progress bar indicator.

5.3. Limitations

Most of the participants were undergrad students, the results for this study might not be appropriate to other age groups. However, the participants can represent the most active users of mobile applications, and therefore a potential target audience (Lauren, 2023). We believe that the participants in this study

can represent the target population. Also, we emphasise that the results of this study are illustrative, not representative. Additionally, this experiment was run in Thailand so the effect of different cultures might play a big role on time perception (Chen, Lee and Hwang, 2018) as well as user's gender might affect time perceptions (Li *et al.*, 2021) that is not investigated in this study. Therefore, it can be suggested that these issues for future works can focus on things such as expanded experiments in the field experiment and, the effect of cultural differences and gender on user's time perception. Moreover, Future's studies could further investigate the different characteristics of progress indicators such as the speed of indicator's motion, display location on a mobile screen, and having or not having an animated icon. These issues can lead to greater insight into understanding the user experience in a mobile environment.

6. Conclusion

In this paper, we aim to explore the effect of displaying different progress indicators on mobile apps on the perception of delay. Generally, a bar progress indicator including ribbed patterns can reduce the user's perception of delay. Our finding also shows the potential of implementing a circle progress indicator without ribbed patterns and that this can even further reduce users perceived delay if the indicator is displayed on mobile apps. Due to the screen size limit on mobile devices displaying appropriate progress indicators should be of concern. To improve the usability and efficiency of user experience, this finding paves the way for further research and future UX design paradigms on mobile apps.

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