



POP

Design of an American Sign Language
mobile learning game

MS-HCI PROJECT REPORT

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1 TABLE OF CONTENTS

2	Introduction	2
3	Background	3
3.1	Literature Review.....	3
3.1.1	Hearing parents of deaf children - factors influencing communication choices	3
3.1.2	ASL & learning habit forming through highly engaging video games.....	5
3.2	Current application in the domain.....	5
4	User Requirements	7
4.1	Personas and Use Cases.....	8
4.1.1	Persona 1: Parent with infant	8
4.1.2	Persona 2: Teacher of young children	1
4.1.3	Description of users:	1
4.1.4	Description of tasks/context of use:	1
4.1.5	Competitive analysis or other analysis of related solutions	1
4.1.6	Development of design requirements:.....	2
5	User Interface	3
5.1	Early design work:.....	4
5.1.1	Design of visual elements, layout, and mechanics	4
5.1.2	Preliminary Evaluation	6
5.2	Design implementation:.....	7
6	User Evaluation	8
6.1	Methods:.....	9
6.2	Results:.....	10
6.2.1	Pre-Trial Questionnaire.....	10
6.2.2	Cognitive Walkthrough, Think-Aloud Protocol	13

6.2.3	Post-Trial Questionnaire	14
7	Discussion and Conclusions	17
7.1.1	Lessons Learned Throughout the Design Process.....	18
8	Redesign based on user evaluations:.....	18
9	Continued and Future Work	21
10	Bibliography	22
11	Appendix A: Screenshots	24
11.1	Frozen Bubble Interface Screenshots	24
11.2	POPSign Interface Screenshots	26
12	Appendix B: Results.....	36
13	Appendix C: Usability Questionnaires.....	39
13.1	Pre-Trial Questionnaire.....	39
13.2	Post-Trial Questionnaire	46

2 INTRODUCTION

The focus of this project was to determine a means by which technology—in particular, educational technology and educational games—might be used to benefit the lives of families composed of deaf children born to hearing parents. This area has been extensively studied by researchers in Thad Starner’s Contextual Computing group, producing a number of prototype systems including games and mobile apps. My goal has been to learn from the lessons provided through evaluation of these systems, as well as the American Sign Language experts *available to us*, in order to derive a design for a learning game that would improve learning outcomes through increased motivation—and consequently, increased time on task—providing a better overall learning experience for users.

3 BACKGROUND

3.1 LITERATURE REVIEW

3.1.1 Hearing parents of deaf children - factors influencing communication choices

The situation in which hearing parents of deaf children find themselves is fraught with uncertainty, fear, and often gross misinformation from those in authority, such as advising doctors, therapists, and teaching professionals[1]–[4]. These households make up 90-95% of families with deaf children. If they have never dealt with individuals from the Deaf community, then they have no prior reference and consequently no support network to fall back on as they try to determine how to proceed in the manner that is best for their child[5]. The primary decision is whether to learn ASL themselves[6], in order to teach their child, to instead attempt to rely solely on medical interventions, such as cochlear implants, or to make use of both of these modes of potential communication for their child[7]–[10]. The answer would seem simple—to take advantage of both, but unfortunately the controversy surrounding this decision often leads to difficulties in getting unbiased guidance on these matters.

The importance of early childhood communication in the home extensively studied, showing lower performance in critical mental development of facilities including perception, memory, problem-solving, concept formation, and theory of mind understanding[11]–[13].

Having decided to take on the challenge of learning a second language such as ASL, these parents are inundated by unforeseen challenges. We must attempt to address these issues in order to mitigate their detrimental effects on these parents' ability to gain working knowledge of ASL. It is commonly understood that parents of a new infant have little free time, so the obvious choice of platform for a learning application is a mobile phone. Kim Xu, former PhD researcher in the Contextual Computing Group, created the SMARTsign mobile app[14] (Fig. 1) to evaluate the effect of mobile access to learning software on ASL learning outcomes.

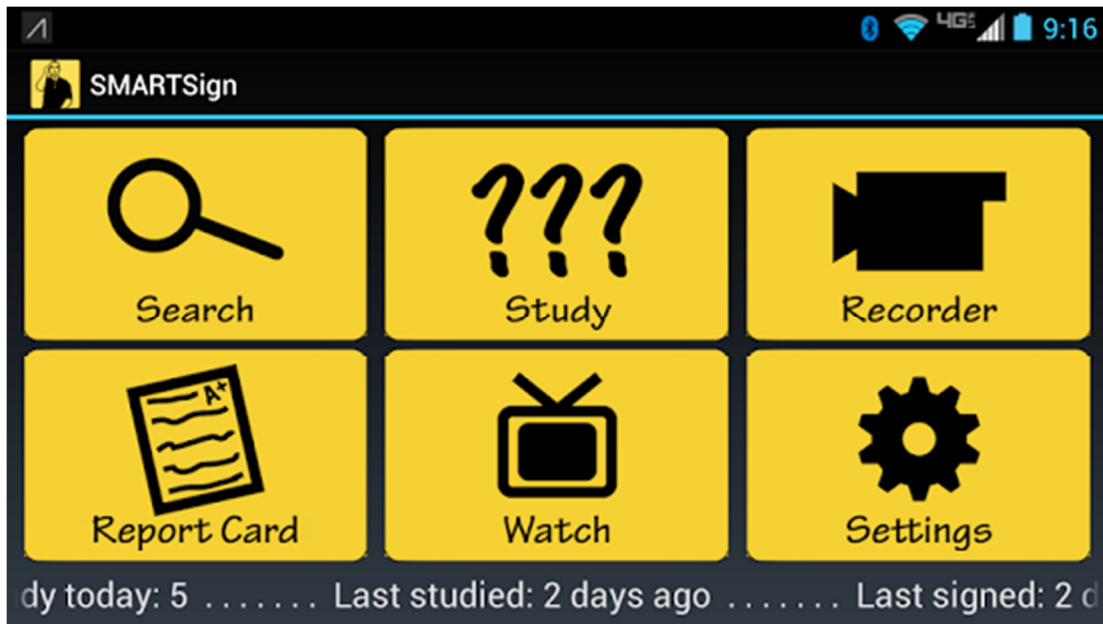


Figure 1. Screen from the SMARTsign mobile learning app

Her results showed that parents were initially excited at the prospect of using SMARTsign, but that their usage trailed off as the weeks went on. The conclusions derived were two-fold: that the interactions of users with the quiz and practice mobile app were not engaging to the point of maintaining continued interest, and that some stigma may have been present when practicing signing that may have dissuaded them from further use. Having spoken to ASL experts in the area, including Harley Hamilton of AASD and Ellen Roalder, Deaf Mentor at Georgia PINES, it is clear that the cultural acceptance of practicing sign is low (and influenced by a number of regional and social factors too complex to address in this report), so the bar to entry in terms of motivation to learn must be lowered in order to provide this beneficial instructional intervention. In recent years, this apparent social stigma has been somewhat mitigated by the success of movements such as “Baby Sign,” the use of sign language by parents of hearing children to communicate at developmental stages where motor skill outpace vocal language development[15]. Additionally, recent changes to school curricula have included ASL as an option for second language requirements. These factors will be relied upon when attempting to devise a proper approach to the popularization of ASL learning through mobile gaming.

This solution proposed entails modification of the highly successful, incredibly addictive, Android port of the cross-platform game Frozen Bubble, by Guillaume Cotteau (Android Port by Pawel Fedorynski). Further discussion of the proposed target audiences for this app will be discussed in the User Requirements section, following this literature review of current research in social aspects of ASL

adoption and the benefits of game-based learning to motivation and engagement—providing marked improvement to learning outcomes.

3.1.2 ASL & learning habit forming through highly engaging video games

Much prior research has been done regarding the potential for incorporation of games in learning curricula to increase attention, motivation, affect, and overall engagement[16]–[19]. The effects of motivational factors (intrinsic and extrinsic motivators),[20] “flow” as a powerful motivator in games,[21] and the tendency for these facets of human behavior to be undermined to produce detrimental habits, such as gaming[22] and gambling addiction[23]. However, some games designers and researchers have taken steps to harness these behavioral tendencies to produce healthy habits, such as maintaining an exercise schedule[23]. For this project, the aim is to try to take a similar approach by adapting the educational goals of SMARTsign to a mobile learning setting.

3.2 CURRENT APPLICATIONS IN THE DOMAIN

However, this approach has not produced many widely used games in the ASL learning domain. The ASL Vocabulary game CopyCat, developed at Georgia Institute of Technology is an example of an immersive gameplay experience where children can learn to recognize and practice production of ASL phrases[24]–[26], as seen in figure 2.



Figure 2. Screen from the CopyCat learning app

An ASL mobile game from Clemson State allows players to practice recognition of fingerspelling skills in a mobile setting[27], is one of the few mobile options available (Fig. 3).

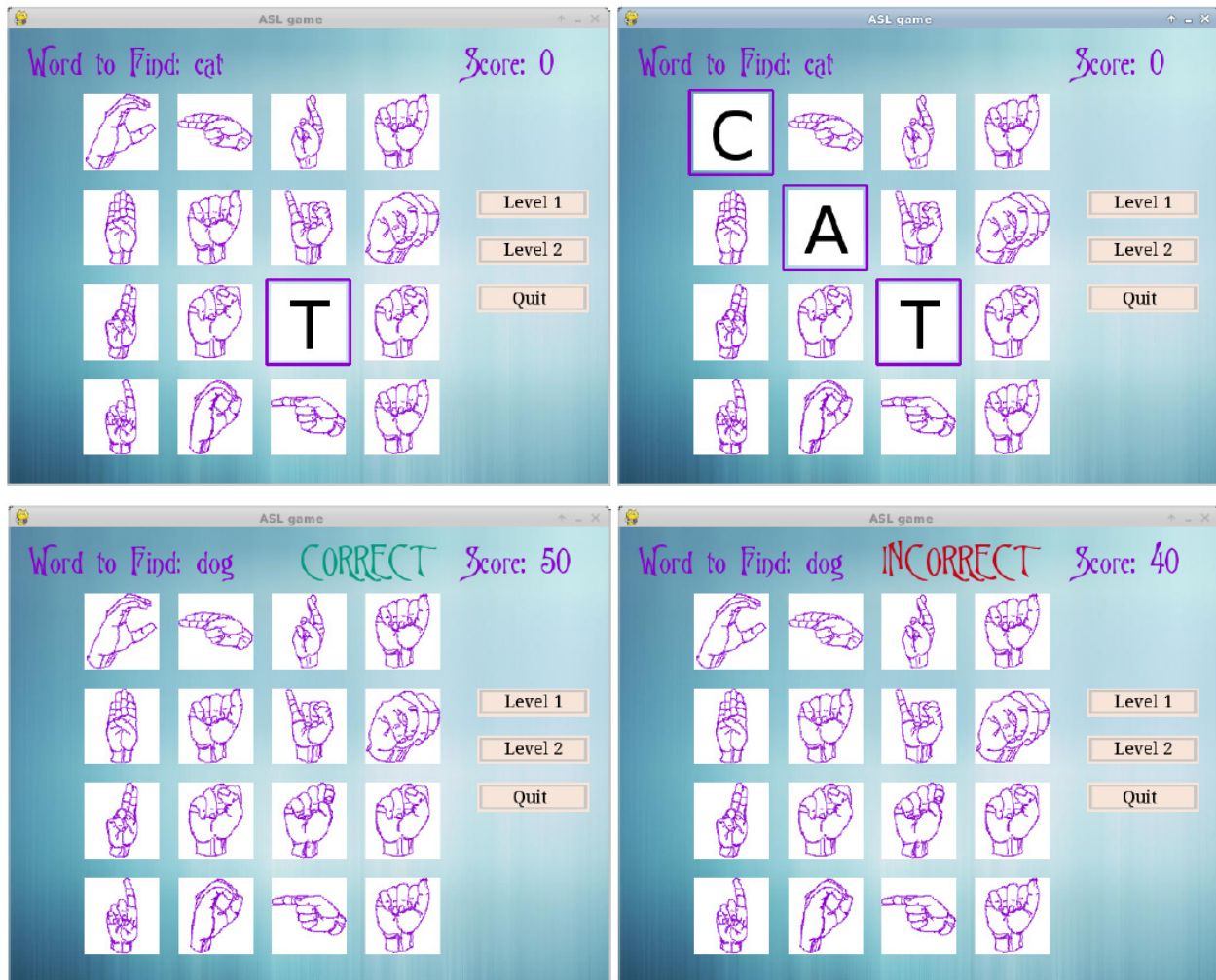


Figure 3. Screen from the Clemson ASL mobile learning game

4 USER REQUIREMENTS

Drawing on advice from domain experts, the best criteria for the user base for this game will be as broad as possible to promote better understanding of what makes a learning game both instructive and popular. But, it is also important to keep in mind the original focus of the project—parents and caregivers of young children. So, while the game might be played and enjoyed by parents, siblings, grandparents, teachers and daycare providers, ASL students and many others, those in a care-giving role to young children will be described in most detail.

4.1 PERSONAS AND USE CASES

4.1.1 Persona 1: Parent with infant



Name: Jack Sisko
Age: 27
Gender: Male
Relationships: Married to Nerise, parents of a newborn girl who may develop hearing issues
Education: BA, MS in English
Currently: Works in Publishing, Online Media as Editor
Location: San Francisco, CA, USA
Status: Primary user
Domain Knowledge: Smartphone (Samsung) Owner - Approximately 8 years

Technical Experience: Computer Skills - Used computers since childhood, early adopter
Plays video games on PC, console, and mobile phone

Attitudes/Values: Enjoys simple, action-filled, addictive games that provide goals and effort-based prizes

Learning Style: Prefers to learn by any means possible, preferably in a variety of ways to keep thing interesting: exploration, videos, reading, and practicing are all helpful

Disabilities: Vision - 20/20
Mobility - No issues, hikes/swims
Dexterity - Good hand-eye coordination, a relatively competitive gamer

Goals: Short-term – Quickly pick up some vocabulary to start
Long-term – Plans to take classes with Nerise to learn Baby Sign (as a start) then move on to more in-depth knowledge as necessary

Tasks: Become proficient with game so that less effort is expended with game mechanics than focus on signs

Requirements: Quick, easy interactions to make better use of minimal free time. A game that was instructive, uncomplicated, and enjoyable would be ideal.

4.1.1.1 Use Case 1: Play during train commute

Jack's wife, Nerise, has been researching ASL and Baby Sign and has found some really great resources. Along with other mobile learning apps, he plans to rotate in POPsign to his daily train commute into the office. He knows he has a fixed length to play, so the addictive quality of the game will be mitigated. He also looks forward to turning up the volume on his headphones and zoning out from the world for that short period. He's hoping Nerise will join him in playing, so they can play together.

4.1.2 Persona 2: Teacher of young children



Name: Valarie O'Shea
Age: 42
Gender: Female
Relationships: Married, 3 Children
Education: BS in Biology, Working on Master's in Education
Currently: Working in Education
Water Quality Inspection, Lab Director (18yrs) /
Care Provider, Educator (2yrs)
Location: Cocoa Beach, FL, USA
Status: Secondary User
Domain Knowledge: Smartphone (Apple) Owner - Approximately 3 years

Technical Experience: Computer Skills - 15 years in lab and educational settings
Attitudes/Values: Prefers phones and other gadgets to be unobtrusive in daily life, providing a simple, seamless experience.
Learning Style: Hands-On learner, would prefer to explore over manual reading.
Disabilities: Vision - Near-sighted, 20/20 with corrective lenses
Mobility - No issues, recent minor knee surgery
Dexterity – Reasonably good, but may be in decline due to arthritis
Hobbies: Hiking, Beach related activities, with kids. Kayaking
Goals: Is planning a shift into early childhood education, with special needs children
Tasks: Would like to extend current (minimal) ASL knowledge to include terms helpful in communicating with young children
Requirements: Wants a game that can be used in brief spurts, or at the beach—essentially effortless play. Simple set up that doesn't have to be constantly altered/tweaked is best.

4.1.2.1 *Use Case 2: Play during class nap time*

Valarie learned about POPsign from another teacher, who plays during brief periods of quiet at the school where they both work. They have been learning simple signs together and have often discussed the benefits of ASL for the children that care for. She is excited at the prospect of learning more in her free time.

