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An Iterative Co-Design Approach to Developing Aphasia-Related Assistive Technologies

Kyle Day

day00090@morris.umn.edu

Division of Science and Mathematics

University of Minnesota, Morris

Morris, Minnesota, USA

Abstract

Assistive technologies are created with the intent to help maintain or enhance the lives of people with certain health conditions. The success of these technologies depends largely on the comfort and usability afforded to their users. As such, researchers have involved people with aphasia as co-designers in iterative development cycles. Over the course of several iterations, the co-designers are given equal say in designing assistive technologies to satisfy their needs. This paper will discuss an approach in which iterative co-design has empowered people living with aphasia to help create assistive technologies that can be used to positively impact their day-to-day life through rehabilitation.

Keywords: co-design, iterative design, assistive technologies, aphasia

1 Introduction

Poor health can make day-to-day life uncomfortably difficult. As a result, *assistive technologies* have been developed as tools for improving or maintaining the quality of life of clients with certain health conditions. However, to make the most impact in a client's life, assistive technologies must accommodate their needs, preferences, and comfort. Designers consult their clients to ensure that the technologies can meet these requirements. How important the designers deem their feedback is for them to decide. Some feedback may be deemed unimportant due to designers' inexperience with the condition, which can lead to some undesirable outcomes. Researchers have sought to avoid such outcomes by removing the element of inexperience from the design process entirely. This removal involves increasing clients' involvement in the design process themselves. One potential solution is *iterative co-design*, which empowers clients with certain medical conditions to work directly with the designers in the process of creating assistive technologies over the course of several iterations.

This paper will analyze Hymes et al.'s iterative co-design process, which produced card-based analog and digital games for people with aphasia. Section 2 will provide definitions for iterative design and co-design for clarity, as well as a brief description of aphasia. Afterward, game-based relief efforts for people with aphasia will be discussed to show what inspired

the researchers to explore games as a medium for aphasia-related co-design. Then, Section 3 will cover the foundations behind their co-design process and the outputted assistive technologies. 3.1 will provide context as to what the goals were behind the research and the technology. Then, 3.2 will specifically describe the obstacles addressed with the co-design methods, while 3.3 will cover aspects of the game design process itself. Afterward, Section 4 will cover the findings of the research. 4.1 discusses changes made to the design process specifically, while 4.2 discusses the games and how they meet guidelines set forth by the researchers. Conclusions will then be discussed in Section 5.

2 Background

Creating assistive technologies can involve several design processes working together in a holistic manner. Two common processes include iterative design and co-design, which are defined in the following subsections. Research discussed in this paper is particularly focused on iterative design and co-design in the context of assistive technologies related to aphasia. As such, a description of aphasia has been provided for context. Research conducted prior to Hymes et al.'s work has also been included to show what inspired their research.

2.1 Iterative Design

Iterative design is a key process in the development of analog and digital technologies. It occurs over the course of several design cycles, which serve to produce iterations of technologies and allow time to revise them from one cycle to the next. Different organizations have different definitions for what constitutes a cycle. In the case of Hymes et al.'s design process, the cycle begins with brainstorming as needed, presenting ideas at the workshops, gameplay demonstration, playtesting, feedback, and revision (see Figure 1). Over the span of three months, each game had three cycles of iteration, each occurring over one or two workshops.

2.2 Co-Design

Co-design is the process by which representatives from various stakeholder groups using and implementing a technology are equally involved in the design process. Sometimes, co-design is described in the context of a similar but not

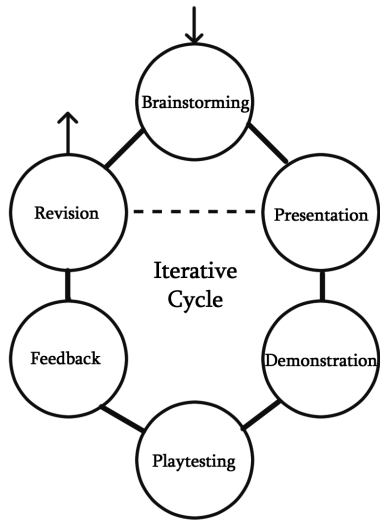


Figure 1. A visualization of an iterative cycle referencing [3]. Brainstorming is the first step, although the researchers cite that it was unnecessary in some iterations. Once a game was complete, the iterative cycle can be broken at the revision phase.

