The Effect of Progress Indicator Speeds on Users' Time Perceptions and Experience of a Smartphone User Interface

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Abstract. The primary goal of this study focused on manipulating the speed of the progress indicator to decrease users' time perception and improve satisfaction with and personal preference for a smartphone user interface. The experiment of this study adopted a 3 × 2 mixed factorial design using ANOVA to examine the three progress indicator speeds, i.e., normal, slow to fast and fast to slow, and two wait durations, 5 s and 15 s, using different progress indicators. The results show that speed has no significant effect on time perception. However, a more complex feedback type may increase participants' time perception, especially for a long wait duration (i.e., 15 s). The speed of "fast to slow" can make participants more satisfied than the speed "slow to fast," just in the case of the bar indicator. Participants were more satisfied with 5 s than 15 s. Finally, there was a positive impact on the participants' preferences when they perceived a shorter wait duration.

Keywords: Progress indicator speed · Time perception · Smartphone application · User interface · User experience

1 Introduction

In recent years, the habit of watching videos on a smartphone has become a popular activity in peoples' daily life. This means that the interface needs to be further improved in terms of user experience for better usage. However, the wait state on smartphone interfaces is unavoidable, especially when using interactive applications to access media videos. Numerous researchers have found that users' experience may be negative when facing the interface wait.

Facing the waiting problem, the original solution was to keep the user informed of the application wait state to alleviate the user's negative experiences. However, modern users require a more intelligent and interesting way to deal with their experience. Hornik (1984) indicated that individuals have a tendency to overestimate wait duration. Therefore, waiting is a problem that is difficult to solve on the user interface. Although some studies have investigated the function of different progress behaviors on website user interfaces, the specific visual progress indicator applied to the smartphone interface needs further study.

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Nielsen (2010) indicated that even a few seconds' waits is enough to create an unpleasant user experience. Thus, it is especially important to design appropriate indicators to deliver the negative influence for smartphone applications. A good indicator behavior should relieve the users' negativity experience of the user-smartphone interaction (i.e., reduce time perception and improve satisfaction). The relationship between the speed of the visual progress indicator and time perception has been found. Some studies have revealed that different progress bar behaviors appear to have a significant effect on users' perception of wait duration for website interfaces (Enomoto et al. 2006; Harrison et al. 2007; Branaghan and Sanchez 2009; Harrison et al. 2010). Kum et al.'s (2008) results showed that the duration estimates were influenced by the user's time paradigm and the variable speed with which time passage is perceived. However, there are still uncertain results in the early literature on the speed of progress indicators. Conrad et al. (2010) indicated that if the early feedback indicated slow progress, the user's subjective experience would be more negative than if the early feedback indicated faster progress. The "fast-to-slow" indicators reduced drop-off rates because they provide the encouragement users need (Villar et al. 2013; Kim et al. 2017). In contrast, Harrison et al. (2007) suggested that users are most willing to tolerate negative progress behavior, i.e., stalls and inconsistent progress, at the beginning of an operation. Participants prefer a linear moving progress bar and will judge that the process duration is shorter (Branaghan and Sanchez 2009; Amer and Johnson 2016). Therefore, this study aimed to investigate how the speed of visual progress indicators and wait durations affected users' wait time perceptions and user experience focusing on smartphone interface design.

2 Method

2.1 Participants

The purposive sampling procedure was used in this study. A total of 96 participants were invited to participate in our study (69 females, 27 males). They ranged in age from 16–39 years. The majority of participants were students (72%) and the others were office workers (28%). Almost all of the participants had experience of using smartphones to watch videos, with 41% watching for less than 30 min every day, 27% spending an average of 31–60 min, and 31% more than 1 h.

