Using Gamification to Motivate Children to Complete Empirical Studies in Lab Environments

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ABSTRACT

In this paper, we describe the challenges we encountered and solutions we developed while collecting mobile touch and gesture interaction data in laboratory conditions from children ages 5 to 7 years old. We identify several challenges of conducting empirical studies with young children, including study length, motivation, and environment. We then propose and validate techniques for designing study protocols for this age group, focusing on the use of *gamification* components to better engage children in laboratory studies. The use of gamification increased our study task completion rates from 73% to 97%. This research contributes a better understanding of how to design study protocols for young children when lab studies are needed or preferred. Research with younger age groups alongside older children, adults, and special populations can lead to more sound guidelines for universal usability of mobile applications.

Categories and Subject Descriptors

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Keywords

Child-computer interaction, touch interaction, gesture interaction, mobile devices, empirical studies, touchscreens.

1. INTRODUCTION

Research in child-computer interaction has often used child-centered methods or has significantly adapted protocols specifically for children; *empirical* studies with children have not been utilized as frequently [8,17]. In some cases, however, laboratory studies are necessary or preferred, such as when making direct comparisons between adults and children or when collecting certain types of data [2,3,5]. In this paper, we present a two-part study (Study 1 and Study 2) conducted with children ages 5 to 7 to collect samples of mobile touch and gesture interaction data. This study is an extension of previous studies we conducted with adults (18 years and older) and older children (ages 7 to 17) [2,3,5]. As mobile device ownership, including iPads, e-readers, and smartphones, has become a growing trend in young children (5 to 12 year olds) in the United States [10,12,14], we aim to understand and characterize how children engage with such technology. Developmental psychology literature points to differences in cognitive and physical capabilities of young children compared to older children and adults [16,18], and has inspired us to extend our work to younger age groups.

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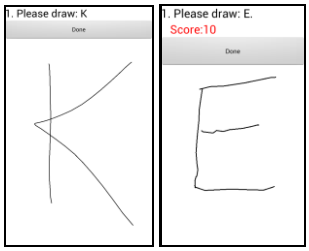
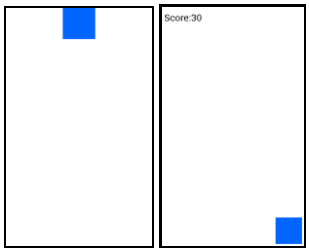


(a) Gesture Task: original (left) and gamified (right).



(b) Target Task: original (left) and gamified (right).

Figure 1. Original and gamified apps for each study task.

Like past work in this space [2,3,5], this study was conducted in a controlled laboratory environment in order to increase the robustness and rigor of the input that was sampled from users. We encountered several challenges working with young children in this environment, including study length, participant motivation (e.g., due to shorter attention spans of young children), and environment. Based on our observations from Study 1, we modified the study protocol to address these challenges by introducing *gamification* components to the empirical protocol. We found all but one participant completed all tasks in Study 2, compared to only 2 participants who did so in Study 1.

Based on this work, we offer guidelines for conducting research with this age group. These guidelines include adding gamification elements such as points, levels, and prizes for progress in the experimental task (Figure 1), understanding how to motivate children as compared to adults, and balancing distractions in the environment. This research contributes a better understanding of how to design study protocols for young children when lab studies are needed or preferred and can lead to important guidelines for universal usability of mobile applications.

2. RELATED WORK

2.1 HCI Studies with Children

A variety of methods have been used in child-computer interaction research. Much work has focused on children as co-designers in the research process [11]. Methods such as *participatory design* [7] and *experience design* [9] focus on how target users can be involved as partners in the design process. Participatory and experience design are particularly well-suited for research with children because they engage children in interactive formats. Studies show that in such methods, children can act as informants and co-designers to give feedback on prototypes [9]. Other researchers have conducted think-aloud protocols with children [1,11]. These examples illustrate that much research has been done exploring children's interactions in natural environments. This approach is important for understanding interaction within the user's context. However, research with children in more formal settings may be necessary or preferable for certain types of research. For example, when the goal is to collect many samples of input data, a laboratory setting may provide an environment that is free from distractions. Similarly, our work requires multiple samples to train intelligent models on expected input data [2,3,5]. We therefore have modified existing protocols developed for adults and older children for our previous formal lab studies to work with young children for this research, in the context of touchscreen mobile device use.