4.1.3 Description of users:

The popularity of mobile games seems to span most demographics, but for this application the ideal users to target would be adults in age ranges typical of parents or those close to entering that age range. A desire to learn ASL would be excellent, but the success of gameplay outside of those conditions is also something to be determined. Ideally, it would be helpful to the members of the Deaf community if more people were capable of communication in ASL.

4.1.4 Description of tasks/context of use:

Two distinct tasks are planned for this relatively simple mobile app. Users will review signs at their own pace in the puzzle game mode. Then, once they feel comfortable with the signs of a given set, they may try their fast recognition capabilities through use of the arcade game mode. This mode allows variation in difficulty through setting of number of signs, between four and eight, inclusive. These functions should be available, with easy access to adjustable options through brief interactions, in any context where mobile phone use is possible to increase opportunities to play and learn.

4.1.5 Competitive analysis or other analysis of related solutions

The functionality of POPsign focuses on practicing sign recognition, but not sign production. This provides a means of learning to recognize sign, and practice recognition at an increased pace, but the physical reality of carrying a mobile phone does not provide as much opportunity to use both hands, at the distance a camera normally operates, in an effort to record and review sign performance. So, the ideal place that POPsign would fit in a network of learning resources is as a complementary solution for learning in spare time, while relying on practice of sign language production in more amenable contexts (at home with a proper, stable, powerful system). There are currently no other mobile games that

approach ASL learning from the position that popularization through focus on addictive gameplay should be emphasized, which still maintaining a rich learning experience featuring full video sign instruction. The closest competing apps would be flashcard style apps, similar to SMARTsign. So, for this project I will compare findings from the SMARTsign interface evaluation studies.

4.1.6 Development of design requirements:

The optimal design in the learning context for the POPsign app was approached through closely modeling it after the SMARTsign app. This would also facilitate experimental design of further evaluations of learning outcomes. The current system has been designed to incorporate a set of 80 simple vocabulary words, drawn from the MacArthur-Bates communicative Developmental Inventory, paralleling the design of the SMARTsign evaluation studies, as shown below in figure 4.

Sign Set 1	Sign Set 2	Sign Set 3	Sign Set 4	Sign Set 5	Sign Set 6	Sign Set 7	Sign Set 8	Sign Set 9	Sign Set 10
BEST	LITTLE	SHOES	HOME	BROTHER	IN	THERE	HELLO	TOMORROW	HELP
BIG	SICK	APPLE	SCHOOL	DAD	OFF	THIS	MORE	YESTERDAY	HURRY
CAREFUL	THIRSTY	BANANA	BOOK	GRANDPA	ON	YOU	WHEN	CAR	LOOK
COLD	TIRED	FOOD	MEDICINE	GRANDMA	OUT	YOUR	NOT	ROOM	LOVE
GOOD	CAT	JUICE	SOAP	MOM	UP	SIGN	PLEASE	DRINK	STOP
HAPPY	DOG	MILK	TOY	PERSON	MYSELF	WHAT	THANK-YOU	EAT	WAIT
HOT	SHIRT	BATHROOM	WATER	SISTER	MY	WHERE	YES	FINISH	WANT
HUNGRY	CLOTHES	BEDROOM	BABY	DOWN	THAT	WHO	NOW	GO	SLEEP

Figure 4. Selection of 80 vocabulary words. Ten sets, with 8 words per set.

This provides a good selection of sample sets in groups small enough for short gaming sessions. The use of these sets in Puzzle Mode should allow users to review signs at their own pace. This practice would prepare them for the face-paced Arcade Mode, where they would be able to practice recognition at a speed more typical of ASL communication. Variation in the number of signs reviewed at once, through adjustable game options, will let users decide how much to practice at any given time. The ideal system would allow them to review and practice vocabulary recognition and production in a static home

environment, using a system like CopyCat to practice signing, then maintain information about progress across systems. This would allow POPsign users to gain a fuller, deeper understanding and greater skill at recognizing and reproducing the vocabulary they are currently focusing on. Users would then be able to play (and learn) whenever they have free time, as they might any similar mobile app.

5 USER INTERFACE

The approach to designing the user interface of the POPsign app entailed introduction of learning ASL elements in a manner that would interfere least in gameplay mechanics. This would ensure that the engaging qualities of the original application interaction might be preserved. Critical elements were identified through use of the app, then the necessary remapping of functional elements proceeded as the optimal location of sign elements was incorporated. Figure 5 shows the typical gameplay screen. Players shoot a random colored ball, at groups of similar colors, clearing groups when in contact with 2 or more of the same color. This is the basic sequence of gameplay events, with some minor variations that continue to maintain interest.

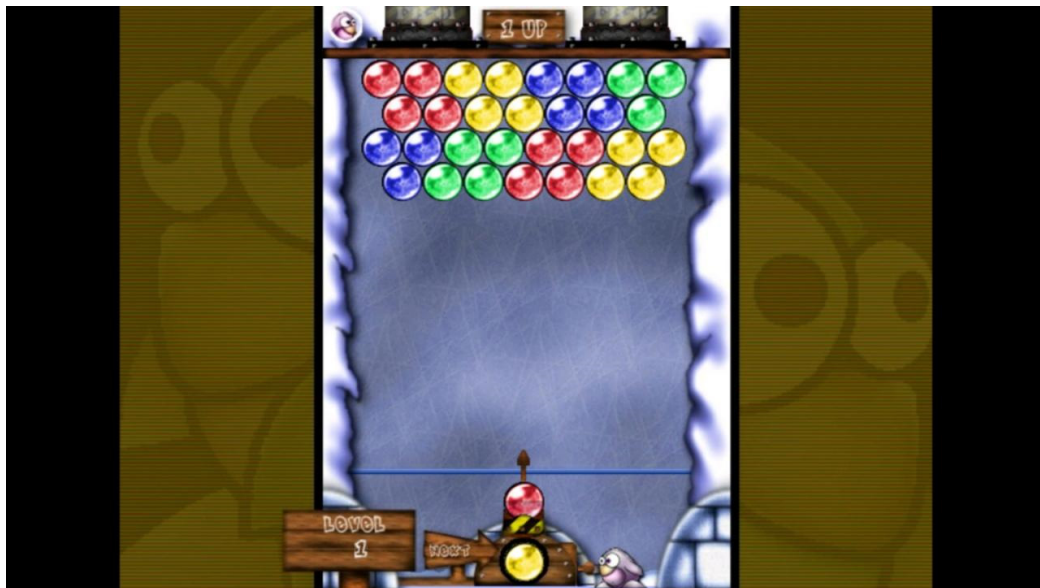


Figure 5. Screen Capture of the Original Frozen Bubble Interface during gameplay

5.1 EARLY DESIGN WORK:

5.1.1 Design of visual elements, layout, and mechanics

The gameplay screen was mapped out, measuring the fields of play and elements maintaining a presence in that space. Sketches and digital mock-ups were created, evaluated, and refined to determine optimal size and placement of new and existing critical gameplay and learning elements. The most important new elements included are the video in the lower left hand corner, displayed on the sign (previously used for level status) and the inclusion of the words relating to the signs within the bubbles. The level label was moved to the top of the screen out of the way of the game space. Secondary functionality, such as the switch feature, was also modified—its sign label was moved to make room for video. Figures 6 & 7 show this progression.

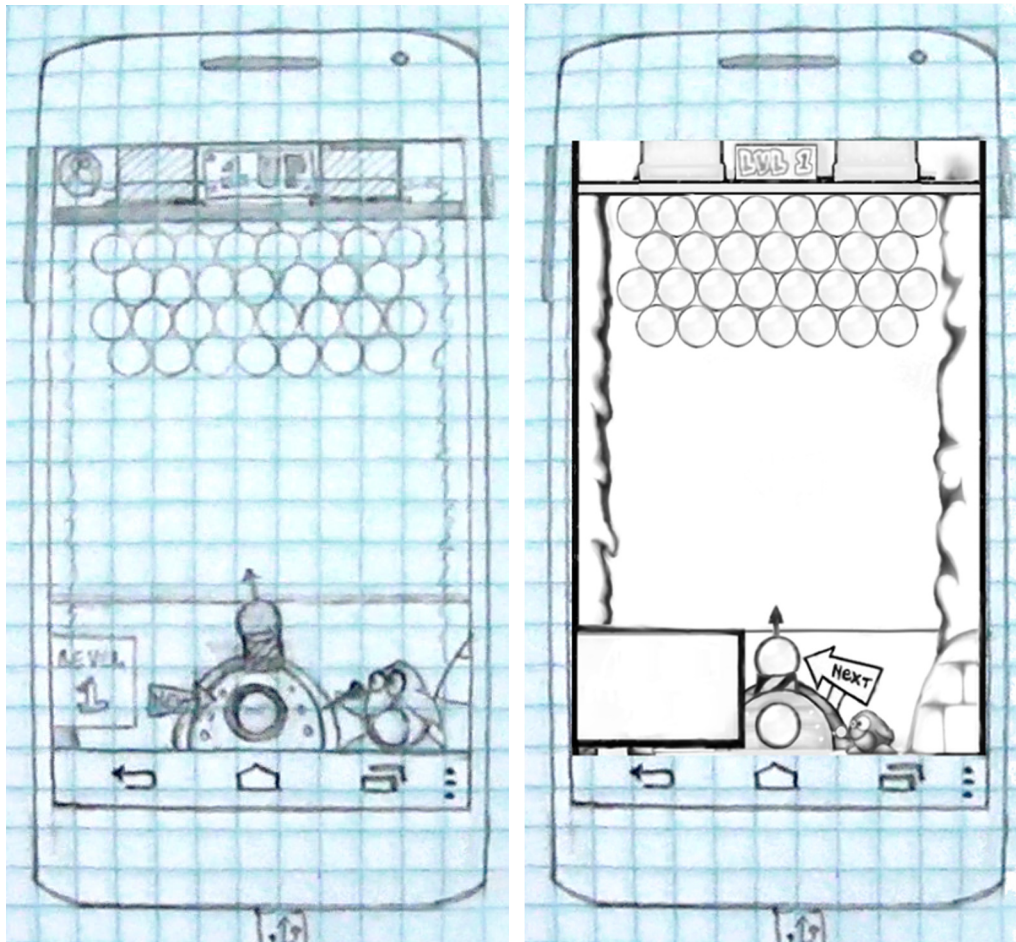


Figure 6. Preliminary sketch used to simplify determination of critical elements for play and sign review

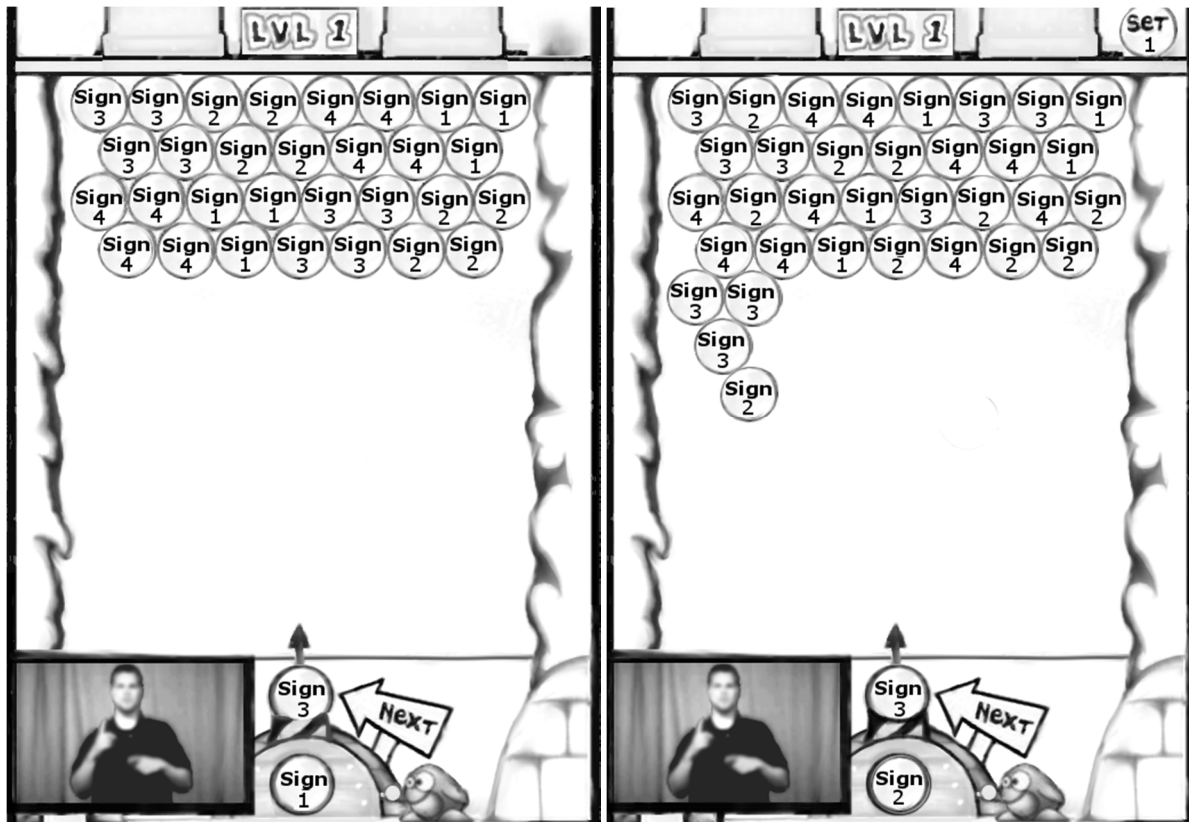


Figure 7. Preliminary sketches showing critical elements in Puzzle (L) and Arcade (R) modes

From here, the visual layout for the preliminary design was determined, along with the Sign Set based learning groups, discussed earlier. Pacing the users' progression through the sets would involve associating each set with the Puzzle mode levels already available to the game, 1 Sign Set increment after 5 levels are cleared (as an example). This increment could also be tunable by the user themselves, based on their evaluation of their progression in a set. Modification of the Frozen Bubble game's graphical resources produced the following rough prototype (Fig. 8), with the addition of accompanying video to simulate a brief gameplay session.



Figure 8. Rough Prototype: POPsign version 1

5.1.2 Preliminary Evaluation

The rough prototype (POPsign v1) game screen mockup, with accompanying full size video, was used for preliminary user evaluation to determine whether video placement, size, and sequencing with the bubble launches was feasible with the planned game screen layout. Evaluator all agreed that the placement would be effective, but the size of the video may be too small to see adequate detail. Variations in video size and placement were also explored, first with paper prototypes (Fig. 9), then during implementation.

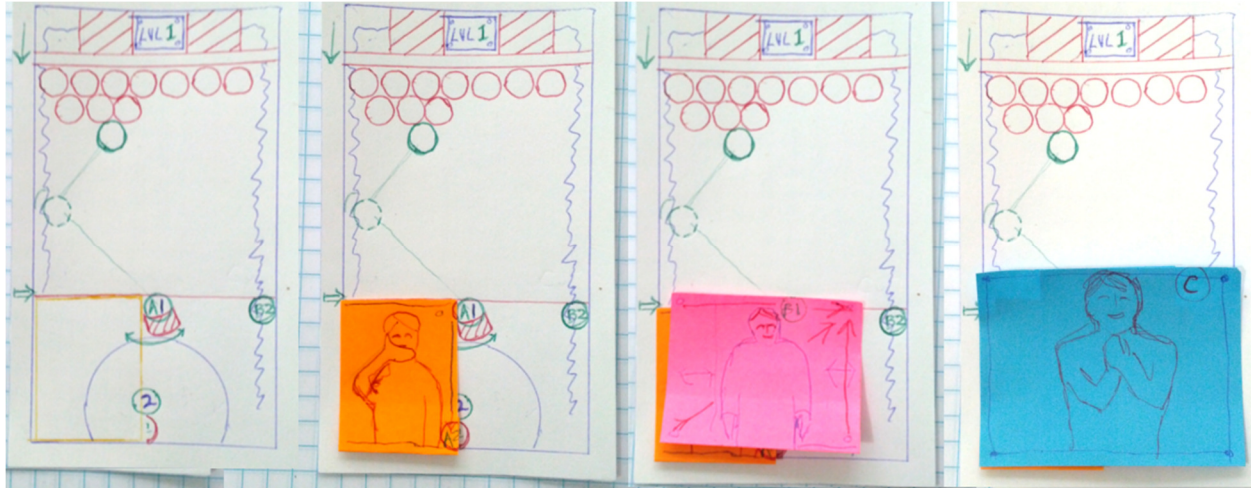


Figure 9. Rough Mockup: POPsign version 2

5.2 DESIGN IMPLEMENTATION:

Implementation entailed direct modification of the source code provided freely by the Frozen Bubble project developers. Preliminary development was done alone, but issues with graphics and resource management led to the need to ask for assistance from a CS PhD student in the CCG lab—Daniel Kohlsdorf. The IDE used was Eclipse with the Android Development Kit. This code is primarily Java, with some incorporation of C++ (along with use of the Native Development Kit for sound functionality).