2.2 Apparatus and Prototype

The experimental design in this study adopted the "Illustrator" software for graphic design, then used the "Flash" software to produce the "progress indicator" gif animation, and finally used "Proto.io" to make the application (app) prototype. The progress indicators are shown in Fig. 1. The prototype is a smartphone app developed to simulate an online video. The target users are young people. We used IOS (Ipone7 plus) version 1.3.3 installed on a smartphone with a 5.5-in. screen. In all, 24 versions of the app prototype were created for the experiment. The progress indicator speeds were normal, slow to fast, and fast to slow.

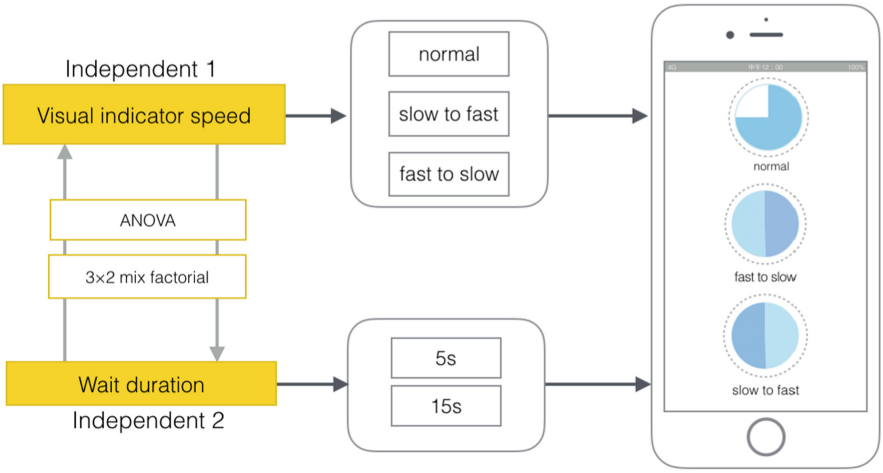

Fig. 1. The progress indicator speeds (normal, slow to fast, and fast to slow). The variable speed of visual types starts from the middle (e.g., Round-cake, 5 s wait duration). The wait durations (5 s and 15 s).

2.3 Design

The research approach included the gathering of quantitative and qualitative data from the experiment. A total of 96 (69 females, 27 males) participants were invited to participate in this study. The study employed a mixed factorial design (3 × 2), whereby each participant experienced three visual indicator speeds, i.e., normal speed, fast to slow ("fast-first-then-slow"), and slow to fast ("slow-first-then-fast"), and two wait durations, i.e., 5 s and 15 s. A total of six experiments were conducted. In the normal speed design, the progress shown is constant to the wait durations. In the "fast to slow" case, the speed of the progress goes from fast to slow across the screen, moving fast during the first half of the progress and slowing down in the second half. The "slow to fast" indicator is just the opposite: the progress is slow during the first half of the progress and speeds up in the second half. Presentation order was randomized for each participant on the smartphone screen. In this study, we used verbal estimation to judge the perceived wait duration. The research model is shown in Fig. 2.

2.4 Procedure

The research approach combined the gathering of quantitative and qualitative data. Participants were tested individually in an area free from auditory and visual distractions. At the start of the exercise, participants were provided with a smartphone, and were informed that the purpose of the study was to focus on the "progress indicators." The task operations were "search for a film," "play the film," and "download the film." Then, the participants were asked to give their personal details, including name, age, profession, and experience of using video apps. After the task was completed, the participants had to estimate the wait duration using a scale ranging from 1 s to 60 s,

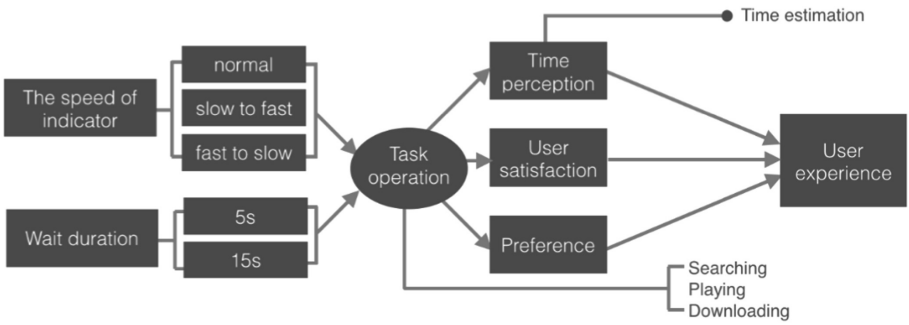

Fig. 2. An Integrative Model of this research.