2.2 Gamification

Gamification is defined as "the use of game design elements in non-game contexts" [6,13]. This principle has been used in a variety of contexts such as fitness and context-aware applications [6], but is only beginning to emerge in research with younger age groups [19]. Rewards, a component of gamification, can drive participation [15]. Also, these components can increase participation and motivation while doing routine tasks [4]. Similar to many empirical studies, the tasks in our study can feel repetitive and tedious, especially for children. After we conducted Study 1, the importance of motivation for study completion with children of this age group became evident. Therefore, we added gamification elements to Study 2.

3. STUDY 1

For this work, we modified existing protocols from our past research with adults, teenagers, and pre-teen children that aimed to find differences in their touch and gesture patterns [2,3,5]. We conducted a two-part study to understand if the same protocol would be appropriate for younger children (ages 5 to 7) and to explore any necessary changes. The study protocol included both touch interaction tasks and gesture interaction tasks [2]. For the gesture tasks, participants were asked to use their finger to draw gestures onscreen. For the target tasks, participants touched square targets onscreen. The study was conducted in an academic usability lab, and (with permission) each participant's interactions were recorded via video camera. Participants were compensated $10 for their time. The sessions lasted about one hour.

3.1 Study 1 Participants

The first part of the study included 7 children with an average age of 6 years (M = 6 yrs, *Range* = 5 to 7 yrs, SD = 1 yr). Three participants were male and four were female. Most (6) were right-handed. All of our participants told us they had used smartphones before the session.

3.2 Study 1 Procedure

The Gesture Task application showed participants a blank screen with a prompt indicating which gesture to make (Figure 1a). Using their finger, participants drew 6 samples of 20 different gestures (letters, numbers, shapes, and symbols) on the device screen; they pressed an onscreen "Done" button when finished [2]. In the Gesture Feedback condition, as participants drew each gesture, a trace appeared under their finger of the gesture. In the Gesture No-Feedback condition, participants did not see this trace. (This lack of visual feedback emulates the behavior of standard command-based gestures such as swipe and zoom on mobile devices. More details can be found in our prior work [2].)

The Target Task application showed one square target onscreen at a time for the user to touch (Figure 1b). The app included 104 targets of 4 different sizes (very small—1/8", small—1/4", medium—3/8", and large—1/2") in 13 different interface positions [2]. After the user successfully touched the target, the app advanced to the next target. The order of targets represented all possible transitions between target positions and sizes, and no two consecutive targets had the same size or position.

3.3 Study 1 Results

During Study 1, we noted that, unlike in our prior work for older children and adults [2,3], children often grew bored or tired of the tasks and requested to end a task or even the entire session early. When this happened, we did not have complete data for those children. We report here the *task completion* rates. Task completion for the two gesture tasks was defined as the percentage of gesture rounds completed (N = 6) per task (participants tended to request to quit the tasks at the ends of rounds). Task completion for the target task was defined as the percentage of targets successfully touched (N = 104).

Overall, task completion rates were quite low with our participants (Table 1). Only two (of 7) participants completely finished both tasks in Study 1. Two of 7 fully completed the Gesture Task, and 4 of 7 completed all of the Target Task. More children completed the entire Target Task, which took much less time overall than the Gesture Tasks. To address this issue of incomplete data, we next investigated ways to motivate young participants to complete all the tasks in the study protocol.

4. PROTOCOL MODIFICATON

Based on our observations, we believe that the completion challenges we encountered during Study 1 with younger children were due to a combination of factors, including (1) participant attention span and (2) study length. These challenges guided the methodology modifications we made for Study 2.