Extensive modification of game graphics to provide a cohesive game experience involved addition of sign glosses (meanings in word form) to each color coded bubble. The ‘Current’ and ‘Next’ bubbles were obscured to shift focus to the sign video. The static elements incorporated into the background were adjusted to make way for the video: level label position (for Puzzle Mode) and difficulty label position (for Arcade Mode), the ‘NEXT’ indicator sign was shifted to the other side and changed to say ‘SWITCH’ based on rough prototype input. Font colors, size, and clarity were altered for greater readability, as seen in Figure 10. An additional Sign Set Key associating Bubble Color to Sign Gloss was added in the unused snow area to the right. This was meant to help gauge optimal font size, and provided a useful secondary coding for moments where the ‘Current’ sign was not present in the active play area. This Key would also become useful in a later planned iteration, where the Bubbles would contain either pictographic elements associated with the elements of the ASL Sign Sets or close-up static frames (or simple frame cycling animations) of the key hand poses/shapes.

The graphical element that has proved most difficult to implement has been the incorporation of the full video recordings of the signers producing signs for each set. The current game uses animations composed of approximately 30-50 frames, but this is pushing the limits of the phone's memory capabilities. Further inclusion of learning sets will require reduction or compression of the framesets, along with a better method of handling the swapping of frame sets into the phone's RAM.

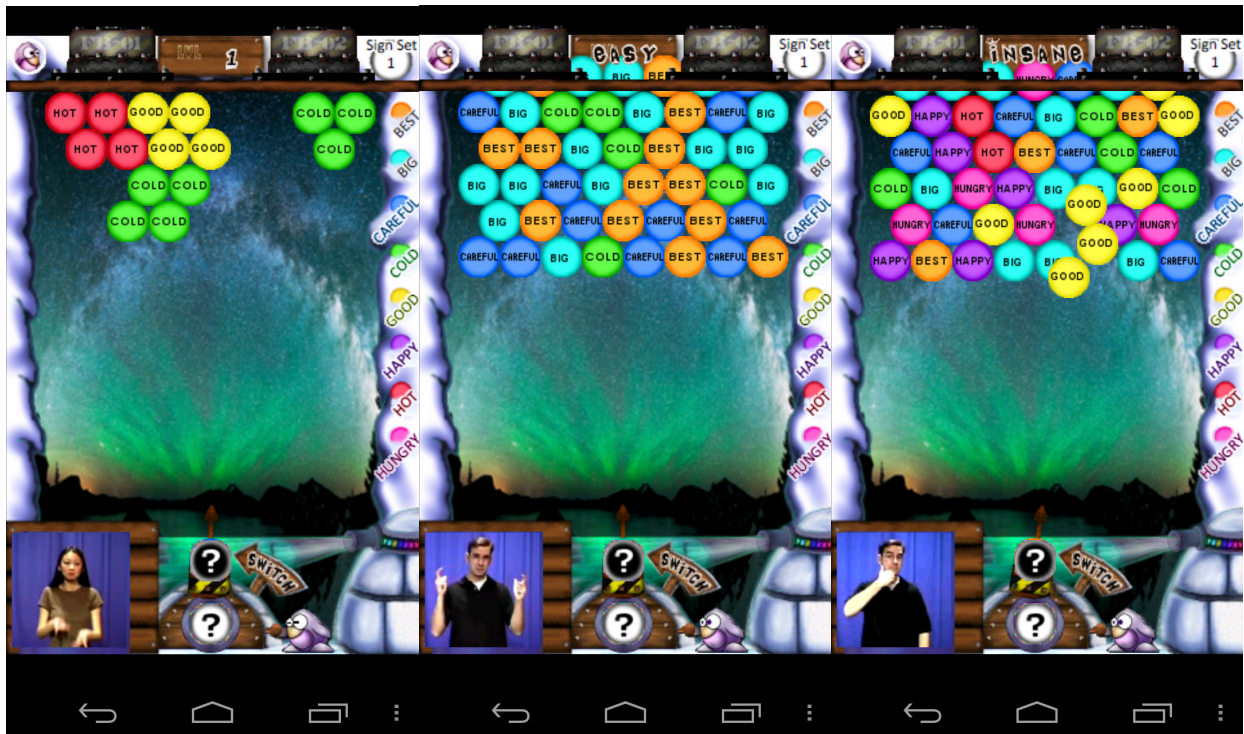


Figure 10. Evaluation Prototype: POPsign v2 gameplay in puzzle (L) & arcade (*easy C, insane R*) modes

6 USER EVALUATION

Evaluation tools created included questionnaires comprised of standard demographic information questions, qualitative assessments of the gameplay interactions, game functionality, game interface, users' perceptions of how this gameplay might affect their ability to retain the information reviewed, and whether the experience was one they would want to continue on a regular basis. These questions were in the form of Likert scales, multiple choice, and short answer. Additionally, the cognitive walkthrough/think-aloud protocol trials utilized a computer, camera, or cell phone to record participants' interactions and responses.

6.1 METHODS:

Participants were recruited through word-of-mouth, email, and flyers placed around GT campus. Meetings were set at locations convenient to the participant. Consent was received orally and in written form through proper IRB consent procedures. Compensation was offered in accordance with criteria described in the IRB protocol. Continued contact with participants was agreed upon for further studies.

User evaluations consisted of questionnaires preceding and following direct user evaluation, by cognitive walkthrough/think-aloud protocol, of the prototype game on an Android system, installed on Samsung Nexus phones. Video recorded during the interface evaluation in order to properly observe and record activity was later transcribed. Notes were also taken regarding participant comments, observable reactions and other events. Following each evaluation, the participants were thanked for their time.

Sample Tasks included in the Cognitive Walkthrough are described in the following script:

POPsign - Cognitive Walkthrough Evaluation

Think-aloud Protocol:

The purpose of this evaluation is to understand which aspects of the application are most effective, enjoyable, and easy to use. We ask that you proceed through the tasks at your own pace, while talking about what you are experiencing. We'd like to hear all opinions (good, bad, or otherwise), or anything that is puzzling, frustrating, or particularly enjoyable. Hope you have fun!

Mobile App Evaluation Instructions:

Turn the phone on and locate the POPsign app in your applications screens.

Action 1: Play POPsign in Puzzle mode

--Please play until you feel comfortable (or for approximately 5 min, 5 rounds)

Action 2: Play in Arcade mode

--Please play until you feel comfortable or bored (or for approximately 5 min)

--Navigate back to the start screen.

Action 3: Change options in the Options screen

--Adjust one or more of the following fields:

Reduce sensitivity

Turn Music off (not Sound Effects)

Change difficulty to 5 or 6 balls/colors

Add a player name

Action 4: Play in Arcade mode again

--Check whether altered options improve gameplay

Post-evaluation Instructions:

After completing evaluation, please fill out the post evaluation form.

Thanks for participating!

The full documentation is included in Appendix C.

6.2 RESULTS:

6.2.1 Pre-Trial Questionnaire

The findings from the Pre-trial questionnaire provide demographic data and shed light on the gaming tendencies of the participant group. Participants' ages ranged from 20-34 years old. Three owned Apple brand phones, 5 owned Samsung phones (one owned both types). Motivations ranged from general interest/curiosity, to "why not?," to the desire to use Baby Sign.

In particular, we find that 3 of the 7 participants do not consider themselves game players, but instead prefer to watch others play. They do however describe games and mobile apps that they use infrequently. All participants reported owning at least 2 gaming apps on their phones, however gamers reported having up to 57 apps at once, the majority of which were games. All Non-gamers owned Apple phones (one also owning a Samsung), all Gamers owned Samsung phones.

Non-gamer game-related preferences showed a clear distinction between average scores of the perceived importance of gameplay elements as compares to the gamer groups in most categories, apart from the following: strategy, puzzles and problem solving, scores, progress reports, and variable difficulty (Figs. 11 and 12). Music and Humor were the only elements non-gamers considered more important than gamers (Fig. 13).