and rate their satisfaction on a 7-point Likert scale (from 1 "less satisfied" to 7 "greatly satisfied"). When the participants experienced the different progress indicators, they were forced to choose which speed of the progress indicator they liked the most. Finally, we conducted a simple interview with the subjects regarding their experience. Each participant took about 20 min to conduct the face-to-face experiment.

3 Results and Discussion

In this study we conducted a mixed factorial analysis of variance (ANOVA). The wait duration was the between-participants factor, and progress indicator speed was the within-participants factor to test the different feedback types. In the analyses, we estimated the effects of the speed of the indicator on the users' perceptions, experience, and preferences, and the interaction effects between the wait duration and progress indicator speed.

3.1 The Mixed Factorial Analysis of "Time × Speed"

The results were generated from the mixed factorial ANOVA, which is related to the comparison of the two wait durations, and the comparison of the three indicator speeds.

3.2 Time Perception

Based on the results illustrated in Table 1, the main effects of the progress indicator speed showed no significant difference for all the feedback types. However, the main effects of "Wait duration" were a significant difference regarding the participant's time perception. The "bar" type was ($F_{1,22}$ = 13.323, P = .001 < .01), the "bear-bar" was ($F_{1,22}$ = 8.695, P = .007 < .01), the "round-cake" was ($F_{1,22}$ = 6.267, P = .020 < .05), and the "bear-cup" was ($F_{1,22}$ = 1.187, P = .004 < .01). The pairwise comparisons of the Wait durations for all of the feedback types showed that the participants estimated the time of 15 s as always greater than 5 s, which seems to be a common sense result.

Table 1. The mixed factorial analysis of time estimation.

Source		SS	df	MS	F	P
Bar	Speed	2.194	2	1.097	.119	.888
	Time	96.681	1	96.681	13.323	.001**
	Speed * Time	38.528	2	19.264	2.095	.135
Bear bar	Speed	12.444	2	6.222	.261	.771
	Time	2123.347	1	2123.347	8.695	.007**
	Speed * Time	38.111	2	19.056	.800	.381
Round-cake	Speed	44.194	2	22.097	1.460	.243
	Time	734.722	1	734.722	6.267	.020*
	Speed * Time	2.028	2	1.014	.985	.381
Cartoon	Speed	4.694	2	2.347	.220	.803
	Time	968.000	1	968.000	1.187	.004*
	Speed * Time	2.583	2	1.292	.121	.886

*P < .05 **P < .01

Through a more detailed discussion, the "bar" and "round-cake" types were overestimated at 5 s and underestimated at 15 s. However, the "bear-bar" and "bear-cup" types were overestimated at both 5 s and 15 s. This is an interesting result, and a possible reason is that the "bear-bar" and "bear-cup" are more complex visual presentations. The overestimation of the long Wait duration can be explained by Vierordt (1968) who stated that in unusual or stressful situations, longer durations are usually overestimated. Brown (1995) suggested that greater numbers of moving stimuli would lead to a further lengthening of perceived time if the stimuli were highly distinctive. The estimation of duration involves memory when the time duration is over 5 s (Fraisse 1984). The processing of long durations requires sustained attention and memory processes (Droit-Volet et al. 2016). Lallemand and Gronier (2012) indicated that users tend to focus on temporal signals in relatively detailed feedback, opening the attentional gate and leaving free passage to many pulses, thus lengthening the time. Therefore, the results can be explained by some theories, and it is easy to increase the time perception of the participants when presenting a more complex visual presentation, especially for shorter wait times (i.e., 5 s).

