A Neurodiversity Design Approach to Design Research About Gamification of Cognitive Ability Training and Learning

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This study aimed to empathize with a neurodiversity of adult learners' expressed interests about the kinds of learning features or learning experiences they desire from a cognitive ability training game. It also aimed to then explore how to translate their interests into design and development of features in a cognitive ability training game. The study used a neurodiversity design approach which intentionally includes both participants with neurodevelopmental conditions like autism and ADHD and participants without neurodevelopmental conditions in the same study. The study used empathy interviews, empathy maps, and personas to empathize with participants' interests. The study used user story writing, story mapping, and feature mapping to translate their interests into the design and development of the game features. The study found participants wanted cognitive ability training games to include a pleasant, consistent visual style, informational features, motivational features, and variety of complexity and content in the game modes.

Introduction

In 2012 I would come home, turn on my television, and see commercials about brain training games like Lumosity from Lumos Labs Inc. and Jungle Rangers from Focus Education. The companies' commercials advertised the promise of being able to play a game which could train one's basic cognitive abilities to have far transfer to complex cognition and benefits for one's everyday life. These promises led me to not only want to play this kind of game, but also want to make a similar game to help people. With this passion to make a brain training game, I looked at these companies' websites at the time and saw indications the games were based on science. I formed an impression: if multiple companies are making brain training games and claiming they are based on science, then the science on which the games are based must say something about how to make these games effective.

When I began exploring the brain training game literature, I expected to find something both actionable and empirically supported, much like what we find from the multimedia learning literature about multimedia learning design principles. However, what I found in the brain training games literature – and monitored for a decade – was an academic reaction to companies' commercial promises by examining the effectiveness of commercial products with a cognitive consequences approach to studying near and far transfer, as well as accusations of commercial overexaggeration beyond available evidence. I did not find a set of actionable, empirically supported design and development processes or design strategies, guidelines, or principles for creating cognitive ability training game tasks or other learning features in them.

What I did not expect to find, yet did find, was not only overexaggeration about the benefits of playing several companies' products, but also a trend amongst several companies which marketed their brain training game or service as a cure for ADHD and "symptoms" of autism, as if these are diseases to be cured (FTC, 2015; FTC, 2016; Furfaro, 2018). However, ADHD and autism are neurodevelopmental conditions and a part of human diversity, not diseases (Bennet et al., 2019; Robertson, 2009). My passion to try to make a brain training game based on science was let down by the lack of actionable, empirically supported design science in the brain training games literature. My other passion to make learning experiences in a brain training game for anyone to learn from without obstacles was let down by the presence of cure language about neurodevelopmental conditions. Holding on to these two passions, I wanted to begin to address both problems with a study which aims to lead the design of learning features in a cognitive ability training game with empathy for the expressed interests of a neurodiversity of adult learners about the learning features or experiences they want to have with such a game. This article characterizes the research questions, empathy-driven analysis methods, and design methods of the first Analysis, Design, and Development phases of Phase 1 of that study.

Research Questions

To drive the design of the learning features of the cognitive ability training game with empathy about participants' expressed interests, I formed the following research questions:

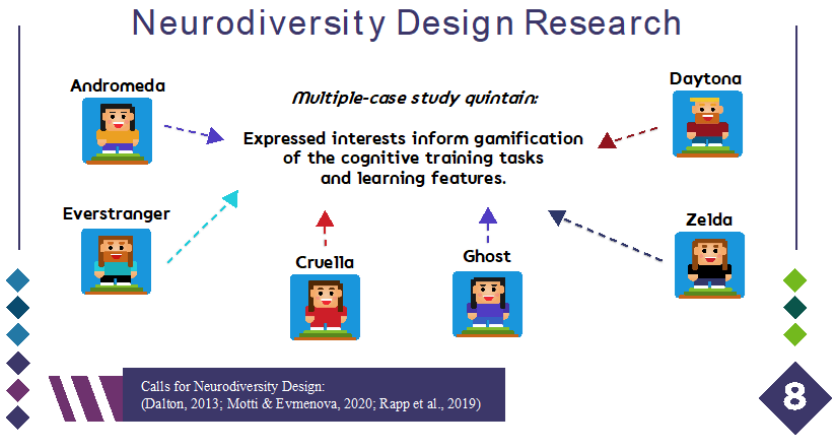
1. What are interested adult learners' expressed interests in gamification features and learning features for a cognitive ability training game?
2. How can we design learning experiences in a cognitive ability training game to support personally meaningful learning by a neurodiversity of adult learners interested in learning about cognitive abilities, cognitive ability training, or cognitive health?