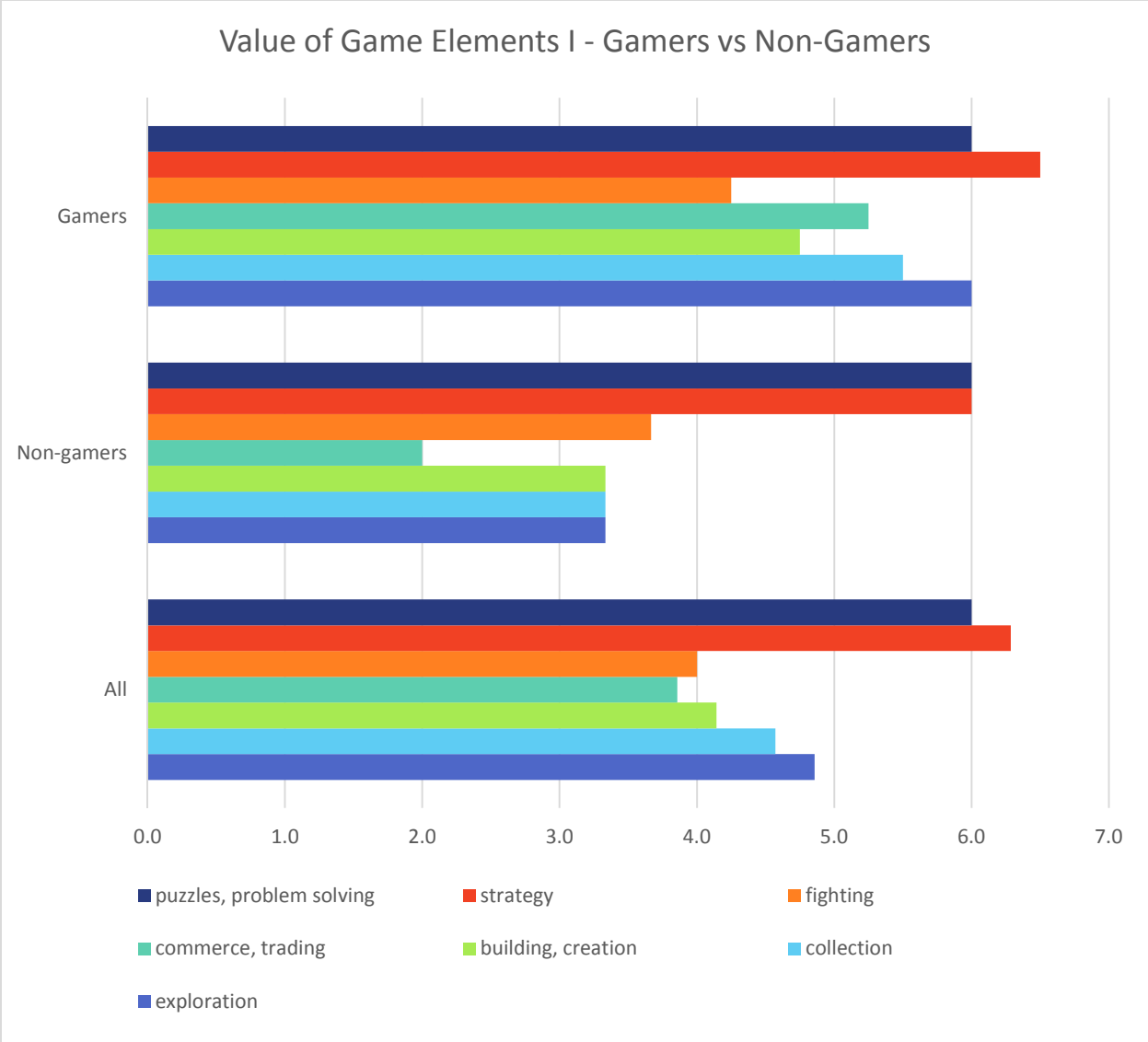


Figure 11. Pre-Trial Questionnaire gauging game preferences

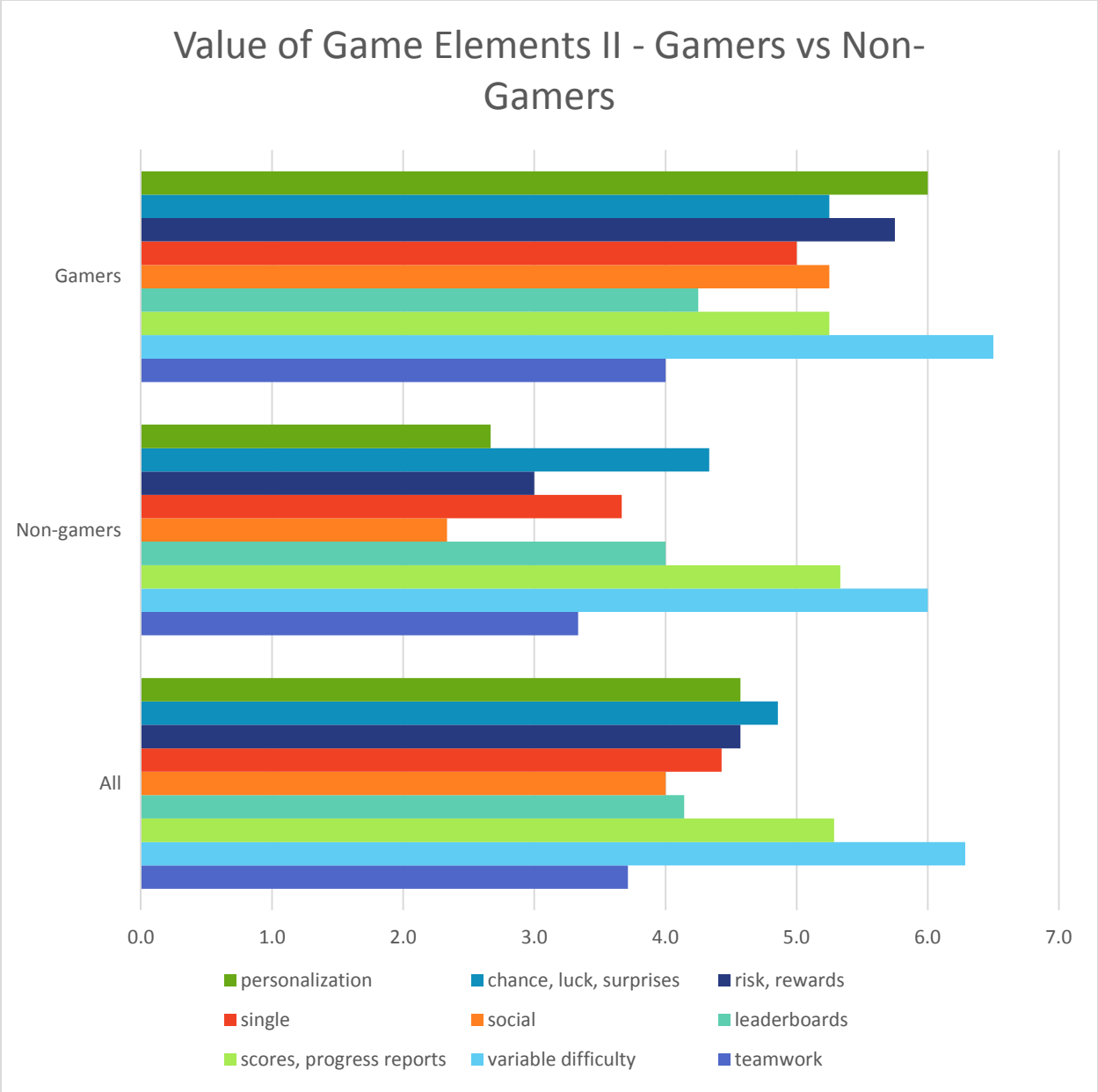


Figure 12. Pre-Trial Questionnaire gauging game preferences

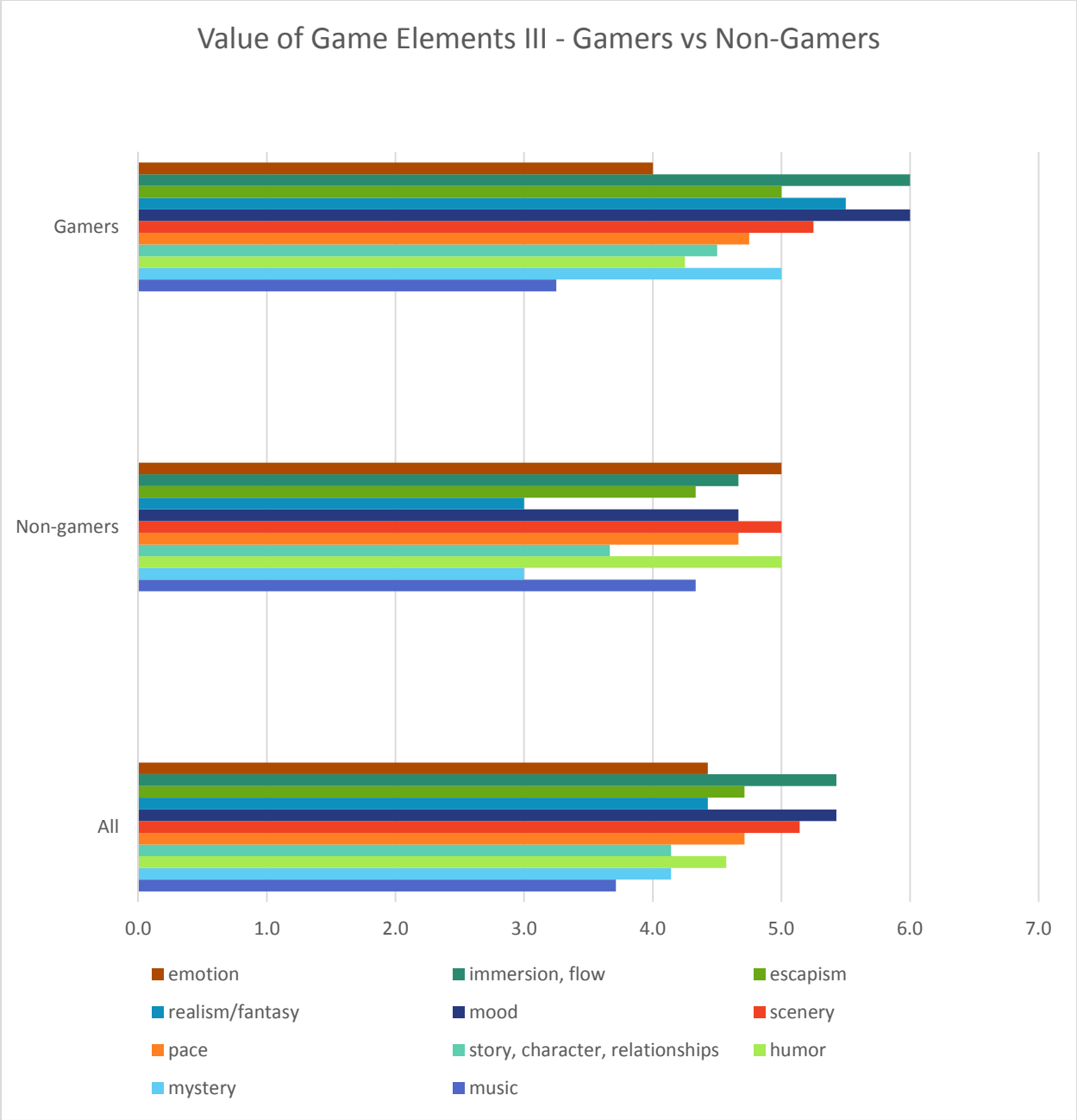


Figure 13. Pre-Trial Questionnaire gauging game preferences

6.2.2 Cognitive Walkthrough, Think-Aloud Protocol

Each of the 7 players participating played or completed 3-5 Puzzle rounds, 1-2 Arcade rounds (at easy difficulty, with 4 signs), altered options in game and through the home screen, and then played at least 1 Arcade round again (at higher difficulty, with 5-6 signs). Sessions lasted between 15 and 25 minutes. The most commented on feature was the sign videos. Issues associated with them included ability to make

out hand detail and the ease with which players could associate signs by signer, rather than signers' gestures.

6.2.3 Post-Trial Questionnaire

Users consistently rated the gameplay experience as enjoyable, with an average score of 6 on a 7 point Likert scale. The incidence of errors and crashes was rated low, at an average of 2.3 (2 = disagree). Participants did not feel that gameplay detracted from recognition overall, with an average score of 3.3 (3 = mildly disagree). They did on average want to continue playing (avg = 5.6) and felt it was a good use of time (avg = 5.9). These results are shown within the context of the other scores in figures 14 & 15.

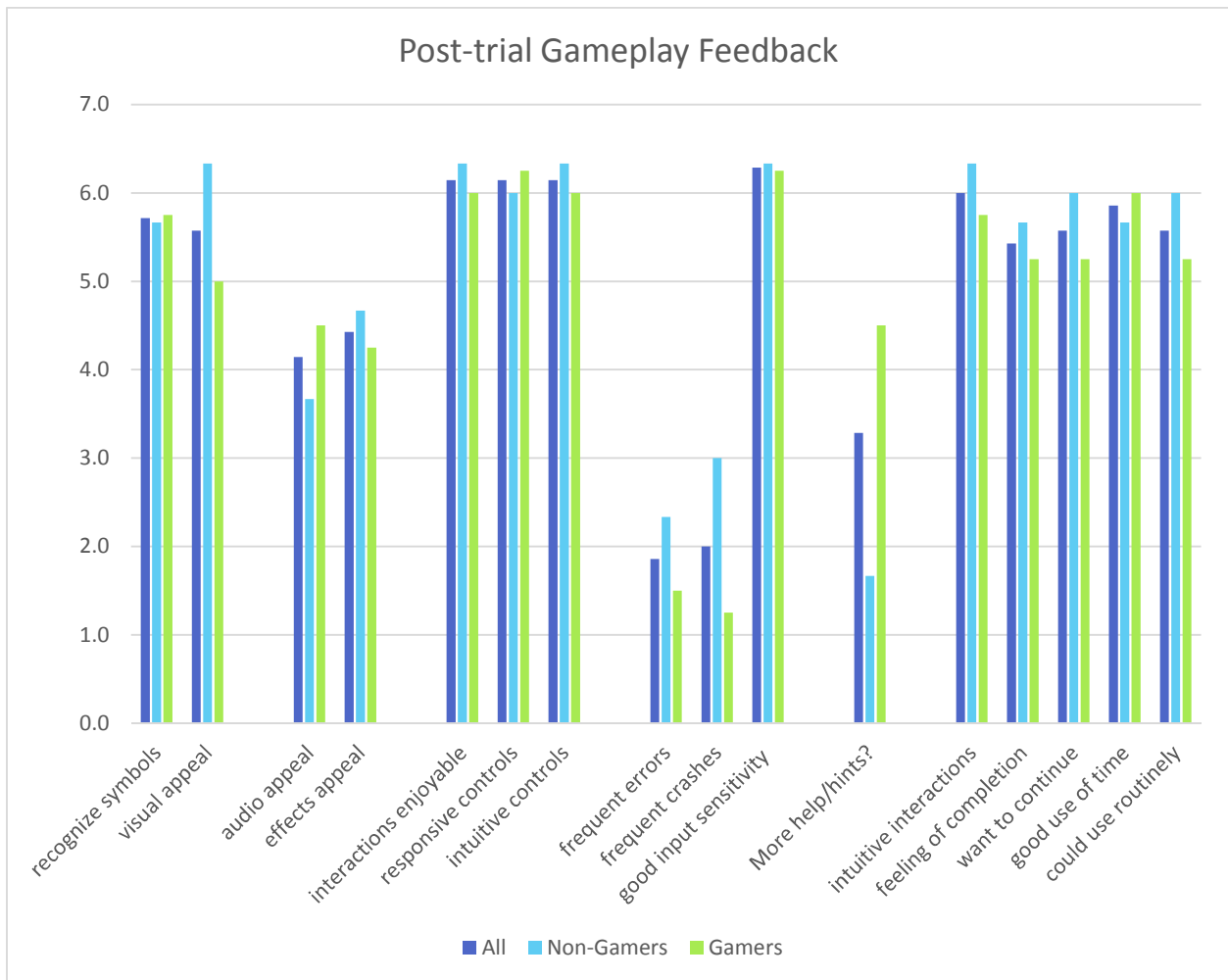


Figure 14. Post-Trial Questionnaire gauging gameplay experience

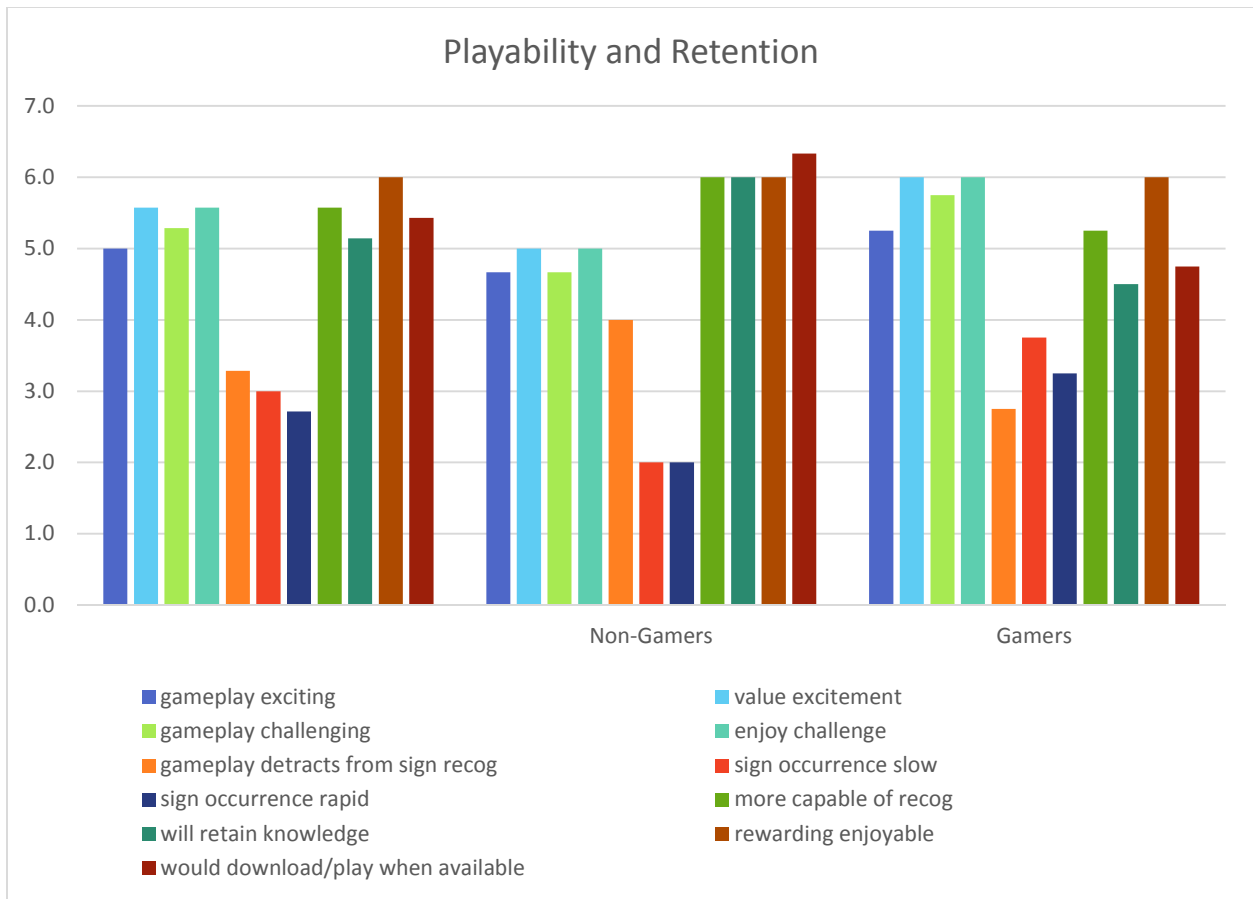


Figure 15. Post-Trial Questionnaire gauging gameplay experience

6.3 COMPARISON TO SMARTSIGN: SELF-REPORTED RETENTION LIKELIHOOD

While the motivation of users may not be comparable between studies, the overall results in questions of intention to continue use are mostly positive for both applications. This information should be tempered by the fact that of the participants in the SMARTsign evaluation, only 2 of the 12 continued using it after the required month. Users of POPsign were less enthusiastic toward the prospect of download the app when available, but said that they could see themselves playing the game on a routine basis (Figs. 16 & 17).

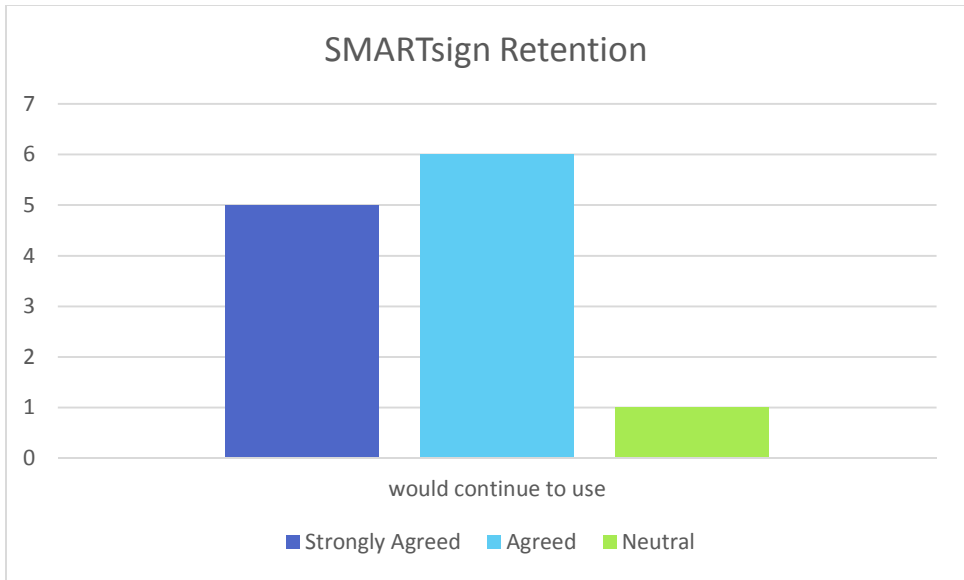


Figure 16. Self-reported retention likelihood for SMARTsign app

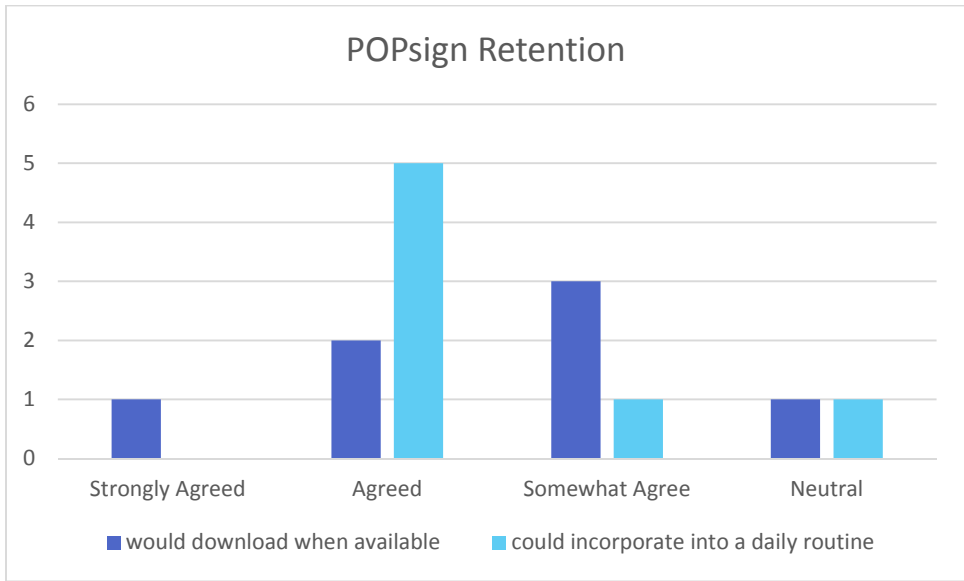


Figure 17. Self-reported retention likelihood for POPsign app

7 DISCUSSION AND CONCLUSIONS

The conditions of the cognitive walkthrough evaluation were such that the most pertinent information gained was from commentary, rather than analysis of error rates or time of task completion. Play is generally a free interaction, so strict adherence to the task flow was not stressed, opting for a more exploratory pace of evaluation. Accordingly, errors may be much more likely.