3.3 The Degree of Satisfaction

Based on the mixed ANOVA results shown in Table 2, for the "bar" type, the main effect of the progress indicator speed showed a significant difference ($F_{2,44} = 3.348$, $P = .044 < .01$). The Post Hoc test showed that the progress indicator speeds of "fast to slow" ($M = 4.04$, $SD = 1.23$) and "slow to fast" ($M = 3.37$, $SD = 1.31$) showed a significant difference ($P = .026 < .05$). Obviously, the participants were satisfied with "fast to slow" and were not satisfied with "slow to fast."

For the "Bear bar" type, the main effect of wait duration showed a significant difference ($F_{1,22} = 7.579$, $P = .012 < .05$). It demonstrated that participants were more satisfied with 5 s ($M = 5.22$), and slightly satisfied with 15 s ($M = 4.19$).

Table 2. The two factors ANOVA factorial analysis of satisfaction.

Source		SS	df	MS	F	P	POST-HOC(LSD)
Bar	Speed	5.444	2	2.722	3.348	.044*	Fast to slow > slow to fast
	Time	8.681	1	8.681	2.492	.129	
	Speed * Time	1.444	2	.722	.888	.419	
	Speed	1.083	2	.542	.378	.687	
Bear bar	Time	8.681	1	19.014	7.579	.012*	5 s > 15 s
	Speed * Time	2.528	2	1.264	.882	.421	
	Speed	.083	2	.042	.064	.938	
Round-cake	Time	33.347	1	33.347	7.497	.012*	5 s > 15 s
	Speed * Time	1.861	2	.931	1.426	.251	
	Speed	.657	2	.328	.749	.487	
Bear-cup	Time	2.731	1	2.731	1.585	.240	
	Speed * Time	3.687	2	1.843	4.206	.032*	

*P < .05 **P < .01

For the "round-cake" type, the main effect of wait duration showed a significant difference ($F_{1,22}$ = 7.497, P = .012 < .05). It demonstrated that the participants were more satisfied with 5 s (M = 5.22), and not satisfied with 15 s (M = 3.86).

For the "bear-cup" type, the interaction effect between the progress indicator speed and Wait duration showed a significant difference (F = 4.206, P = .032 < .05).

As described in the caption in Fig. 3, the analysis shows that the participants were more satisfied with 15 s and less satisfied with 5 s for "slow to fast." In contrast, the participants were more satisfied with 5 s and less satisfied with 15 s for "normal" and "fast to slow."

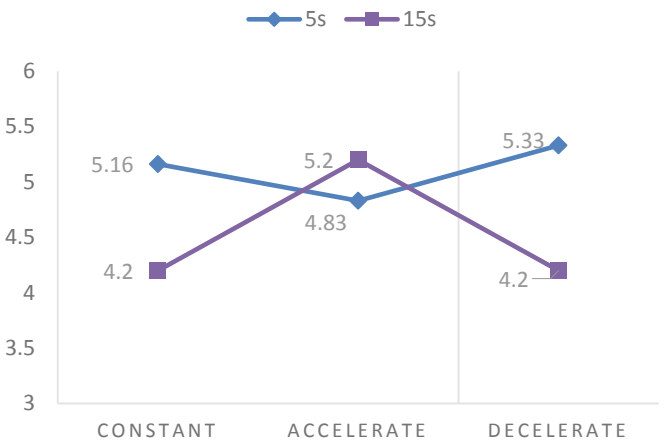

Fig. 3. Interaction effects of Speed × Time for the "bear-cup" type. Note: The vertical axis reflects the score, where higher scores on this measure indicate that time was more "satisfactory." The horizontal axis represents the progress indicator speed.

