From App Users to App Designers & Developers: Apps for Pediatric Speech-Language Therapy

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The use of mobile apps and mobile devices in pediatric speech-language therapy has moved from the experimental phase to wide clinical adoption despite issues with design, institutional challenges, and gaps in research (e.g., evidence-based practice). Children are motivated by mobile apps and devices and conversant with touchscreens. Speech-language pathologists (SLPs) are flexibly incorporating apps and games into their interventions and working around the challenges while keeping limitations in mind. However, both the design and implementation of mobile apps within the field of speech-language pathology have not been thoroughly explored. This study synthesizes interviews of multi-perspectives of stakeholders in the designing and development process of pediatric speech-language therapy apps. Through the lens of designers and developers, this paper aims to disseminate a multi-year qualitative mobile app study, discuss the creation and implementation of mobile speech-language therapy apps for pediatric populations, and highlight new user challenges and app design opportunities.

Keywords: Children with Communication Disorders, Speech-Language Therapy, Mobile App Designers and Developers, Collaboration

Introduction

It is estimated that one in 12 children in the United States between ages 3 and 17 are likely to suffer from speech, language, swallowing, and voice disorders, and these children work with speech-language pathologists (SLPs) across diverse early intervention, educational, and medical settings to address these disorders (Du & Tekinbas, 2020). Due to the exponential growth and use of touchscreen devices in modern households, these children with communication disorders (CwCD) have increased access to mobile apps (Ibrahim et al., 2022; Gallud et al., 2021). Mobile apps are being used as digital therapy materials by app designers and developers with different backgrounds for children with communication disorders (Heyman, 2018; Edwards & Dukhovny, 2017; Cohen et al., 2017; Douglas et al., 2012). Previous studies have found that clinicians utilized a variety of hardware and software technological tools during therapy sessions toward diverse speech-language therapy goals (Du et al., 2022; Sauermilch, 2022); however, limited research has been conducted regarding the design and development of these apps used by SLPs for CwCD, especially with perspectives from both clinicians and technologists. This qualitative interview study reports on interviews with mobile app designers and developers with and without clinical background in speech-language pathology to examine how technologists approach the design and development of apps used by SLPs.

Research Design & Methods

Semi-structured interviews were conducted with 27 participants who designed or developed mobile applications used by children in speech-language therapy. The Consolidated Framework informed the interview protocol for

Implementation Science (CFIR) by Damschroder et al. (2009), a theoretical framework used by researchers across a wide variety of study objectives and settings to evaluate the implementation of mobile technology as a tool for intervention (Olswang & Prelock, 2015). Among the participants, 21 individuals were from North America, five individuals from Europe, and one from the Middle East. Specifically, 14 individuals (will be referred to as "SLP app designers") had a background in SLP (Table 1), and 13 individuals (will be referred to as "none-SLP app developers") had a background in other fields (Table 2), such as children's interactive media and web development. These non-SLP app developers included parents of children with disabilities, Ph.D. students, producers and designers. With the interviews, we conducted a qualitative analysis using a codebook to analyze important aspects when designing speech-language apps for children. Interviews were analyzed using template analysis and thematic analysis (King, 2004) and then summarized in clinician user personas (LeRouge et al., 2013), a technique used in the field of human-computer interaction. Validity and reliability were ensured with teams of two coders, with differences resolved by the larger research team using member checking (Creswell and Miller, 2000). Using qualitative coding, a total of seven emerging themes were identified, including clinical practice, app characteristics, support systems, developer characteristics, design and development, influential factors, and recommendations.

Table 1

Demographics of 13 Non-SLP App Designers and Developers (SLP app designers)

Participant ID	Work Setting	Location	Areas of Clinical Specialty
P1	Play Designer Children's Game Company	Sweden	Children's Games
P2	Ph.D. Student Researcher	CA, USA	Speech Recognition Game
P3	Interactive Producer	Canada	Speech Recognition Game
P4	Parents with Children who are Disabled	WA, USA	Children's Games
P5	Web Developer/Parent with Child who is Disabled	UT, USA	Speech-Language Therapy Apps
P6	Parents with Children who are Disabled	CA, USA	Speech Recognition Game
P7	iOS Developer	Israel	Children's Games
P8	Ph.D. Student Researcher	CA, USA	Speech Recognition Game
P9	Ph.D. Student Researcher	TX, USA	Speech Recognition Game
P10	Director of Operations	NC, USA	Speech Therapy Product
P11	Interactive Producer	Lithuania	Children's Games
P12	iOS Developer	Sweden	Children's Games
P13	iOS Developer	Sweden	Children's Games

Table 2

Demographics of 14 SLP App Designers and Developers (non-SLP app developers)