Errors that depend on game reactions/skills are not fair indicators, nor are lowered hit rates when random bubble occurrences are taken into consideration. The only interactions that might be useful to gauge relative rates or are incidence of first discovery of auxiliary gameplay mechanics (switch/bounce), and determination of whether their use increases enjoyment (along with scores). This might be a scenario in which inexperienced gamers would benefit most from instruction or hints--related to gameplay, rather than learning content.

However, some important conclusions to draw from commentary include:

Sign Set Selection

Sign selection for sets should keep in mind that players might be tempted to “game the system” by associating vocabulary terms with the signer. So, to discourage this behavior, it might be best to use signs from only one to two signers per set or multiple signers per sign.

More Hand Detail in Signs

From the Post-trial Evaluation, it is clear that the game was found to be conducive to learning to recognize signs, with only minor concern regarding the ability perceive hand details.

Help

The factors of greatest concern are the apparent interest in a tutorial or instructions functionality.

Music

Of the gameplay elements, audio saw drew the greatest criticism.

From the Post-trial Evaluation, it is clear that the game was found to be very enjoyable overall, with only minor concern regarding the ability to recognize signs. The factors of greatest concern are the apparent interest in a tutorial or instructions function and the overall dislike or disinterest in the stock audio, both music and sound effects.

7.1.1 Lessons Learned Throughout the Design Process

It is clear that undertaking design, implementation, and evaluation of even a relatively simple system is an undertaking that requires planning, attention to detail, and focus on continual iteration. In terms of research design, I continually wished I could revamp my user evaluations to refine the details of questions, but felt that these must be balanced by consideration of participants' time. Concerning implementation, I had no idea when I began that the system specifications/requirements for media in terms of resource management would be so strict. It is a good lesson, but it would have been interesting to be able to evaluate the game with more sign sets.

8 REDESIGN BASED ON USER EVALUATIONS:

Evaluations and expert input both indicated the need for some sort of tutorial, instructions, or hints. Redesign of the background image to incorporate simple instructions and reuse of the “Colorblind Mode” as a “Hint Mode” is shown in figure 18.

Also, a means of differentiating bubbles, and providing hints or a brief glimpse at the associated meaning of the sign (as shown in figure 19) through activation of “hint mode” (using the unnecessary “colorblind mode” function).

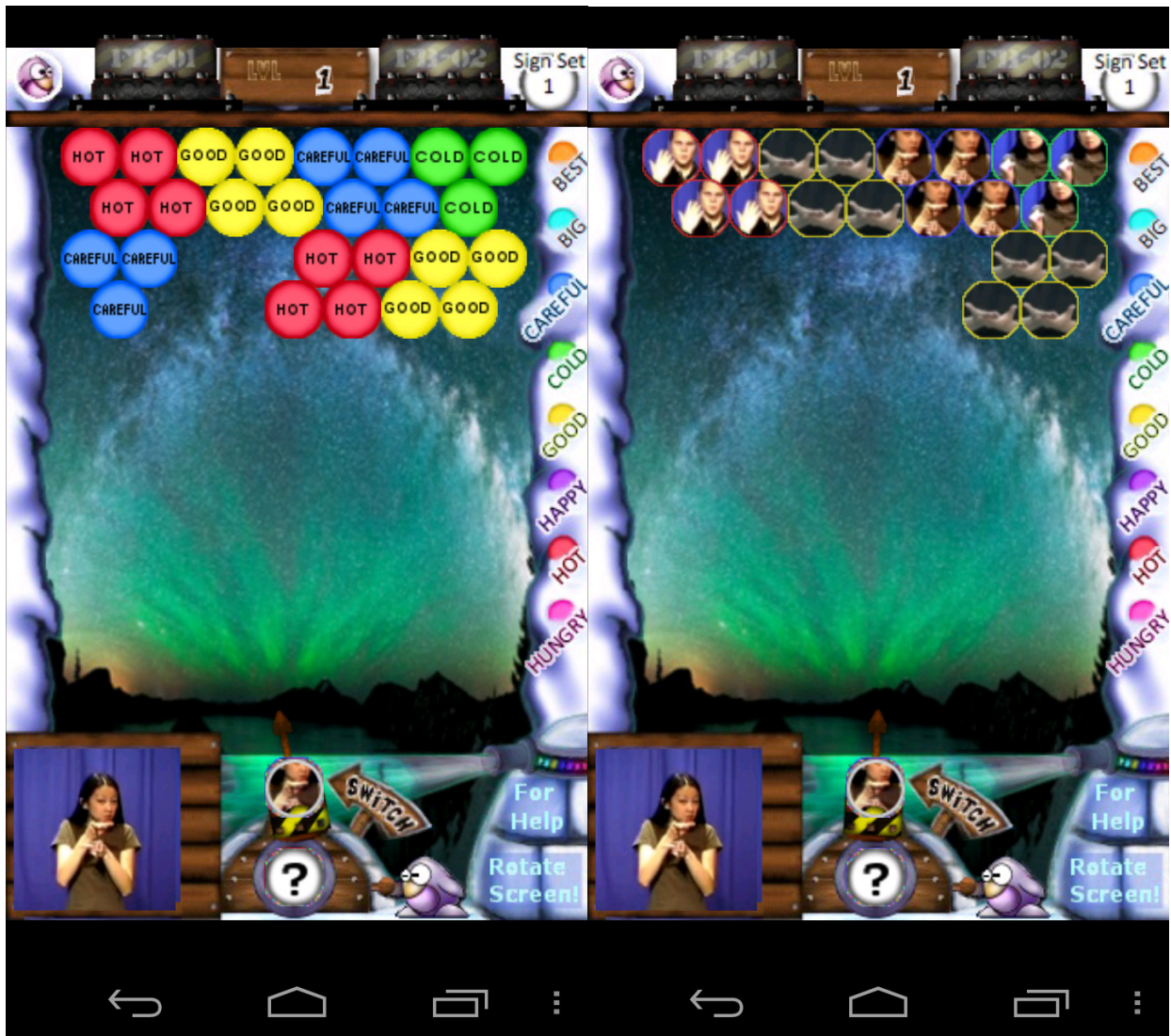


Figure 18. "Hint Mode" in POPsign version 3

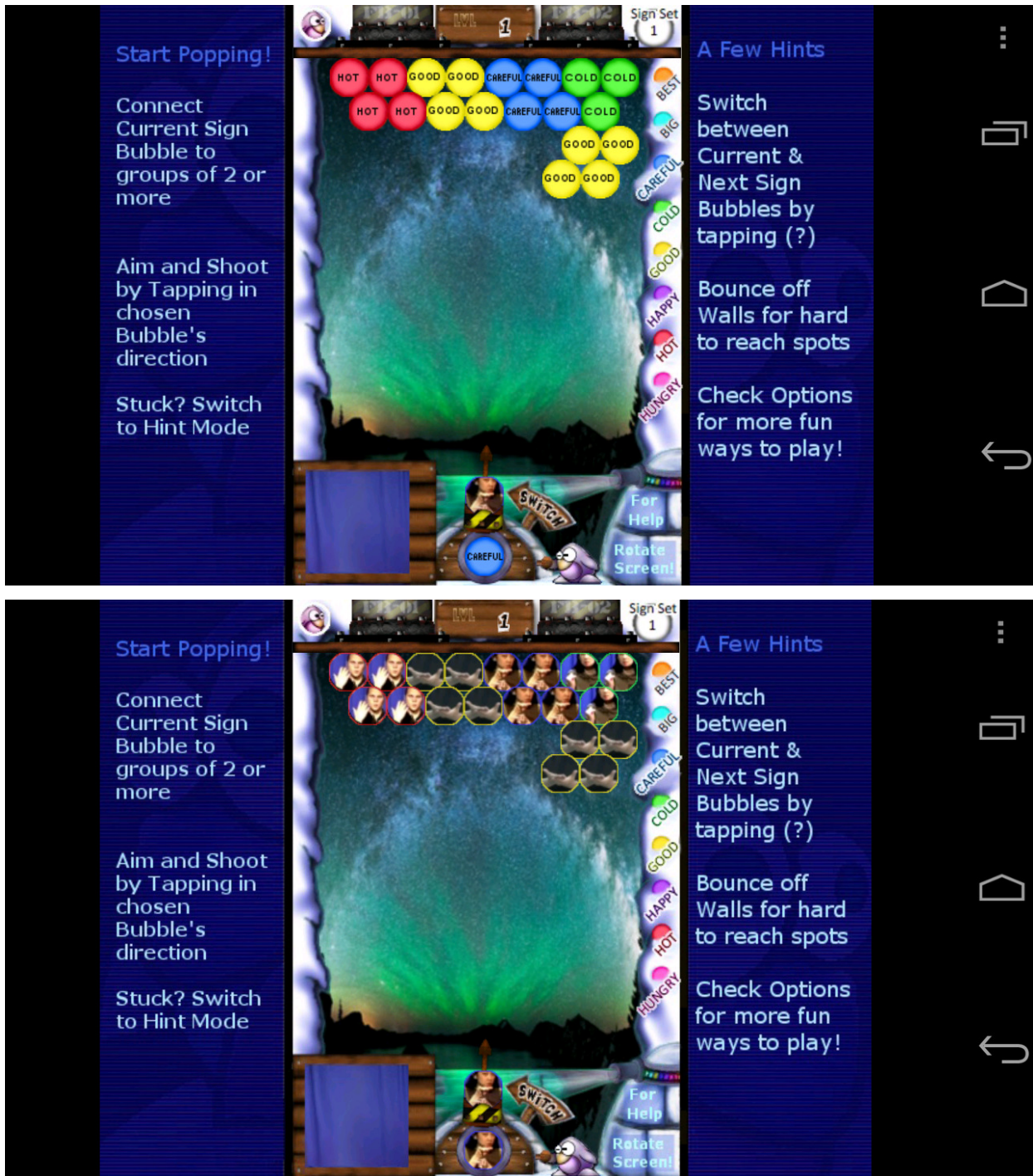


Figure 19. Quick access instructions in POPsign version 3

9 CONTINUED AND FUTURE WORK

Continued evaluation of the latest iteration of the POPsign app will entail a two-week field trial with participants of this user interface evaluation study. This will entail a pre-assessment through a vocabulary quiz, post assessment of the same 80 vocabulary terms, and a survey to gauge the effects of continued refinements to the system. Participants will be assigned phone installed with either POPsign or SMARTsign in order to compare usage patterns. This study will also attempt to determine whether participants are more willing to play to learn, over traditional quiz-type learning, leading to more time-on-task, and (hopefully) improved learning outcomes. Will revamp the way this is worded.

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11 APPENDIX A: SCREENSHOTS

The following screenshots are meant to show the progression from original Frozen Bubble game to the POPsign learning game.