entirely synonymous term called *participatory design*. Participatory design involves the participation of different stakeholders in a project, but not all of those who participate will bear equal standing in the decision-making process. Hymes et al. in particular have coalesced their research under participatory design, but their process and methodology employs co-design methods to produce language games to help those with aphasia recover.

2.3 Aphasia

The Mayo Clinic describes *aphasia* as a communication disorder affecting how one communicates, typically caused by an injury or a tumor in the brain. Some common symptoms which inform an aphasia diagnosis include reduced speech capacity, using gibberish, misusing words and phrases, struggles with thinking and cognitive processes, reduced literacy, and reduced understanding of one’s conversation [1]. Hymes et al. state that, on the road to recovery, those diagnosed with aphasia often undergo sessions of speech therapy in an effort to regain lost language skills. However, research cited in their article suggests that this form of therapy can be difficult to come by in adequate amounts. Such research informed their initiative in developing games for aphasia patients, as games are much more readily accessible [3].

2.4 The Value of Group Games in Recovery

Prior work referenced by Hymes et al. include Romani et al’s “Playing a team game improves word production in post-stroke aphasia,” their article on a study which analyzes a

Table 1. Two categories of codes, modified from [2]. Each code has an identifier and a description which the researchers use to document certain interactions. Some categories were present from the start of the study, such as the *Social Presence* code. Others like *Initiative* were added during the analysis stage. In the table, P means player, while SW means support workers.

E. Social Processes		
E.i	Seeking/enjoying being with others	P seeks out another P in EVA Park
E.ii	Wanting to be alone	P moves their avatar away from other Ps
F. Initiative		
F.i	P taking initiative	P suggests an activity to SW
F.ii	SW taking initiative	SW suggests an activity to P
F.iii	SW enabling P to take initiative	SW asks P where they go/what they should do next

rehabilitation exercise involving 12 participants with aphasia playing a game together in teams. Each team was tasked with naming and describing pictures depicting certain nouns and verbs thrice weekly for 6 weeks. Team members were permitted to assist each other with each picture. The study suggests that picture identification improved by 25 percent, while accurate descriptions increased by 17 percent. All but a pair of participants with severe cases exhibited these improvements six months after the rehabilitation concluded. The findings show that team-based games can help bolster positive, long term effects in aphasia-related rehabilitation [5].

Meanwhile, Hymes et al. also refer to Galliers et al.’s research on EVA Park, a video game which brings players with aphasia and health care professionals together in one online 3D virtual world. Over the course of five weeks, they studied the effects of EVA Park on a group of 20 aphasia-diagnosed participants. Their interactions with one another and the game world were also closely monitored and labeled using a series of *codes* (see Table 1) based on positive effects, negative effects, conversation types, miscommunication/misunderstanding, immersion, social presence, initiative, and flow [2]. In the end, the researchers uncovered that participants had mostly positive interactions with each other and the in-game environment. Furthermore, they note that while the change in the amount of positive and negative interactions did not change significantly, negative interactions tended to subside at a greater rate. The other codes also showed strong scores indicating pleasant experiences overall. When asked whether players preferred to be together or alone while playing the game, they almost unanimously rated their experiences together a 5/5. The only negative rating came about during a question inquiring whether the players enjoyed playing the game alone. Other results were reportedly more varied. These findings indicate that online games have the potential to create positive group experiences for those living with aphasia.

Romani et al. and Galliers et al.'s work both influence Hymes et al. to pursue games as an assistive technology for those with aphasia. An emphasis would be placed on making the recovery games compatible with groups of multiple people and making sure elements of positive interaction were present during the playtesting stages.