Participant ID	Work Setting	Location	Areas of Clinical Specialty
P14	University/Private Practice	NJ, USA	Fluency & Games
P15	University research lab	IN, USA	Augmentative Alternative Communication (AAC)
P16	Public School/Telepractice	OR, USA	Prosody
P17	Private Practice	TX, USA	Assessment (Bilingual)
P18	University Clinic	ND, USA	Articulation & Language
P19	Public School/App Company Owner	TX, USA	Articulation & Language
P20	Senior Product Management	WA, USA	Assessment
P21	Public School	CA, USA	Articulation & Language
P22	Research lab (Telepractice)	NY, USA	Biofeedback
P23	University Research	TX, USA	Assessment (Bilingual)
P24	SLP/Graphic designers	UT, USA	Articulation & Language
P25	Private Practice	CA, USA	Auditory Processing
P26	Private Practice	MA, USA	Social Groups
P27	Hospital SLP/iOS developer	Sweden	Articulation & Games

Results

Interview results indicated that SLP app designers skillfully integrate apps into therapy sessions to replace or augment traditional materials in order to elicit speech sounds, language targets, and social behaviors (e.g., animal sounds, turn-taking). They value the integration of apps and believe they could use apps to support various therapy goals. Another reported benefit was that apps reduce preparation time and assist with behavior management (e.g., as a reward between therapy activities). They also explored apps that support evidence-based practice and are informed by learning theories and educational rubrics. When discussing app characteristics, SLP app designers indicated the value of tracking and reporting, pacing controls, and reinforcement, while expressing concerns with overstimulating features (e.g., flashing graphics, loud noises). Other themes were found amongst non-SLP app developers, including financial issues, participatory design process, and identifying administrative features that increase usability for SLPs (e.g., individual goal setting, group therapy).

Design and Development
In clinical practice, mobile applications were designed for various purposes to improve treatment efficiency. As P25, a private practice SLP app designer described, due to the increased adoption of mobile technology, the client

population drove the need for change of novel therapy materials, approaches, and techniques. For example, SLP designers highlighted app design goals to maximize therapy time, increase client attention, and add client-clinician interaction during therapy sessions. SLP developers seemed to be more informed on evidence-based practice and established goals based on well-researched teaching methods and learning theories. Non-SLP app developers emphasized the importance of participatory design throughout the development process. In addition to surveying clients in the early stages to understanding CwCD's communicative needs to perform usability testing to assess app features and solicit feedback, contributions and continual feedback from caregivers (e.g., families, parents), health professionals (e.g., SLPs, occupational therapists, physical therapists, doctors, surgeons), educators (e.g., teachers), technologists (e.g., play designers, developers, engineers), and organizations (e.g., service agency, ASHA), were all crucial to the design and development of apps. Because of the feedback from stakeholders other than SLPs, some non-SLP developers have other design goals to extend and monitor speech exercises outside therapy, considering that parents do not always have time to work with their children directly or misreport practice time. These developers integrated administration and management features, including generating qualitative reports for the SLPs, assisting therapy organizations for the school districts, tracking user progress, etc. These features aim to help SLPs monitor speech practice outside of therapy and generalization of skills to the home setting.

When incorporating therapy goals into app design, SLP designers and non-SLP developers emphasized the importance of improving user engagement. Across both participant groups, we found that designers and developers prioritized creating simple but aesthetic content appealing to the target age group. Additional design elements, such as interactive graphics and enticing audio effects, are included to motivate gameplay features. For example, when designing game-based apps, most designers and developers include themes from daily life that children are familiar with, allowing children to build upon their existing play paradigms and create intuitive gameplay. Developing and maintaining an app is a significant investment (e.g., expensive, time-consuming, hard to compete with bigger companies, and requires ongoing maintenance and updates). The development cost of an app can run hundreds of thousands of dollars. Developers must create product plans, prioritize features, hire coders, and support multiple platforms (e.g., Android, iOS) and mobile device types. Additionally, apps must be marketed to recoup these costs, which requires time, skill, and expertise in marketing channels and social media.

Influential Factors
We also investigated several influential factors related to the design and development of apps, including sociocultural factors, financial/economic factors, political factors, ethical/moral factors, and motivating factors.