11.1 FROZEN BUBBLE INTERFACE SCREENSHOTS



Figure A1. Original Frozen Bubble game screens: Home and Puzzle Mode



Figure A2. Original Frozen Bubble game screens: 2-Player Arcade Mode

11.2 POPSIGN INTERFACE SCREENSHOTS

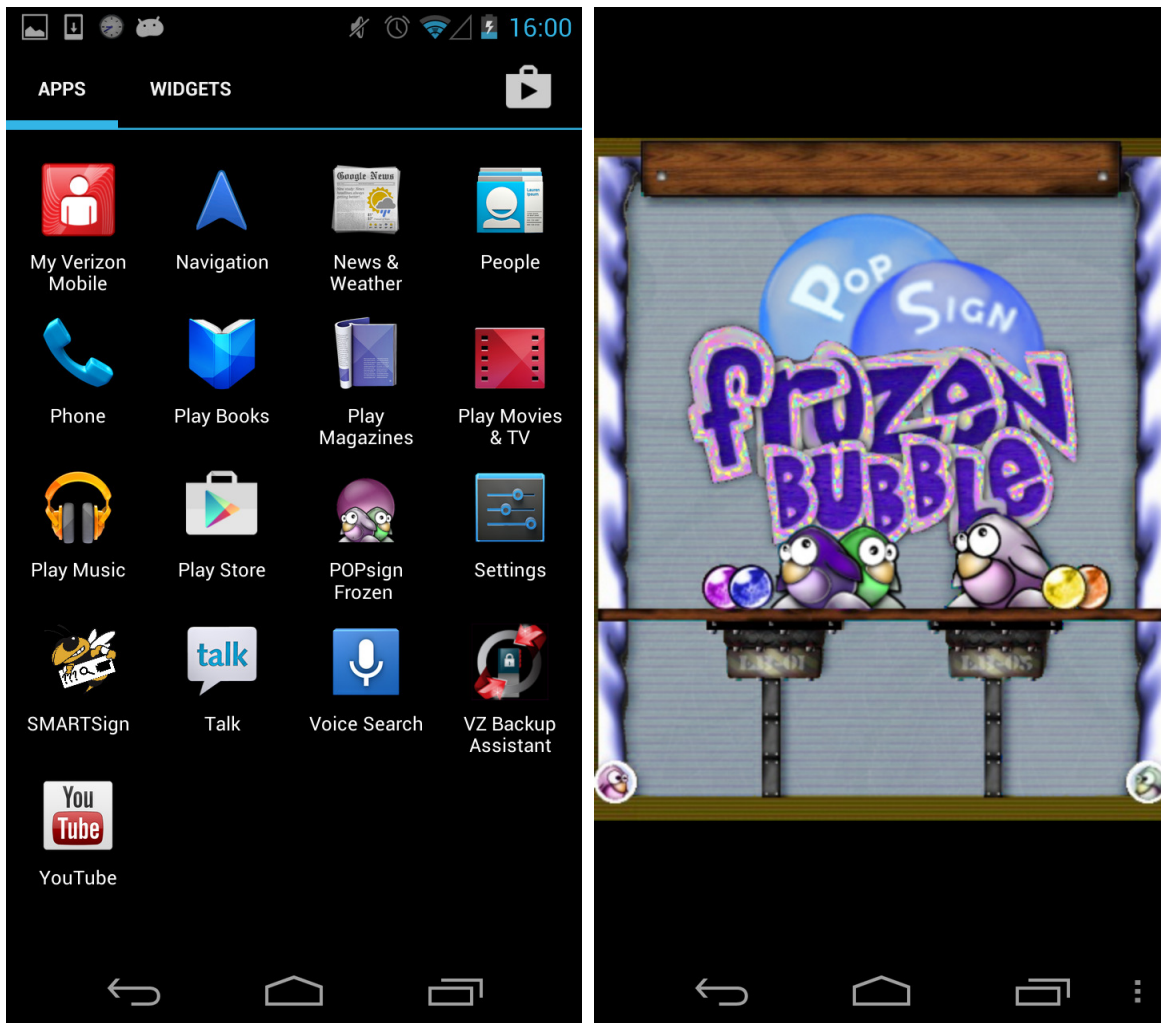


Figure A3. POPsign game screens: Icon and Splash

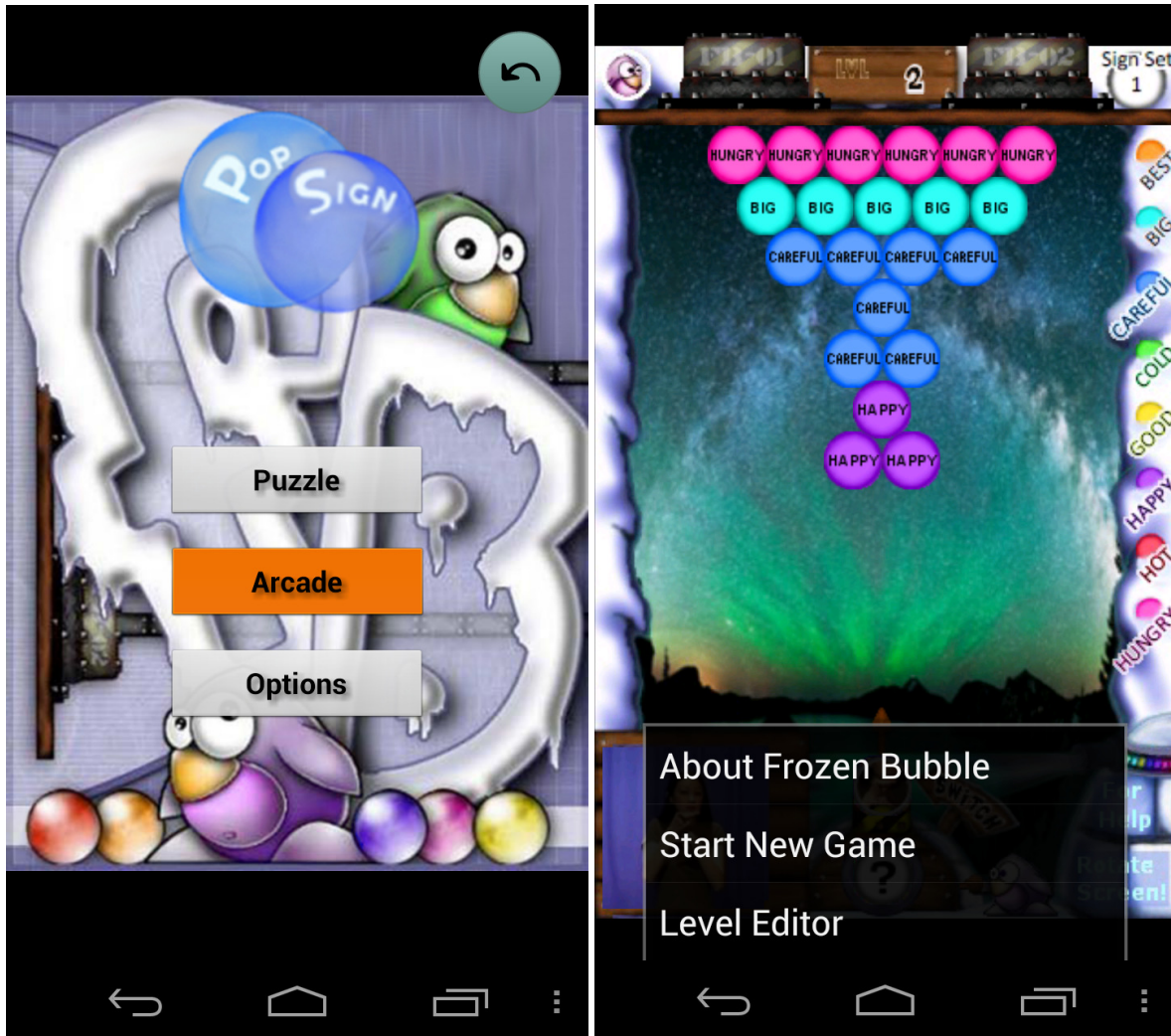


Figure A4. POPsign game screens: Home and In-game Options

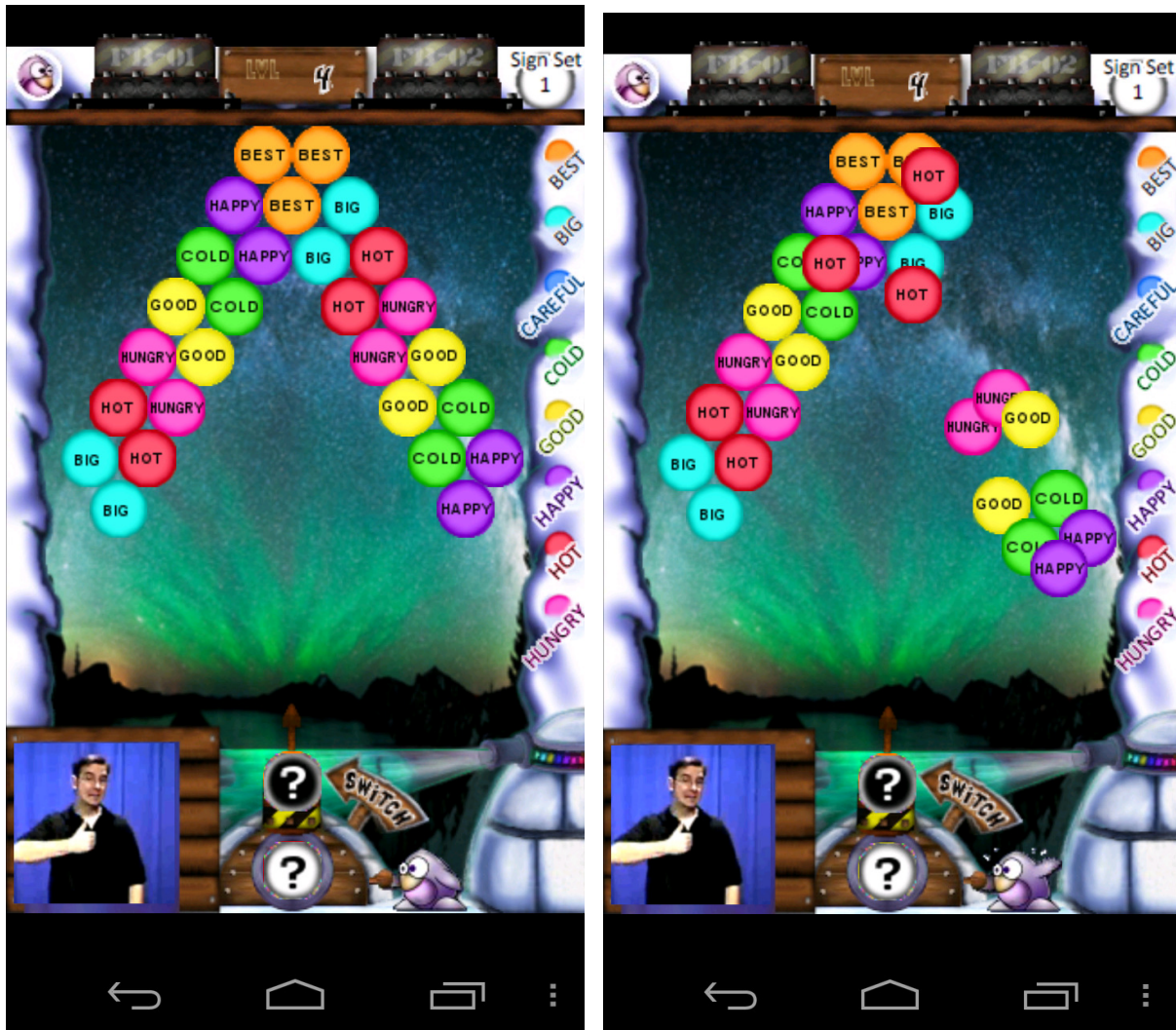


Figure A5. POPsign game screens: Arcade in action

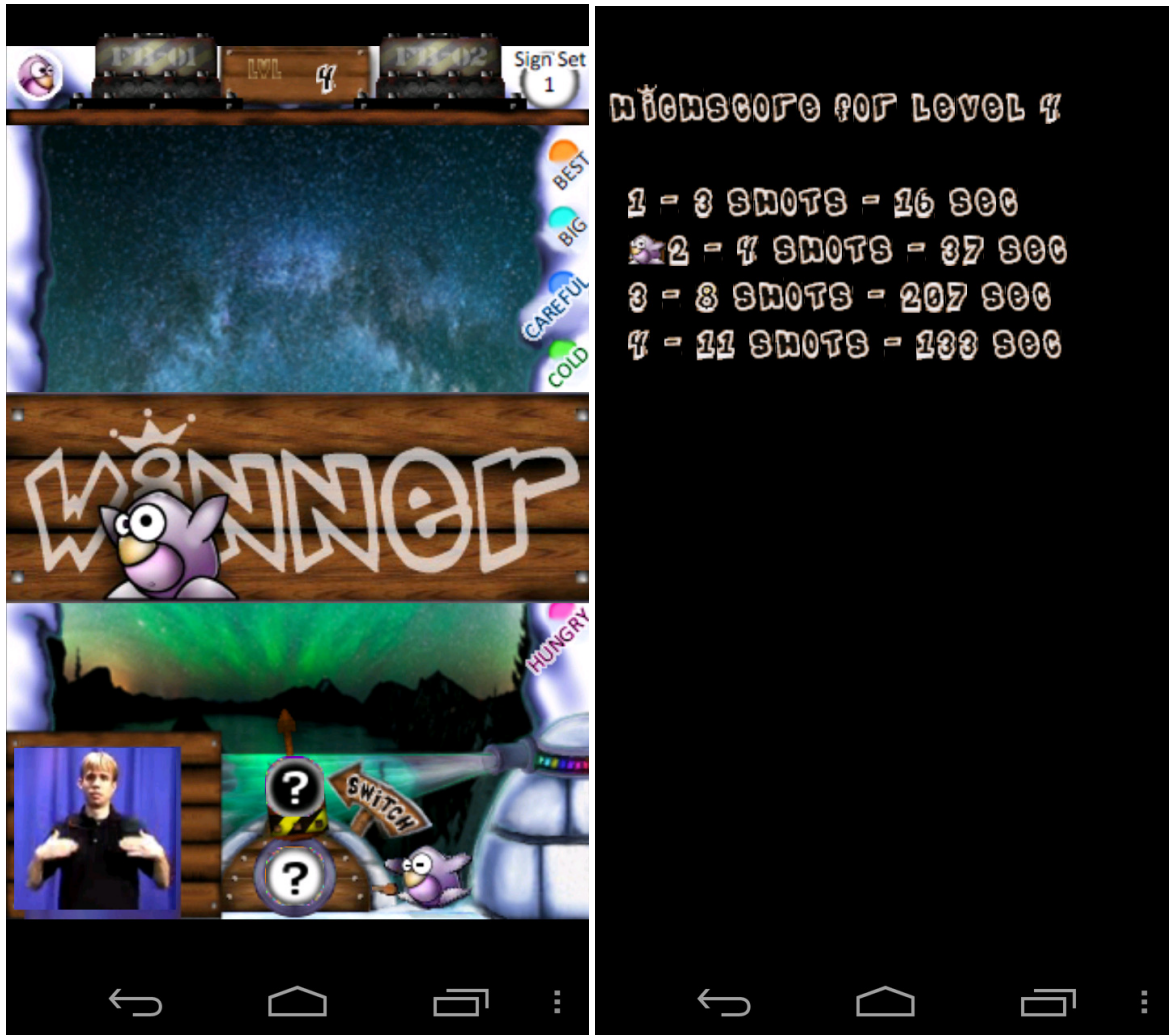


Figure A6. POPsign game screens: Winning Game Results

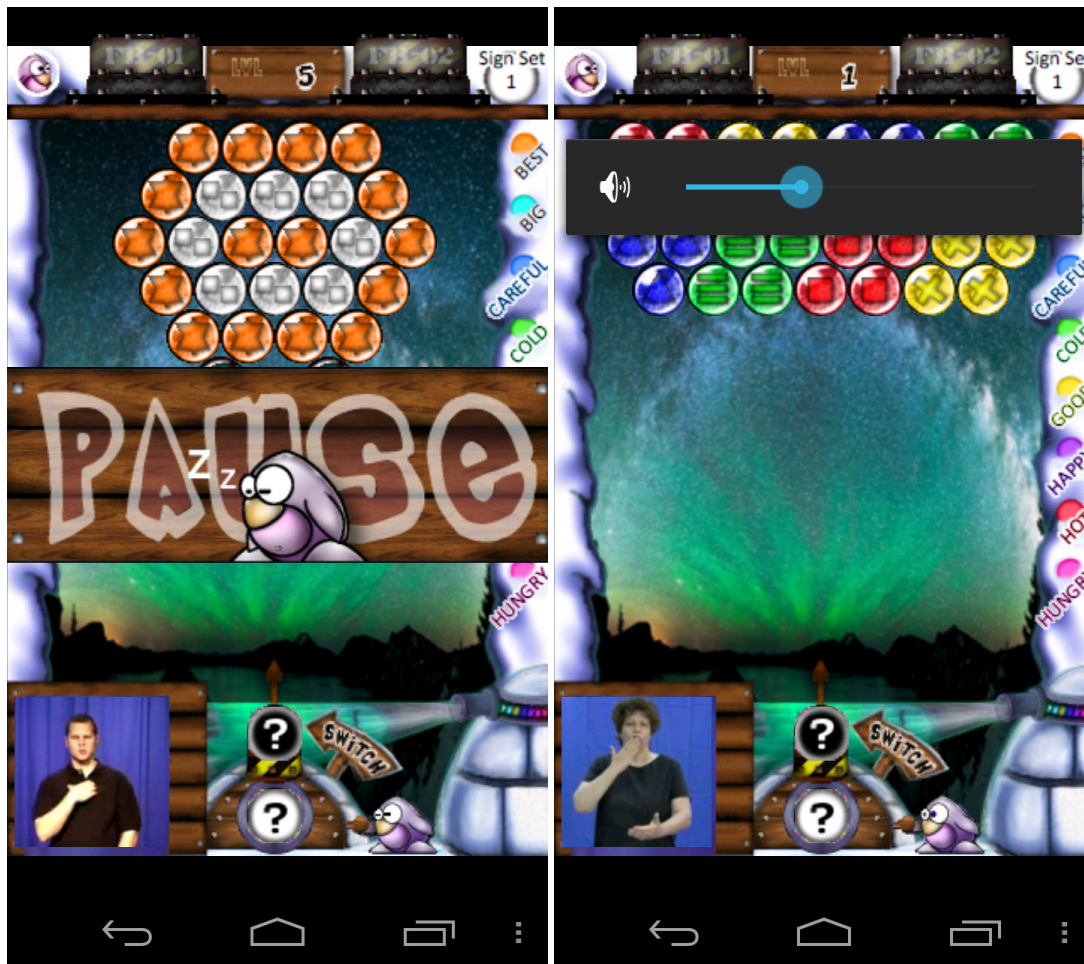


Figure A7. POPsign game screens: Screen Pause and volume adjust in old Colorblind Mode