3 Co-Design of Assistive Language Games

Hymes et al. produce a set of card-based analog and digital games for those living with aphasia. Game designers, a speech pathologist, and people experienced with aphasia create the game set to assist people with aphasia in rehabilitating language, comprehension, and socialization skills [3]. The goals, obstacles addressed, and game design qualities for their project will be explained in the following subsections.

3.1 Goals

Hymes et al.'s research into the co-design of the aphasia game set can be described as working toward two goals:

The first research goal entails refining a co-design methodology to support language recovery in people with aphasia. In a co-design process involving aphasia community partners (described as a combination of the people living with aphasia and a supporter), game designers, and a speech pathologist, the relay of ideas between each group must address inequalities in knowledge and expertise in matters of aphasia, game design, and speech pathology. A lack of proper communication can impede progress toward finishing games. Thus, the researchers are especially interested in determining what accommodations should be made to support the co-design team.

Meanwhile, the second research goal comes in the form of the methodology's product: language games which can be used to help people with aphasia recover language and communication skills lost with the disorder's onset. Hymes et al. actively apply their methodology by having all parties involved work together to create games functional beyond the research cycle. These games are designed to be used with digital conferencing software, allowing for players to group up and play with each other remotely. In addition, elements of each game support the recovery process.

In refining and applying their co-design methodology, Hymes et al. hope to demonstrate how co-design can be used to involve people with aphasia in designing and producing language-recovery games.

3.2 Addressing Obstacles

To begin their research, Hymes et al. focus on potential obstacles in engaging with people with aphasia. They directly cite Moffatt et al.'s list of challenges [4] working with communities with health conditions, such as the aphasia community. In the context of those with aphasia, these challenges include:

- Finding people with aphasia

- Providing accessibility to people with aphasia at distances
- Facilitating effective communication
- Interpreting the diversity of data produced by variations of aphasia

Finding people with aphasia is essential for any co-design process to take shape. To find them, Hymes et al. collaborate with a non-profit support group called the Aphasia Recovery Connection. They get in touch with one of the organization's co-founders. Eager to help, she joins the co-design team and posts a recruitment inquiry on the organization's Facebook page. Three people are selected from those who applied, varying from having moderate to mild aphasia.

The researchers next work to resolve the obstacle of accessibility over distances. Each team member with aphasia comes from a different part of the United States. People with aphasia often are dealing with other after-effects of stroke, head injuries, or brain tumors, which can affect movement and make traveling difficult. In addition, the COVID-19 pandemic limits how the researchers and co-designers can potentially work in person. Thus, the researchers decide to facilitate communication between team members over unspecified digital conferencing software. Use of the software keeps team members safe at home, in comfortable environments which do not require significant movement or travel.

Ultimately, the usefulness of the research depends on how well the data from varying forms of aphasia can be interpreted. Each co-designer's severity with aphasia as well as the symptoms they struggle with most impact inputs and outputs of data. Hymes et al. alleviate this issue through recruitment and training processes. On the aphasia-end of the co-design team, the very first member, the co-founder, brings in experience working with people with various forms of aphasia. The speech pathologist shared this experience. In addition, the co-designers with aphasia bring in their own firsthand experience dealing with different forms of aphasia. The only part of the team needing training on aphasia-related topics were the game designers. In preparation for the workshops ahead, they immerse themselves in lectures, reading materials, and the aphasia community at large with game sessions as well as a meeting with the core team to ask questions.

3.3 Game Design Qualities

Similar to noting obstacles to address, the researchers set up a series of game design guidelines to help guide game designers. They reference from ARC support materials, aphasia research, as well as answers gathered from game experience interviews with people with aphasia generating a total of eight answers per question. Ultimately, these guidelines require games to:

- Support recovery in various ways
- Incorporate varying stages of difficulty

- Convey recovery progress to players
- Be replayable

A game’s design is deemed supportive for recovery if it incorporates at least one activity shown in research to rehabilitate people with aphasia. To give the game designers’ ideas on which sort of activities to incorporate into gameplay mechanics, the researchers provide them with "sample design considerations" (see Table 2). These considerations identify reliable rehabilitative techniques as well as provide examples for the game designers to reference.