Neurodiversity Design and Participants

There is no normal brain (Armstrong, 2015) for which to design learning, so this study pursues an ethical shift away from medicalization of messages about people with ADHD or cures for them. This study shifts design research towards empathizing with and considering the expressed interests of people with and without diagnoses of neurodevelopmental conditions. A Neurodiversity Design approach (Dalton, 2013; Motti & Evmenova, 2020; Rapp et al., 2019) calls for including participants with neurodevelopmental conditions (e.g., ADHD or autism) and participants without neurodevelopmental conditions in the same design research study. The study did not plan to design for specificity of learner types or interests, nor a discoverable generality of learner types or interests. Instead, the study planned to design for including and supporting a diversity of learners (see Figure 1) by getting to know them, empathizing with their expressed interests, translating their interests into feature designs, and developing a game that supports each of them to experience learner agency for pursuing their learning interests with the game.

Figure 1

Neurodiversity Design with 6 Participants



The study included total of 6 participants, and I allowed them to pick their own pseudonyms as a method of engaging their interests and participation in the study: 2 adults with no neurodevelopmental conditions (Cruella and Ghost); 1 adult diagnosed with autism (Andromeda); 1 adult diagnosed with ADHD and autism (Everstranger); 2 adults diagnosed with ADHD (Daytona and Zelda).

Design Research Methodology

The neurodiversity design research process in this study blends techniques from design thinking and user experience (UX) design (e.g., empathy maps and personas) with other research methods (e.g., interviews; member checking; participant observation; journaling; and thematic analyses) to inform learning experience design processes. Since this study values both working software and documenting relationships between data, design strategies, and game features, I organized the overall process within a non-waterfall version of Analysis, Design, Development, Implementation, and Evaluation (ADDIE). As a domain-and-theory-agnostic process (Molenda, 2003), ADDIE can form a responsive approach with design thinking and iterative development. Since this article is focused on empathy and translating expressed interests into design, the activities from Implementation and Evaluation phases of Phase 1 of this design research project are beyond the scope of this paper.

Empathizing with Participants' Expressed Interests

Analysis phase activities included initial 60-minute interviews with participants, thematic analyses (Braun & Clarke, 2006; Saldaña, 2015) of the interviews and notes to produce player-level themes, creation of empathy maps (Gray, 2017; Schmidt, 2021; Schmidt & Tawfik, 2022) that bring design empathy to player-level themes, member checking interview notes and empathy maps with participants, and construction of personas from empathy maps (18F (n.d.); Schmidt, et al., 2020; Schmidt & Tawfik, 2022) with persona-specific user story maps (Kaley, 2021; Scaled Agile, Inc., 2022). Table 1 below summarizes player-level themes about each participant's expressed interests in features or experiences with a cognitive ability training game.

Table 1

Participants' Expressed Interests

Name	Expressed Interests in Features or Experiences
Andromeda	• Puzzle solver; animal lover. • Plays to improve her brain, satisfy her curiosities, and achieve self-satisfaction of completing challenges which involve using her brain. • Wants to learn about how to use her brain and abilities. • Wants to learn facts to satisfy her curiosity, but also wants to get smarter – i.e. to be able to memorize, focus, think, or create an effective thought process to reach an answer to a question or solve a problem. • Wants easy-to-use menus, pleasing graphics, levels of difficulty, personalized feedback, and to not feel alone. • Avoids on-screen timers or social scenarios/rankings that make her feel bad, different, or misunderstood.
Cruella	• Puzzle solver, brain trainer, and psychic ability trainer. • Values simplicity, conciseness, clarity, repetition, cute graphics, visual points, funny jokes, quotes and external validation. • Wants her brain to be stronger, better, and faster, learn about how to use her brain more efficiently with less effort, be the best possible version of herself, and achieve self-actualization or enlightenment. • Wants to receive recognitions for win streaks, personalized feedback and pointers, and positive affirmations for overcoming difficulty. • Gets frustrated at losing, having to go through it again, or having to spend too much time.
Daytona	• Puzzle solver; gamer. • Open to trying repetitive tasks involving reaction time, pattern recognition, memorization, language memory access, or other abilities (except fast math). • Wants to improve his cognitive abilities with related improvements to help him do things outside the game. • Wants to get explanations, compete with himself, measure his performances and improvements, get win streak notices, play different task formats, control the difficulty himself, and maybe a leaderboard. • Puts the game down if it is annoying, becomes boring instead of memorable and engaging, or does not offer both rewards and a larger overarching goal to achieve.