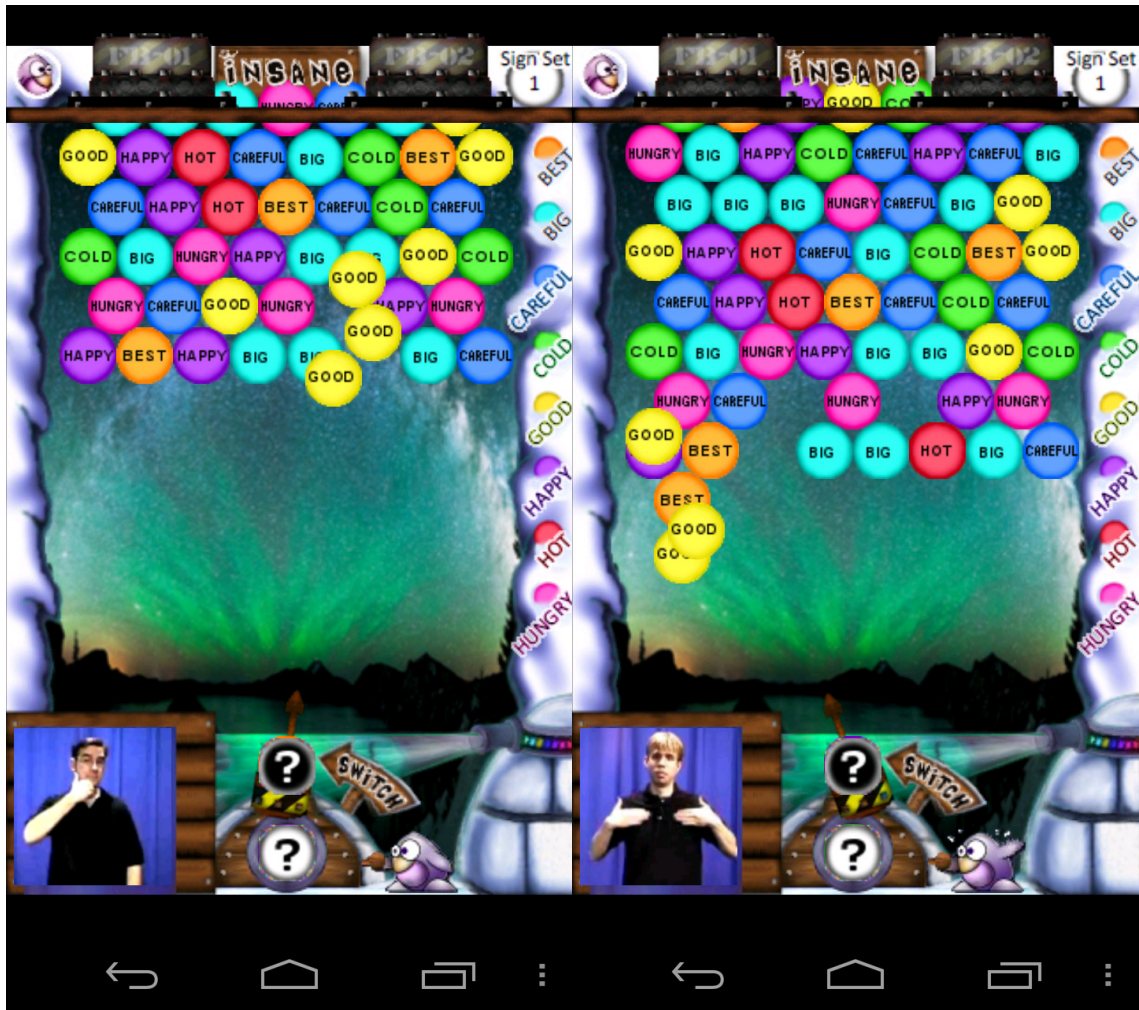


Figure A8. POPsign game screens: Progression through highest difficulty Arcade Mode - 1

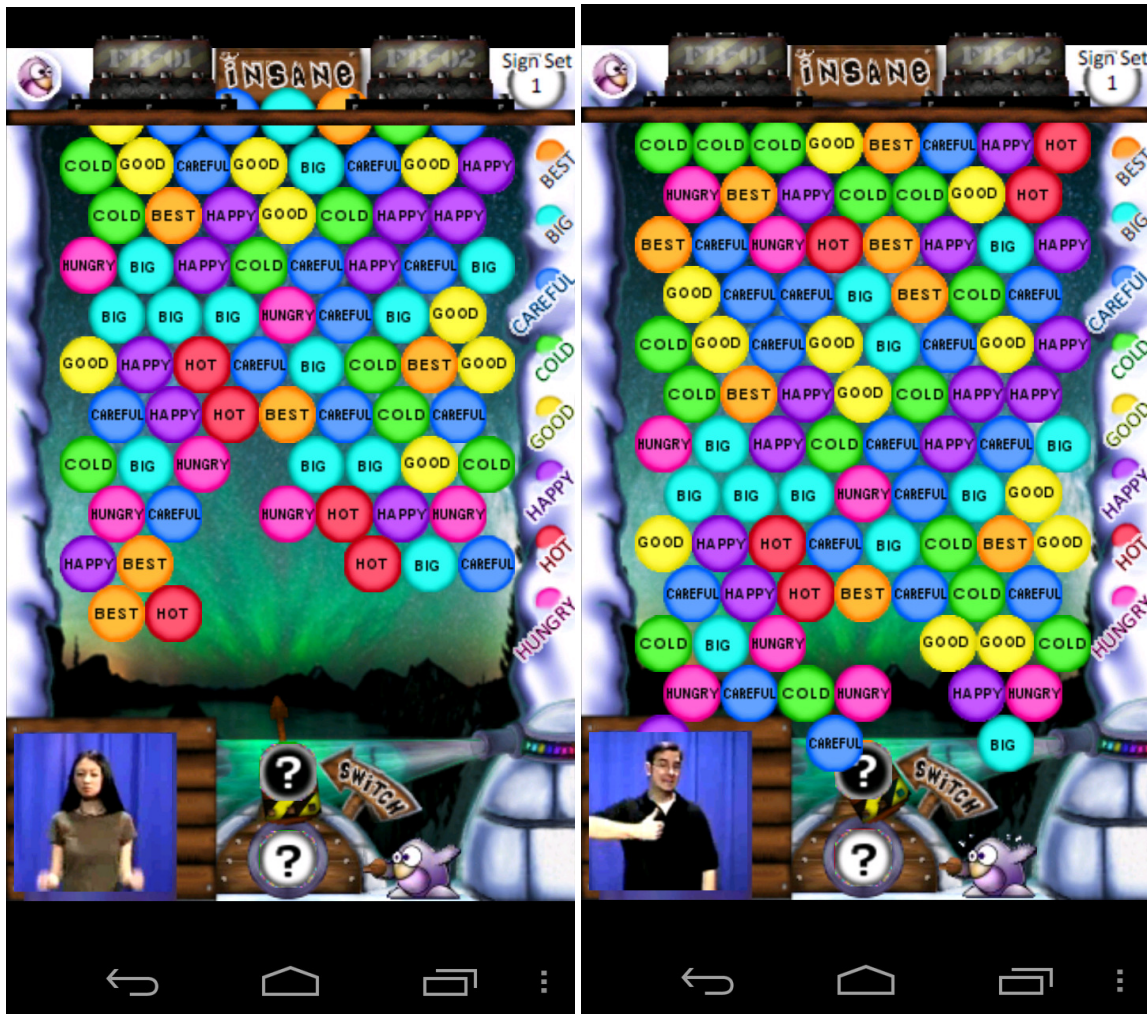


Figure A9. POPsign game screens: Progression through highest difficulty Arcade Mode -2

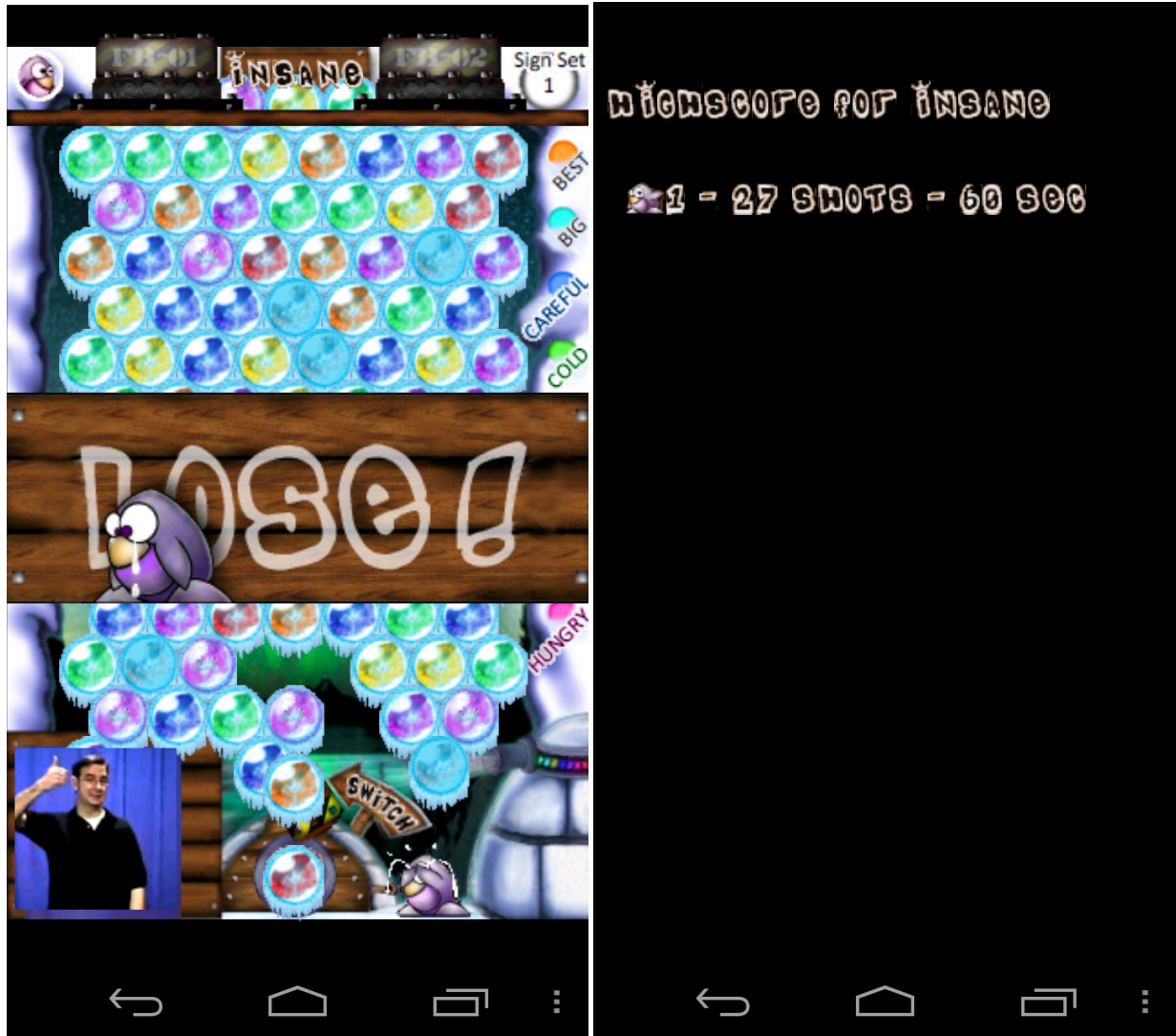


Figure A10. POPsign game screens: Progression through highest difficulty Arcade Mode -3

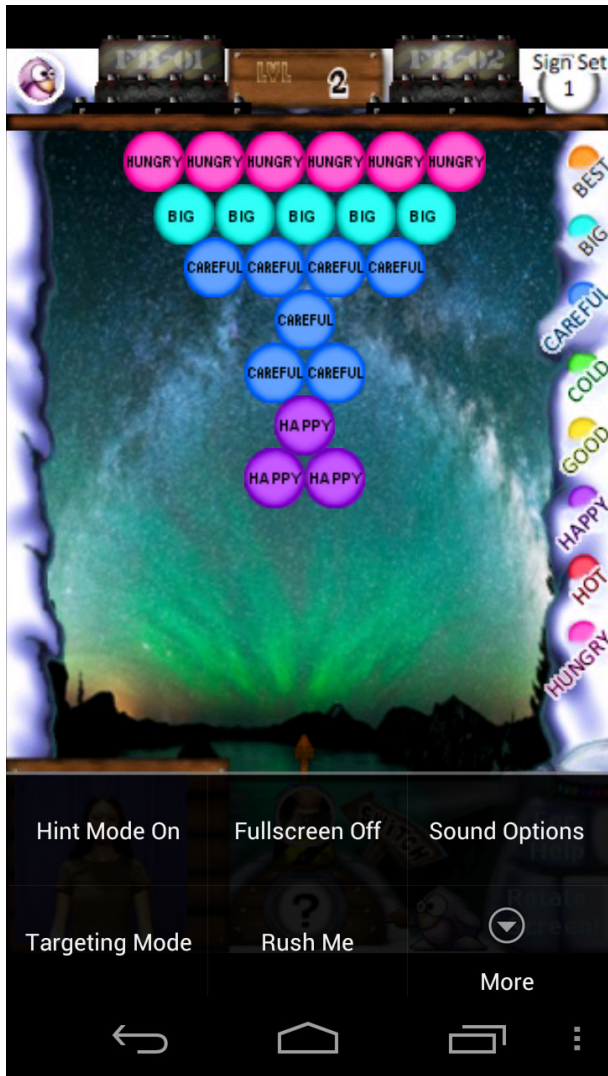


Figure A11. POPsign V3 game screens: In-game Options showing Hint Mode

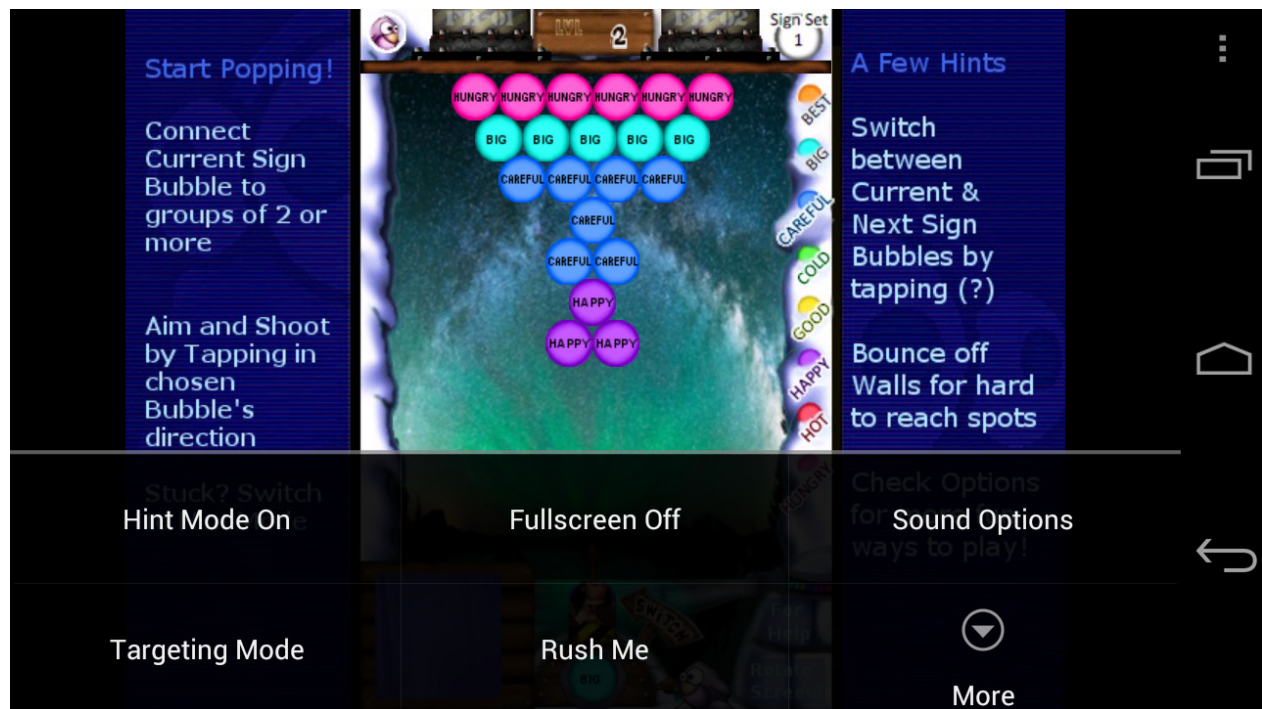


Figure A12. POPsign V3 game screens: In-game Options showing Hint Mode and Instructions