Sociocultural Factors
Sociocultural factors were associated with design challenges related to the cultural/linguistic barriers (P20) and resulted from different languages for international audiences (P15, P16, P21, P23, P27). European languages including dialectal variances). P27 was an SLP app developer in Europe who emphasized the need to include different English dialects when designing speech sounds, since English apps may be used by speakers from different geographical regions. When receiving app feedback for English vowels, P27 reported it has to consider integrating such feedback on the American "ER" sound and a solution to include the British "UR" sound. In the U.S., there is also a high demand for materials to serve Spanish-speaking children. P19 was an SLP who practiced in Texas and created a series of articulation and language apps inspired by the clinical need of materials to help serve the Spanish speaking children in their native language. Beyond linguistic considerations, localizing apps into multiple languages also brings additional cultural adaptation challenges in visual design and clinical workflow. It is difficult to develop a universal symbol set for visual icons, since every culture has its own conventions for symbolic representation. A researcher who creates augmentative alternative communication (AAC) systems mentioned a large international need for AAC, yet "every culture has its own rules or conventions on how symbols are used or represented; difficult for developers to accommodate (P15)." P23 and P21 who worked with clients in China and India reported some cultures and countries are unfamiliar with speech-language therapy and may have very different evaluation and treatment protocols. It is common to spend 1.5-2 hours to diagnose a child with a speech-language disorder, however, due to the large population of children in need and limited number of therapists, "spending that much time with one child to do the diagnosis and evaluation is unusual…when the child has an issue, the child will go to the pediatrician not to a therapist…Pediatricians in the U.S. can influence the pediatricians in China to understand and work as a team (P23)." This means when developers adapt a similar speech-language assessment app developed in the U.S., they need to consider local pediatricians as a key user, and also need to learn from pediatrician's practices in the U.S. to inform the cross-culture adaptation. App designers and developers also need to consider different attitudes around technology perceptions and readiness from clinicians and families. For example, "some parents adopt iPad therapy use and others use iPad as more of a babysitter (especially with children on the autism spectrum)" while clinicians also hold different beliefs that "some apps will work with students" but others won't (P16). SLP P27 offered a different perspective: "Parents accepted the use of iPad and apps because I was the professional who recommended it." Therefore, these sociocultural factors lead to complex considerations for app design and development.

Financial/Economic factors

Interview participants highlighted several financial/economic factors, such as expensive costs of app development, lack of funding and budget difficulties, challenges in business decision-making, and lack of school support for apps and sustainability of apps. App development requires a huge budget for expenses such as hiring developers, buying audio-visual elements, and maintaining apps. SLP P15 and P22 are researchers who work on innovative mobile app solutions in research institutes. Both of them highlighted that technologies are relatively unattainable and expensive, therefore "manufacturing must come up with solutions to fit most clients to target a large market. There is a need to sell one product for price efficacy (P15)." Despite the high cost for app design and development, the app users may be unable to afford the apps, including clients who "do not have access to phones, tablets, or a good computer (P16)." For example, some hospitals and public school settings have a budget and institutional constraints. School districts can vary their support with apps; some will preselect apps for use and others do not have the budget for apps. Due to the increased competition on the mobile app stores and many alternative free apps, app users are unwilling to pay for apps after paying for the expensive device. They expect free or cheap apps, which results in low sales for expensive apps, making it difficult to generate enough revenue for consequent app updates. In addition to these intersectional financial factors, app designers and developers have to consider the competition of traditional non-paper-based materials, since clinicians and other stakeholders can easily choose not to adopt mobile technology. The director the operations for a company that produces speech-language therapy materials, P10 discussed the business decisions that are made; "As a business, you have to step back and say, is this something we'll want to pour more resources into or less resources, because everyone has limited time and resources either at an individual level or as a business. I'd have to ask, should I spend six months developing a new app, or should we develop a new product that everyone can buy rather than just the people that have this phone?" Even developing apps in a sustainable way has become a challenge overtime, since developers are "constantly dealing with technology issues and updates to the IOS system" while "production of paper copies and things are expensive" as well (P17).

Political Factors
Political factors related to app design and development primarily focused on privacy rules/laws for children. For example, cloud-based content management will need to keep data HIPAA (Health Insurance Portability and Accountability Act) compliant (P15); a simple act of emailing progress data or videos taken within the app to parents may lead to violations, and it requires parental permission to use children's data. Both clinician users and app designers/developers need to make sure there is compliance with all laws related to data security and data privacy. P6 described that due to laws such as COPPA (Children's Online Privacy Protection Rule), "I can't really use recordings of kids for my app because that's against the law and Apple won't allow that either. I had to even hire an attorney to draft my privacy policy to make sure I said everything that I needed to say. I think because of child protection privacy concerns that does limit the amount of data that's needed to produce the technology that can help them" P20 agreed: "HIPPA laws, SIPA laws, and anything related to data security and data privacy, we were bound by all those and accountable for that…if you are the developer of a digital tool that will store personally identifiable information, it would be wise for you to know that law very well, because you're responsible if something happens to the data that somebody puts in your system." Participants further specified that many mobile devices have to obey specific institutional and organizational rules. For example, many students who rely on AAC systems to communicate may not be able to take their mobile devices home, since AAC devices need to stay in schools and in the organizations (P15); some school districts can be more strict about accessing WiFi, limiting access to additional mobile app features (P16).