The data above reveal that no matter for which feedback type, the participants were satisfied with "fast to slow" and were not satisfied with "normal" or "slow to fast." In addition, they were more satisfied with the wait duration of 5 s and less satisfied with the wait duration of 15 s. This is consistent with Hoxmeier and DiCesare (2000), who indicated that satisfaction decreases as response time increases, and there appears to be a level of intolerance in the 12 s response range.

3.4 Individual Preference

The mean average of preference is shown in Fig. 4. Overall, 29% of the participants preferred "normal," 28% preferred "slow to fast," and 39% preferred "fast to slow." The results indicated that the participants preferred the Speed of "fast to slow" compared to "slow to fast" and "normal." An explanation for this result from the analysis of the qualitative interview data is that: (1) progressing fast at first gives a better first impression and anticipation that the loading will finish soon, and (2) becoming slow at the end is acceptable because loading is almost finished. These results were consistent with the work by Kim et al. (Kim et al. 2017).

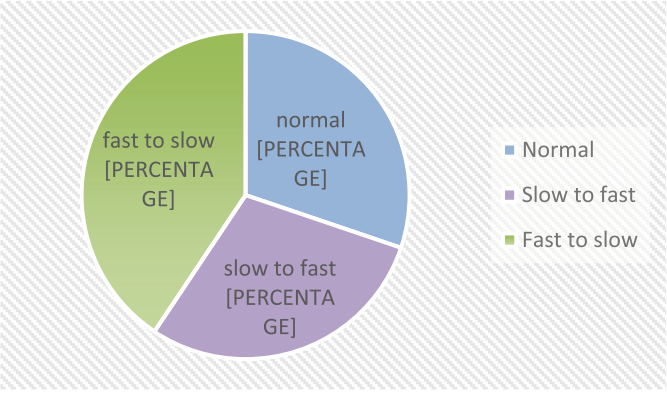

Fig. 4. The preference of feedback types (The fraction represents the percentage and the range is 0–60).

Additionally, we found that participants are more likely to fast speed at beginning:

'if the initial speed was slow, they did not want to wait'.

Conrad et al. (2010) indicated that encouraging early feedback led respondents to perceive the whole experience more favorably. Through the results of the mean analysis and interviews, we concluded that preference also depends on the individual's characteristics.

4 Conclusions

In this paper, we have several implications about the visual speeds indicator and wait duration impacts for several indicator types on the smartphone user interface. The present research concludes with several design guides which can be applied to smartphone applications that employ visual indicators to contribute to a faster perception, greater satisfaction, and user preference. The results of our study are summarized as follows:

1. The different speeds of the visual indicator did not significantly reduce the participants' perceived time for any of the wait durations. Thus, smartphone application designers should not consider that the visual indicator speed will reduce perceived time.
2. It should be noted that the wait duration of 15 s was not always underestimated. More complex visual patterns may increase participants' time perception for relatively long wait durations.
3. The visual indicator speed of "fast to slow" can help participants perceive a shorter wait duration than "slow to fast."
4. The participant's satisfaction could be possibly improved as the wait duration decreases. Participants were more satisfied with 5 s than with 15 s.
5. Most of the participants preferred the speed of "fast to slow" to "normal" and "slow to fast." From the interviews, we noted that user's preference was also dependent on the individual's characteristics.

The speed of visual feedback experienced on a smartphone wait interface can have interesting theoretical implications and important commercial consequences. Designers can contribute to progress indicators to either reduce users' wait duration or improve the user experience.

5 Limitation and Future Work

The factors that may influence the perception of Wait duration deserve mention: the block area size of the progress indicator, the participant's level of interest in the video contents, the screen background color, and the gender difference, with women providing longer duration estimates than men (Block et al. 2000; Yarmey 1993). In our study, the number of women are more than that of men. Users may have different levels of perception and cognition. Finally, our study focuses on a no percent-done progress indicator design.

The future research might expand the feedback types and speed behaviors, the amount of feedback information, and at least several levels of duration in an attempt to manipulate the users' time perception, experience, and preference.

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