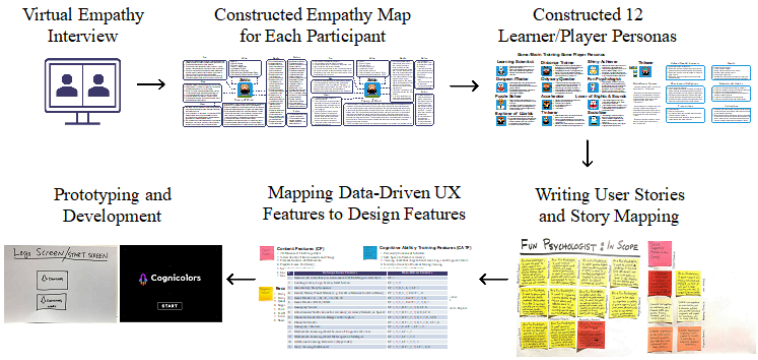
Everstranger	• Puzzle solver; gamer; mods games. • Loves good visual design, games, game mechanics, figuring out how to play games, and good game loops of challenge and reward. • Wants to be smarter and more flexible, learn new things, learn about how he learns, learn new learning techniques, and expand his capacity to learn. • Wants initial assessment and the right level of challenge without making him feel like bad. • Avoids a game when it has on-screen timers, is just busy work with no feeling of personal investment or accomplishment, or gameplay that is too fast-paced.
Ghost	• Puzzle solver; gamer; formal logic lover; spelling bee winner; writer; marathoner of sudokus and wordles; self-identified “word person” and “nerd.” • Loves using pattern recognition, logic, abstraction and generalization to achieve beautiful satisfaction of solving puzzles or end states of complex wholes. • Wants leaderboard, win streak notices, to learn the why/how behind tasks, and to learn how to use trained abilities or patterns in everyday life outside the game. • Puts games down if they don’t supply enough support for learning what she wants to learn, beyond puzzles.
Zelda	• Puzzle solver; gamer; self-identified “nerd.” • Cares about the why and how of brain training, but cares more about challenges and leveling up. • Wants initial assessment, aesthetically pleasing look and feel, novelty in the next experience or puzzle/task, novelty in cognitive ability improvement, skip level feature, leaderboard, achievement rewards, win streak notices, feedback, self-discovery, self-competition, and facts about use of the trained ability in everyday life. • Puts the game down when the game feels repetitive or boring, has lack of novelty, or get stuck with no hints.

Translating Participants’ Interests into Feature Ideation

I used persona-aligned stories to guide ideation about game features, and mapping user stories (Kaley, 2021; Scaled Agile, Inc., 2022) with benefit hypotheses (Scaled Agile, Inc., 2023a; b), and acceptance criteria (Kaley, 2021; Scaled Agile, Inc., 2022) for features aligned to personas and participant’s expressed interests and personas. Next, I combined related user stories with notes about needed multimedia features in storyboarding (18F (n.d.)), and created low fidelity paper prototypes (18F (n.d.); Schmidt, et al., 2020). Figure 2 provides an overview of this process.

Figure 2

A Design Research process for translating empathy about expressed interests into design and development



Developing Features Based on Participants' Interests

Development activities included creating low fidelity paper prototypes (18F (n.d.)) and then creating game art in Sketch and functional prototypes (18F (n.d.); Schmidt, et al., 2020) of the game-based learning environment in Articulate Storyline, including any needed audio, gamification, and learning features. Example prototypes are shown in Figure 3.

Figure 3

Three Examples of Feature Sets Designed and Developed Based on Empathy for Participants' Interests

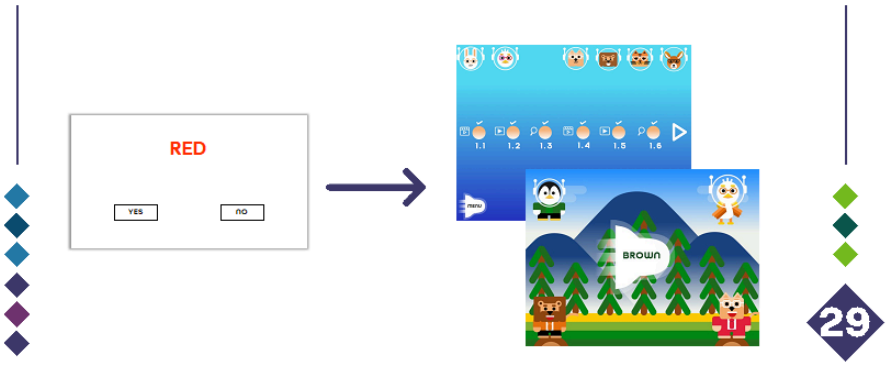
Conclusions

This study was an opportunity to call into question my own assumptions about what a cognitive ability training game mode should be like, as well as an opportunity to innovate based on empathizing with a neurodiversity of adult learners' interests in playing and learning from such a game. For example, prior to approving this study, when the IRB asked me for a visual prototype for a concept of a game task, I made a basic Stroop task with a color word stimulus and two response items (yes and no) on a white background, since this is what the Stroop task literature has researched. However, several participants would have put this kind of game mode down, given its lack of variety of content and task complexity (i.e., given its lack of fit with their interests). By empathizing with participants' interests and threading their interests into the design and development process, I was able to mix strategies to make a cognitive ability training game that not only allows them access to game

modes with a variety of task complexities, but also interweaves multimedia learning opportunities into a playable story. The evolution of this development is seen in Figure 4.

Figure 4

Mixing strategies: Playable story with a variety of content, complexity of tasks, and multimedia learning



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