Ethical/Moral Factors
Ethical/moral factors reported by participants related to ethical dilemmas with in-app advertisement, content censoring for child safety, and a lack of awareness for ethical practice when using apps during therapy. App developer P13 reported that although in-app advertisement brings remarkable revenue for developers, "that's just impossible to do with children in Sweden. You can't really push ads to children. It's yeah, it might be illegal in school. But it's even if it's not illegal, yes, people don't like it. So you can't really sell apps" (P13). P15 highlighted that although there are many existing products on the market, "there are difficulties for manufacturers to throw a solution to fine-tune solutions…The entire community must learn to provide more education, training, and background technologies on how to use and integrate them effectively and efficiently as well as to how to evaluate them and engage in evidence-based practice around new technologies."

Motivating Factors
The most common motivating factor among the app designers was the desire to have the apps be entertaining. As a parent with children who are disabled, P4 believed "kids learn well by playing and being engaged so we really sought to make these apps fun and entertaining, something that the kids could do. Also something they could be creative with and that was fairly easy to put together, something they could be proud of. It was really based on fun is what we wanted to do." Some of the appealing app design elements include auditory feedback and visual stimulation, which act as reinforcement to enable greater engagement and longer attention span. For example, P14 was able to use apps with filters and allow clients to see themselves; P26 observed intrigue and engagement in the beginning of sessions from iPad use and enabled greater engagement on clinician's modeled speech instead of toys and further enriched better elicitation of early language. Many SLPs believe that touchscreen devices allow the use of tactile and integration of

games, adding fun elements in addition to the perceived amount of "work" that clinicians are doing (P15, P22, P27). P21 stated that "Kids just want to have fun. Language is hard for most of these kids, it's got to be fun and motivational for them. That's all you need on the kid's perspective and keep them interested." P16 further added that "...because of their experience with this technology or it is something new/natural/flashy and is more exciting." Another motivating factor was that children were not only motivated by the app but the actual device themselves (e.g., computers, iPads, phones). As P17, a private practice bi-lingual speech pathologist noted, mobile devices are "more enticing, more engaging, more motivating for the client to handle that format." To some clinicians, apps can make children want to do certain activities, and there are indeed positive feelings/emotions children get from the apps.

Recommendations

When designing and developing apps, SLP designers and developers identified a need for more accurate feedback, automated scoring and the importance of evidence-based evaluation of treatment. They want apps that are not reliant on English with more language tools for assessment. For example, P13 stated, "I would love to see more language tools for assessment.…it would be really nice to have things organized and come up with a nice report so that you can facilitate the report writing process. I think the fact that it takes us longer to write a report than it does to test the child is problematic." Overall, they felt that there is more research needed on technology and its benefits as well as evidence-based studies on apps. They stated that it was important to identify technology groups to connect with and more technology grants because clinicians who have little background in AAC need to be trained. Non-SLP app designers and developers also recommended improving the accuracy of score recognition of speech sounds. P3 discussed their frustration with app design saying, it "cannot recognize core phonetic sounds in isolation, it is extremely difficult." and audio should be added to enhance the client's understanding. The technology needs to understand "stress points", and apps should have the ability to be used in a variety of settings. The design should focus on age spans and evaluation of the user's experience. As P1 stated, the "iterative process is helpful, by testing kids at every milestone and re-evaluating ideas." Finally, there needs to be collaboration on the app across constituents. One stakeholder that P1 discussed was, "Not all developers have children with special needs in their business model, but it would be helpful to learn game aspects that would benefit most of the kids."

Conclusion

This qualitative study addressed the design and development of mobile apps for pediatric clients who have speech-language disorders. Interview findings from a total of 27 app designers and developers with and without a background in speech language pathology reported both clinical and technical design implications, as well as unmet therapy-driven needs and challenges related to mobile app adoption and use. By examining multi-disciplinary perspectives, this study explored new app design opportunities through the lens of SLP and app designer and developer in order to generate best practices for creating and adapting a plethora of digital tools for therapy services.

As more children and clinicians adopt and implement touchscreen devices and mobile apps in pediatric speech-language therapy, issues with design, institutional challenges, and gaps in research (e.g., support for evidence-based practice). Successful app development for pediatric clients who receive speech therapy services requires a multidisciplinary design and research team (e.g., graphic and game designers, app developers), as well as collaboration with multiple stakeholders (e.g. children with communication disorders, family members, SLPs) in the participatory design process. This study is one of the first known studies that shed light on the larger body of research in special education technology research through the inclusion of multi-stakeholder perspectives from clinicians and technologists in the designing and development process. Future research that stems from this study will continue to dive into individual app analysis and usability studies to better understand CwCD's experiences with apps, especially when these young users experience communication difficulties.

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