In light of people with aphasia experiencing different types and severity of symptoms over the course of their recovery, the researchers deem varying difficulty an important aspect of gameplay. And, the co-designers with aphasia desire it. The co-designers with aphasia and game designers worked together to find ways of increasing difficulty. For one game, they provide varying difficulty by including cards with multiple prompts. Players may include these cards in their session if they are looking to challenge themselves, or, if they wish to start recovery easy, they can exclude them.

For understanding where to go next with recovery, people with aphasia need to be able to determine where they are improving and where they need to practice more. Thus, the co-designers use the team-play aspect of their games to allow players to assess and better their performance. Each game allows for players to help each other out with prompts when necessary.

Since recovery happens over time and over several sessions, the researchers deem the replay value of games to be especially important. Games need to be playable over the course of multiple sessions to support people with aphasia throughout their recovery. With that, the games need to be fun in order for people with aphasia to want to play them more. One of the outputted games, *The Minister’s Cat*, supports replay value by incorporating cards which vary in theme. Not all games will go through each theme, allowing for people with aphasia to vary each play session. The lack of a set theme is also said to provide fun to the players (see Figure 2).

Reasonable access must be allowed in order for the games to succeed. One way to bolster access is to allow for remote play - each game is designed around digital conferencing software, addressing that constraint. To keep game costs low, games are limited to one deck of cards each, while other items required should be acquirable at home (e.g., pencils). Based on feedback from co-designers with aphasia, games are also tailored to be played between 2-6 players with aphasia. There is also an option for people with aphasia to play the games alone with a person assisting them. The researchers cite these differences in play-style to be important in choosing to make the games playable in both a physical and digital setting.

Table 2. The top two rehabilitative techniques, modified from [3]. There are a total of eight techniques provided, each with examples.

Rehab Design Considerations	Examples
Modifying the level of difficulty for a task by cueing	Clues for meaning ("it is a type of bird"), clues for sounds ("starts with a 'p' sound", rhymes with "edible"), or providing parts of the target, or even the full target for repetition
Input (comprehension) vs. Output (production)	Understanding and producing language are very different tasks and can be handled differently



Figure 2. A couple of cards from [3]’s *The Minister’s Cat*. Each card has a theme and a starting prompt for generating sentences.

4 Findings

Hymes et al. detail a number of changes made to the game design process, before then describing the three games which came out of their co-design process.

4.1 Changes to the Process

In applying their co-design process, the researchers find that training and adaptations for those with aphasia needed to be expanded upon over the course of the design iterations.

Initially, only game designers are trained to work with other co-designers, particularly those with aphasia. Meanwhile, the speech pathologist and co-designers experienced with aphasia were brought in without knowledge of game design. The researchers surmised that having a background in playing games was sufficient for making games. Though, the outcome suggests otherwise. The first iterative cycles proved to be challenging for some of these co-designers: they offered input on possible issues with a game’s design at inappropriate times (notably the start of new stages) due to not knowing how to address them when first discovered. That hindered progress. The team needed to backtrack and fix these issues before moving forward. As a result, the game designers conducted a workshop outside of the design time

for the speech pathologist and co-designers experienced with aphasia to learn the basics of game design. From there on, revision guidelines were also put together at the end of the iterative workshops to gather the group's opinions and determine how to move forward. The researchers convey that subsequent workshops proved to be more effective as a result.

Some co-designers with aphasia struggled to bear the cognitive burden of designing games. Thus, some sessions went overtime to leave enough time to give everyone a chance to express their ideas before leaving. However, this solution was not sufficient for everyone. One co-designer got tired 45 minutes into sessions and "needed to push... to listen" [3] all the way through overtime. In order to rectify this issue, the researchers gave co-designers two additional options for relaying afterthoughts on the day's work. The first option was to let co-designers electronically submit their feedback at their discretion following the meeting. Or, if a person-to-person meeting was preferred, the speech pathologist agreed to do appointments with those wanting to express feedback. As a result of these feedback opportunities, co-designers with aphasia were able to express themselves more openly and comfortably on certain aspects of the work put into each game's design.