During Study 1, we observed that children often asked for breaks while completing the study tasks. Some of these breaks included time to get water and use the restroom, while others involved the child pausing to tell the researchers about something interesting that happened in their day or with a family member. Children were reminded before and during the study that they could take breaks or stop at any time. Some children did exercise this right, sometimes declining to complete activities and asking to move to the next, leading to our poor task completion rates. Moreover, we often conducted the sessions with two participants at a time. In Study 1, two sessions included two children. In both sessions, the

Task	Study	Mean	Min	Max	SD	N
Gesture	**1**	61%	37%	100%	27%	2/7
	2	95%	67%	100%	13%	6/7
Target	**1**	85%	39%	100%	26%	5/7
	2	100%	100%	100%	0%	6/6
Overall	**1**	73%	41%	100%	23%	2/7
	2	97%	84%	100%	7%	5/6

Table 1. Completion rates for both tasks for both studies. N = number of participants fully completing both tasks, out of the total number of children participating.

children were siblings. Neither of these pairs of siblings completed all activities, perhaps due to peer pressure and distractions during the sessions since they knew each other. We provide more insights based on challenges with siblings as guidelines for researchers at the end of this paper.

We see the challenges we encountered in Study 1 as primarily issues of motivation. If the young participants were more motivated to complete these tasks, we might see less impact of attention span and study length. We therefore decided to investigate *adding motivating factors to the protocol in order to better prompt this younger age group to complete tasks in laboratory studies*. We considered two possible ways to improve motivation of child participants in Study 2: (a) applying gamification features to the study, and (b) altering the environment to be more comfortable for the child. In this paper, we focus on the use of gamification.

4.1.1 Gamification

We introduced two modifications to make the study tasks seem more game-like to the children. One modification was adding a scoring system to the study task applications. For each gesture that was drawn or target that was touched, children received points. These points appeared on the screen as the child made progress, mimicking games that children currently play on touchscreen devices and computers such as Temple Run[1] and Club Penguin[2]. Another modification we introduced was the use of prizes. At the end of the session, children could "turn in" their points for physical prizes, which were small inexpensive trinkets that children enjoy, such as matchbox cars and stickers. Modified, gamified screenshots of the app are shown in Figure 1.

5. STUDY 2

After modifying the study protocol to include the gamified components we mention above, we then conducted a second study to examine whether these changes would better motivate the children to complete the tasks while still achieving our research goal of eliciting robust and rigorous input data.

5.1 Study 2 Participants

The participants in Study 2 were 7 new children, also with an average age of 6 years (*M* = 6 yrs, *Range* = 5 to 7 yrs, *SD* = 0.82 yr). Three participants were female and four were male. Most (5) were right-handed. All of our participants told us they had used smartphones before the session.

[1]https://play.google.com/store/apps/details?id=com.imangi.templerun

[2]http://www.clubpenguin.com/

5.2 Study 2 Procedure

The basic tasks for Study 2 remain unchanged from Study 1. To gamify the apps, we added points and scoring features. For the gesture tasks, participants received 10 points per completed gesture, with a possible total of 1200 for completing all six rounds of data collection (2400 total between the two gesture tasks). In the target app, participants received 5 points per successfully touched target, with a possible total of 520 points for completing the task. Since children could not lose points during the task and could only complete the tasks successfully, these scores merely represented their progress through the app. We also included prizes that the children could win based on how much of the task they completed (represented by the score). We divided the total points possible for completion of all tasks into five equal prize levels. Before the session, the participants created a personal ranking of the available prizes to allow us to arrange them in order of least to most desirable, corresponding to the increasing degrees of completion required to obtain the prizes. The value of each prize was no more than US$0.50 and consisted of small items such as toy cars, stickers, bubbles, plastic turtles, and miniature play-dough containers.