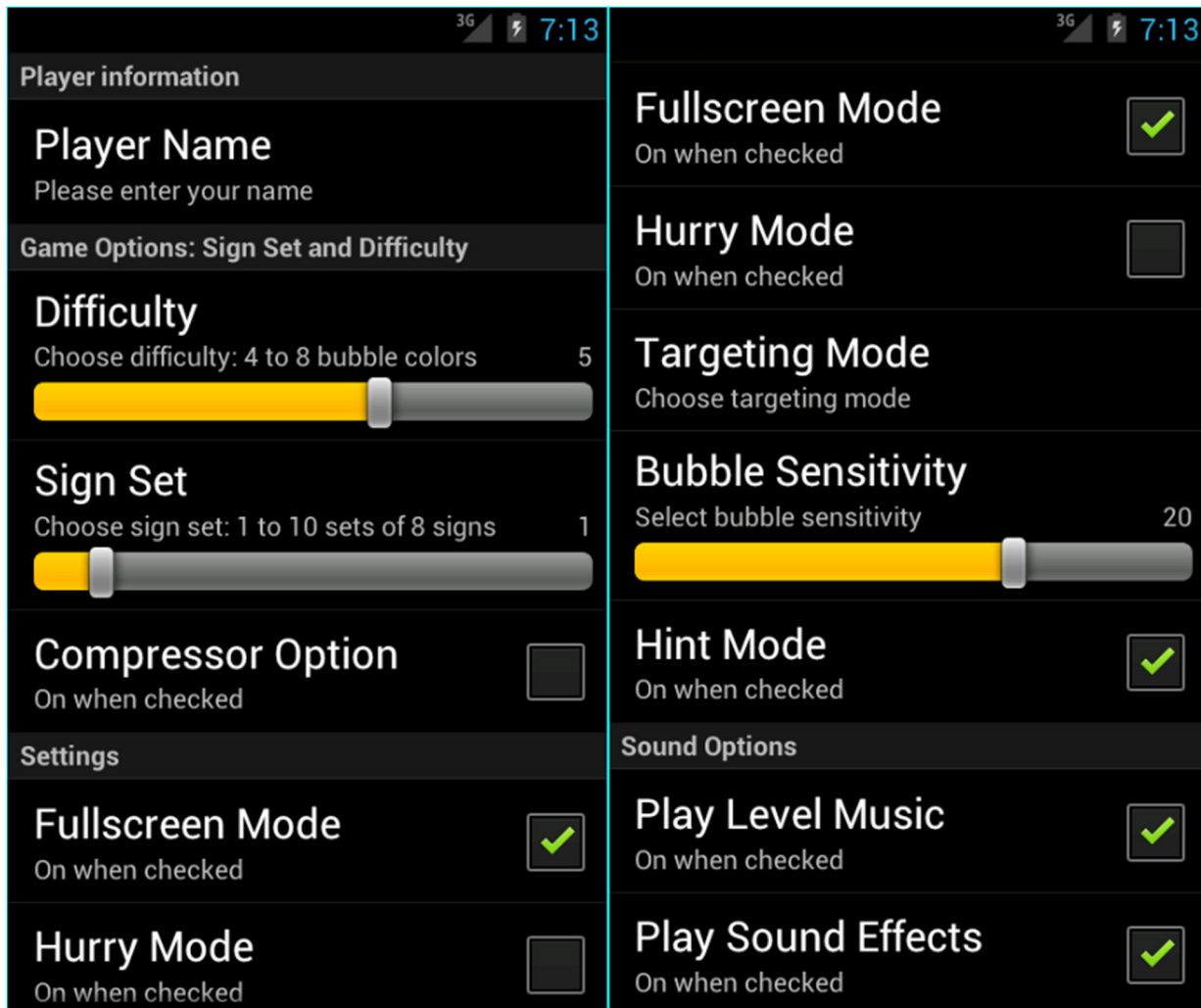


Figure A13. POPsign V3 game screens: Options Page

12 APPENDIX B: RESULTS

The result included here represent a broader and more detailed description of the data and feedback resulting from the evaluation of the POPsign user interface.

Cognitive Walkthrough – Participant comments and Observations

Participant	Rounds	Signs, other details	Comments	Observations
P1	5		silent	attempts to swipe, rather than tap
			(even after prompting)	consistently tapping by R5
	2	w/ sound		
				more hits, wall bounces
P2	4			
	R1	best?	why is it doing this sparkle thing?	guessing bubbles?
	R2	Careful		
		good	if I reach the bottom I lose, right?	
	R3	happy	I'm about to lose!	focusing on game mechanics
			(sweet!)	focusing on which signer is which
			happy or big or hungry?!	
	R4		can I move this? I can! Good to know!	bounce off the walls
			doesn't seem to like being observed	
P3	3		So, I'm trying to match?	
	R1		Can I enlarge her?	
			So, is the goal to build or blast? Ahh.	
			Can I bounce off walls?	
			What's this, Switch.	
			hmm, flashing.. Why...	

	R2		getting stuck on Careful	
			(eliminate completely)	
	R3		Dislike music and audio in general	
P4	4 R1		Oh, the penguin is cute	Mostly concentrating on gameplay
	R3		not as fun as candy crush, but its alright	seemed tired
	R4		Pretty non communicative, onward	
P5	5		What's this?...	Mostly concentrating on gameplay
	R1		oh, theres this little video...	
			and its like a bubble blaster?	
			Ok, oh!	
	R3		Hands are difficult to see	
	R5		So, are there more signs?	
P6	3		still doing that one, or next?	
	R1		need a tutorial	
			hmm, hungry	
			almost looks like he's saying big	
			if I hover over her, is it going to bounce	
	R2		think he was guy who said best	
			don't want cold... cold... cold...	same sign 5-6 times
	R3		she was big, no, good	
	R4		thought she was good	
			restart game	screen goes blank while checking out puzzle screen

P7	R1		so what am I doing here?	
			shoot bubbles corresponding to sign?	
			what's that flashing	
			I hear something?	turns up volume
			Aww	unpause tap sends ball to wrong place
	R2			
	R3			discard to right, no stack
				wall bouncing
	R4			switching, wallbounce
	R5			

Figure B1. Will include graphs of data and all comments from evaluations, grouped by subject.

13 APPENDIX C: USABILITY QUESTIONNAIRES AND COGNITIVE WALKTHROUGH SCRIPT

The following questionnaires were presented to study participants before and after the cognitive walkthrough user interface evaluation.

13.1 PRE-TRIAL QUESTIONNAIRE

Age: _____

Sex: _____

Educational Background: _____

ASL experience: _____

Skill level: (Select One)

- Beginner
- Conversational
- Expert

Learned through: (Multi-select)

- Classes
- Online
- Friends or relatives
- Books
- Other: _____

Motivation to learn:

- Friends or relatives
- Work
- Second Language Skill Requirement
- Other: _____

Mobile phone ownership

Manufacturer: _____
 Possession Period: _____

Mobile game & app usage

How many mobile games?: _____
 Types?: _____
 How often do you play?: _____
 How many mobile apps?: _____
 Types? (learning, entertainment, etc...): _____

Gameplay:

Do you play games regularly (or have you in the past)?

How often? _____

For approximately how long per session? _____

Prefer to watch others play? _____

What types?

Genre: (Multi-select)

- Strategy
- Roleplay, RPG, MMO
- Puzzle
- Action
- Story
- Other, Please list : _____

Platform/Venue: (Multi-select)

- Video, Subtypes:
- Console
- Computer
- Mobile
- Tabletop/boardgame
- Sports
- Other, Please list: _____
- Single
- Multiplayer
- Online
- Subscription
- Free-to-play

Rewards:

What incentive do you prefer?

- Badges
- Points
- Titles
- Power-ups
- Bonuses

Please list games you play regularly (with favorites *starred):

Gameplay preferences:

Exploration

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Unimportant	Unimportant	Somewhat Unimportant	Neutral	Somewhat Important	Important	Very Important

Collection

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Unimportant	Unimportant	Somewhat Unimportant	Neutral	Somewhat Important	Important	Very Important

Building, Creation

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Important	Important	Somewhat Important	Neutral	Somewhat Unimportant	Unimportant	Very Unimportant

Commerce, Trading

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Unimportant	Unimportant	Somewhat Unimportant	Neutral	Somewhat Important	Important	Very Important

Fighting

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Important	Important	Somewhat Important	Neutral	Somewhat Unimportant	Unimportant	Very Unimportant

Strategy

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Important	Important	Somewhat Important	Neutral	Somewhat Unimportant	Unimportant	Very Unimportant

Problem solving, Puzzles

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Unimportant	Unimportant	Somewhat Unimportant	Neutral	Somewhat Important	Important	Very Important

Teamwork

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Unimportant	Unimportant	Somewhat Unimportant	Neutral	Somewhat Important	Important	Very Important

Game features and mechanics preferences:

Leaderboards

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Unimportant	Unimportant	Somewhat Unimportant	Neutral	Somewhat Important	Important	Very Important

Social, Player dynamics

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Important	Important	Somewhat Important	Neutral	Somewhat Unimportant	Unimportant	Very Unimportant

Singleplayer

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Unimportant	Unimportant	Somewhat Unimportant	Neutral	Somewhat Important	Important	Very Important

Risk, Rewards

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Important	Important	Somewhat Important	Neutral	Somewhat Unimportant	Unimportant	Very Unimportant

Scores, Progress reports

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Unimportant	Unimportant	Somewhat Unimportant	Neutral	Somewhat Important	Important	Very Important

Variable difficulty

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Important	Important	Somewhat Important	Neutral	Somewhat Unimportant	Unimportant	Very Unimportant

Chance, Luck, Surprises

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Important	Important	Somewhat Important	Neutral	Somewhat Unimportant	Unimportant	Very Unimportant

Customizability, Personalization

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Important	Important	Somewhat Important	Neutral	Somewhat Unimportant	Unimportant	Very Unimportant

Mystery

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Important	Important	Somewhat Important	Neutral	Somewhat Unimportant	Unimportant	Very Unimportant

Humor

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Unimportant	Unimportant	Somewhat Unimportant	Neutral	Somewhat Important	Important	Very Important

Story, Character and Relationships

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
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Very Important	Important	Somewhat Important	Neutral	Somewhat Unimportant	Unimportant	Very Unimportant
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Pace (fast or leisurely)

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Unimportant	Unimportant	Somewhat Unimportant	Neutral	Somewhat Important	Important	Very Important

Music

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Unimportant	Unimportant	Somewhat Unimportant	Neutral	Somewhat Important	Important	Very Important

Scenery

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Important	Important	Somewhat Important	Neutral	Somewhat Unimportant	Unimportant	Very Unimportant

Mood

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Important	Important	Somewhat Important	Neutral	Somewhat Unimportant	Unimportant	Very Unimportant

Realism, Fantasy

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Unimportant	Unimportant	Somewhat Unimportant	Neutral	Somewhat Important	Important	Very Important

Escapism

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
-----------------------	-----------------------	-----------------------	-----------------------	-----------------------	-----------------------	-----------------------

Very Important	Important	Somewhat Important	Neutral	Somewhat Unimportant	Unimportant	Very Unimportant
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Immersion or Flow

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Unimportant	Unimportant	Somewhat Unimportant	Neutral	Somewhat Important	Important	Very Important

Emotion

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Unimportant	Unimportant	Somewhat Unimportant	Neutral	Somewhat Important	Important	Very Important

13.2 POST-TRIAL QUESTIONNAIRE

Application Experience:

Visuals:

I could understand and recognize symbols/visual elements.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly Disagree	Disagree	Mildly Disagree	Neutral	Mildly Agree	Agree	Strongly Agree

I found the visuals pleasant or appealing.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly Agree	Agree	Mildly Agree	Neutral	Mildly Disagree	Disagree	Strongly Disagree

Audio:

I found the audio/music pleasant or appealing.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
-----------------------	-----------------------	-----------------------	-----------------------	-----------------------	-----------------------	-----------------------

Strongly Disagree	Disagree	Mildly Disagree	Neutral	Mildly Agree	Agree	Strongly Agree
-------------------	----------	-----------------	---------	--------------	-------	----------------

I found the sound effects pleasant or appealing.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly Disagree	Disagree	Mildly Disagree	Neutral	Mildly Agree	Agree	Strongly Agree

Controls:

I found the interactions enjoyable.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly Agree	Agree	Mildly Agree	Neutral	Mildly Disagree	Disagree	Strongly Disagree

The controls were responsive (quick enough).

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly Disagree	Disagree	Mildly Disagree	Neutral	Mildly Agree	Agree	Strongly Agree

The controls were intuitive/easy to understand.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly Agree	Agree	Mildly Agree	Neutral	Mildly Disagree	Disagree	Strongly Disagree

Bugs:

There were frequent application errors.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly Agree	Agree	Mildly Agree	Neutral	Mildly Disagree	Disagree	Strongly Disagree

There were frequent crashes.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly Disagree	Disagree	Mildly Disagree	Neutral	Mildly Agree	Agree	Strongly Agree

The input sensitivity was good.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly Disagree	Disagree	Mildly Disagree	Neutral	Mildly Agree	Agree	Strongly Agree

Help:

The application needs more/different hints or instructions.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly Agree	Agree	Mildly Agree	Neutral	Mildly Disagree	Disagree	Strongly Disagree

Overall Experience:

The interactions “made sense”.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly Agree	Agree	Mildly Agree	Neutral	Mildly Disagree	Disagree	Strongly Disagree

It provided a feeling of completion.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly Agree	Agree	Mildly Agree	Neutral	Mildly Disagree	Disagree	Strongly Disagree

I usually wanted to continue using the application.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly Disagree	Disagree	Mildly Disagree	Neutral	Mildly Agree	Agree	Strongly Agree

I felt the application would be a good use of time.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly Agree	Agree	Mildly Agree	Neutral	Mildly Disagree	Disagree	Strongly Disagree

I could get into a regular use routine (practice/play at a certain time of day)?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly Disagree	Disagree	Mildly Disagree	Neutral	Mildly Agree	Agree	Strongly Agree

----Game-related Questions (SMARTsign users may skip)----

The gameplay was exciting.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly Agree	Agree	Mildly Agree	Neutral	Mildly Disagree	Disagree	Strongly Disagree

I value exciting gameplay.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly		Mildly		Mildly		Strongly

Disagree	Disagree	Disagree	Neutral	Agree	Agree	Agree
----------	----------	----------	---------	-------	-------	-------

The gameplay was challenging.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly Agree	Agree	Mildly Agree	Neutral	Mildly Disagree	Disagree	Strongly Disagree

I enjoy the level of challenge.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly Agree	Agree	Mildly Agree	Neutral	Mildly Disagree	Disagree	Strongly Disagree

The gameplay detracts from ability to recognize sign.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly Disagree	Disagree	Mildly Disagree	Neutral	Mildly Agree	Agree	Strongly Agree

The sign occurrence rate seems too slow.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly Disagree	Disagree	Mildly Disagree	Neutral	Mildly Agree	Agree	Strongly Agree

The sign occurrence rate seems too rapid.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly Agree	Agree	Mildly Agree	Neutral	Mildly Disagree	Disagree	Strongly Disagree

----End of Game-related Questions----

I feel more capable of recognizing the sign language terms studied.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly		Mildly		Mildly		Strongly

Disagree	Disagree	Disagree	Neutral	Agree	Agree	Agree
----------	----------	----------	---------	-------	-------	-------

I believe I will retain this knowledge.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly Agree	Agree	Mildly Agree	Neutral	Mildly Disagree	Disagree	Strongly Disagree

The experience was rewarding/enjoyable.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly Agree	Agree	Mildly Agree	Neutral	Mildly Disagree	Disagree	Strongly Disagree

I will continue to play, or download this app if publicly available.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strongly Disagree	Disagree	Mildly Disagree	Neutral	Mildly Agree	Agree	Strongly Agree

Would you like to see more/varied content?

- Yes
- No

If so, please provide examples: _____

Would you like to add your own content (learning materials, music, skins)?

- Yes
- No
- Maybe

Please add any additional comments or suggestions here.

In particular, what do you feel would improve the ability of such an app to make learning a habit for more people?

App Improvements:

Would you like to see any additional features or refinements?

13.3 POPSIGN - COGNITIVE WALKTHROUGH EVALUATION

Think-aloud Protocol:

The purpose of this evaluation is to understand which aspects of the application are most effective, enjoyable, and easy to use. We ask that you proceed through the tasks at your own pace, while talking about what you are experiencing. We'd like to hear all opinions (good, bad, or otherwise), or anything that is puzzling, frustrating, or particularly enjoyable. Hope you have fun!

Pre-evaluation Instructions:

Please fill out both IRB consent forms and the pre-trial questionnaire. Once your proctor has signed the IRB consent forms, make sure to retain your copy.

Mobile App Evaluation Instructions:

Please turn on the camera, adjusting to ensure a clear view of the phone screen.

Turn the phone on and locate the POPsign app in your applications screens.

Action 1: Play POPsign in Puzzle mode

--Please play until you feel comfortable (or for approximately 5 min, 5 rounds)

--Navigate back to the start screen.

Action 2: Play in Arcade mode

--Please play until you feel comfortable or bored (or for approximately 5 min)

--Navigate back to the start screen.

Action 3: Change options in the Options screen

--Adjust one or more of the following fields:

Reduce sensitivity

Turn Music off (not Sound Effects)

Change difficulty to 5 or 6 balls/colors

Add a player name

--Navigate back to the start screen.

Action 4: Play in Arcade mode again

--Check whether altered options improve gameplay

Post-evaluation Instructions:

Please turn off the camera.

After completing evaluation, please fill out the post evaluation form.

Thanks for participating!