Each accommodation made for the team improved communication between the various co-designers. As a result, feedback could be provided and collected in a variety of ways, at the comfort of the people involved.

4.2 Outputted Games

A total of three games came out of the project, each aiming to rehabilitate people with aphasia with different needs. Hymes et al. provide detailed information on how each game fulfills game design requirements, which are described with each game below.

The Minister's Cat, the first game to come out of the process, has 2-6 players craft a narrative by taking turns contributing their own sentences. Then, at the end, each have to recount the narrative which they told together, with or without help from other players. Researchers explain that *The Minister's Cat* supports recovery by tasking players to remember previous words and final narratives, which in turn require retrieving words via cueing. The game varies in difficulty depending on how complex players can make their sentences and how many players are around (more increases memory usage). Players can offer help to other players who are struggling, such as in the form of clues or gestures, to help them understand and improve their strengths and weaknesses.

What follows next is *Audition*, a 2-4 player game in which players are actors improvising key parts of a script in an audition with the support of acting coaches. Unlike the previous game, retrieving certain words or phrases is more dependent on a scripted context. In addition, recalling them is meant to

utilize short term memory. Difficulty varies depending on whether a player is acting or coaching, as well as choosing more complicated script cards, some of which include scene checklists rated for difficulty. Unlike last time, only coaches are providing feedback to the players, as they know more about the script contents.

Finally, the last game is *Do You See What I See*, a game "that combines storytelling, 20 questions, and environment interaction at a distance"[3] which can be played between 4-16 players. Players ask each other about items in the rooms they are playing from. In doing so, players can be personal with one another about what certain possessions mean to them. That supports social skills, as well as being able to understand question-and-answer related conversations. Questions may vary in complexity, allowing for players to challenge themselves to get learn information about each other. Furthermore, more players and objects makes each game session more difficult. Co-designers found the variety of objects to ask questions about made the game much more fun to play over time.

With each game, co-designers with aphasia found that the assistance-based assessment made the game much more fun to play. Each card deck also had themes, which are said to increase the replay value for all games by varying topics and scenarios. All games can be played over digital conferencing software and in-person, making the game very available.

5 Conclusion

With team games having been shown to support recovery in those with aphasia, even in online environments, Hymes et al. set forth to create three card-based games that could be played either in-person or online using digital conferencing software. They assembled a team of co-designers experienced in aphasia, speech pathology, and game design for this task. They considered aphasia-induced obstacles and recovery-based game design guidelines, putting together an iterative workshop-based co-design process to permit the games' creation. Iterative co-design for those with aphasia is heavily dependent on communication. As such, adaptations, such as visual aids and text-based cues were used to ensure people with aphasia had multiple ways of understanding what others were conveying. Prior immersion in aphasia helped game designers use these cues to the best extent. As issues arose with communication, Hymes et al. and the co-designers adapted. Issues with conveying feedback were met with a game design workshop and revision guidelines, which helped non-game designers on the team understand how to best identify issues and note things that could be improved. Furthermore, when people with aphasia experienced cognitive inertia, workshops were adjusted to include additional means of communication: e-mail follows ups and interviews with the speech pathologist. Adaptations, co-experience, and

flexibility allowed for the project to be carried through by maximizing communication and comfort.

Further research into co-design for those with aphasia should consider qualitative analysis following the creation of language recovery games. Hymes et al. provide empirical reviews on how their games may help people with aphasia, but due to their work being more focused on the co-design process, statistics are not collected for how the games benefit those with aphasia. In addition, as Hymes et al. suggest, it may be worth working with specific subgroups of the aphasia community to work on games catered to recovering specific skills. What can be learned from playtesting with those specific groups and the aphasia community at large could help make the iterative co-design process more workable. The data from these efforts could then be used to guide designers of assistive technologies in directly involving people with medical conditions beyond aphasia.

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