5.3 Study 2 Results

One target task log file for Study 2 was lost due to technical difficulties. But of the remaining 6 participants, only one participant did not fully complete both tasks, a large improvement over the only 2 out of 7 who fully completed both tasks in Study 1 (Table 1). Overall, we can conclude that the points and prizes were successful in their goal of motivating the children to complete all the tasks. The one child who did not *complete* all tasks in Study 2 did at least *attempt* all tasks. Based on our observations, we hypothesize that this participant may have been distracted by the other participant in the same session.

6. IMPLICATIONS FOR STUDY DESIGN

Based on this work, we offer recommendations for future researchers conducting studies with younger children, including incorporating gamification elements, understanding children's motivation, and removing acquaintances from the environment.

Use gamification elements such as points, prizes, or game design patterns. Our research showed that gamification, in the form of (1) points that the children could earn as they completed the tasks, and (2) prizes that the children earned throughout the study but only received at the end, can be used to motivate children to complete tasks in empirical lab studies. During Study 2, we noted that the children constantly referred to the number of points they were gaining throughout the study. At the end, these points counted towards winning the "grand prize". These elements of gamification served to motivate participants in this study, and we believe additional elements could be incorporated in the future to retain focus, perhaps for longer periods of time or for a variety of tasks. The gamification elements did not negatively impact task completion performance; therefore, we did not sacrifice data robustness with their addition. We suggest researchers consider these gamification elements (points and prizes) when designing study protocols for children, as well as others such as increasing challenges, adding narratives, or even game design patterns such as badges, leaderboards, and levels [6].

Personalize motivating elements to the individual child. When we modified the study, we not only decided to use prizes as motivation, but also to ask the children which prize they most

preferred. Once we knew which prizes they weren't as interested in, we knew the best relative ordering of the prizes to maximize motivation to complete the session. While the $10 compensation may have been a sufficient prize for adults, it was an unseen reward during the study (and was given to participants whether or not they completed all tasks). Tangible prizes chosen from the perspective of a child seemed to work best.

Avoid conducting sessions with children who know each other. Because some participants that were recruited were siblings or neighbors and we didn't want to inconvenience the children or parents by requiring the sessions to be run separately, we originally decided to conduct studies with multiple children at once. In Study 1, our observations indicated that conducting the study with siblings in the room may have affected the child's progress during tasks. Therefore, in Study 2, we purposely did not conduct studies with *siblings* in the same room. However, we saw that the same distracted behavior occurred when *friends* were completing the activities in the lab at the same time. The level of distraction siblings or friends afford could be a confound variable when conducting research with children. Where applicable, we recommend researchers consider this variable when designing study protocols and aim for consistency between sessions.

Consider a balance of distraction in controlled environments. A goal of many studies conducted in controlled lab settings may be to eliminate distractions that occur in the natural environment. In Study 1, we refrained from adding toys and other child-friendly elements to the environment as has been recommended by other studies [8]. However, we saw that children constantly referred to the gamified elements while completing the tasks in Study 2, and were actually *more* motivated to complete the tasks. Therefore, we suggest that it is best to aim for a balance in terms of *purposeful* vs. *accidental* distractions.

7. CONCLUSION

We have presented recommendations for how to address the issue of engaging and motivating children to participate fully in empirical studies. We investigated challenges and developed insights based on a two-part laboratory study that extends our prior work (done with older children and adults) in the context of touch and gesture interaction on mobile devices [2,3,5], to children ages 5 to 7. Based on motivation and data quality challenges encountered in Study 1, we modified our procedures by including *gamification* elements to better motivate the children to complete the tasks. In Study 2, we saw much improved completion rates. We recommend researchers use gamification elements, such as points and prizes, to encourage children to complete studies. Our findings can be useful not only to researchers conducting studies with young children, but also to researchers trying to motivate participants of all ages to complete laboratory tasks. In the future, we plan to use the gamified study task paradigm to compare data collected in 'natural environments' to data collected in more formal settings to understand how to move toward *in vivo* studies with children while retaining data robustness and rigor.

8. ACKNOWLEDGMENTS

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