Older Adults' Perceptions of Video Game Training in the *Intervention Comparative Effectiveness for Adult Cognitive Training* (ICE-ACT) Clinical Trial: An Exploratory Analysis

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Abstract. Video game-based interventions have been increasingly explored as a means to prevent or reverse age-related declines in attention, executive control, memory, and processing speed. Further, the gamification of interventions aimed at improving mental and physical health, and encouraging healthy behaviors, holds promise with respect to promoting intervention engagement and adherence. Successful implementation of game-based and gamified interventions depends on the ability to design games that older adults are willing and able to play, which ultimately depends on understanding the game preferences of older adults, and the challenges and barriers to video gameplay. To explore these issues, this paper presents data collected from U.S. participants as part of the *Intervention Comparative Effectiveness for Adult Cognitive Training* (ICE-ACT) clinical trial. This trial aimed to understand the impact of various interventions on cognition and everyday task performance. Three intervention arms involved video game play: BrainHQ training (gamified cognitive training), Rise of Nations training (commercial complex real-time strategy game), and a control group that played Sudoku, crossword, and word search computer programs. After each game session, participants rated their game experience and provided comments in a game diary. This paper presents analyses of these diary data. The largest differences observed were between attitudes toward the control games and Rise of Nations. Control games were strongly preferred and were perceived as more motivating compared to Rise of Nations, and there was a trend for Rise of Nations to be perceived as more frustrating than BrainHQ. The observed preference for puzzle games, and an aversion for the violent and complex content of Rise Nations, is consistent with previous survey and focus group data of older adults' game preferences. Results have implications for designing game-based and gamified interventions for older adults that will encourage enjoyment, engagement, and adherence.

Keywords: Older adults · Video games · Cognitive intervention · Gamification · Adherence · Engagement

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1 Introduction

Some researchers have proposed that video game play may serve as an effective intervention to combat age-related perceptual and cognitive decline [1, 2; but see also 3]. Others have proposed that gamification, the addition of game and video game-like elements to non-game activities, holds promise with respect to encouraging engagement with, and adherence to, health interventions and healthy behaviors [4]. This includes recent trends in the use of "exergames" to encourage physical activity and exercise [5]. Common gamification elements include the introduction of points systems, achievement badges, leaderboards, stories, themes, feedback, rewards, progress tracking, and challenges. However, a lack of experience with, and enthusiasm for, video game play by older adults has potentially important implications for the effectiveness of these interventions and techniques across the lifespan. Specifically, the age-related "digital divide" must be considered before applying these approaches to improving the cognition, wellbeing, and health of older adults.

In general, older adults are less likely to adopt many newer technologies, including the internet, smartphones, tablet computers, and smart home devices [e.g., 6, 7]. This gap in technology adoption extends to digital gaming and the devices that support video game play. In the United States, only 24% of older adults (ages 65+) report playing video games, compared to 60% of younger adults (ages 18–29), and 43% of adults in general [8]. With respect to device ownership, only 8% of older adults own a video game console, compared to 40% of adults in general [9]. Although video gameplay is a common activity for many younger adults, it is a relatively infrequent activity for many older adults.

Why are older adults reluctant to adopt video game technology? Many older adults have not adopted the prerequisite technologies necessary to engage in video game play, including the internet, smartphones, and gaming consoles. Lack of technology adoption, and as a result, technology skill, represents a substantial barrier to engaging in video gameplay. Attitudinal barriers also exist. Some older adults believe that video games are too challenging, a waste of time, or too childish [10–12]. Older adults also report an aversion to the violent content of many video games [13–16], and in the United States, erroneously attribute frequent mass-shootings to the influence of violent video games [17]. Finally, video game design that does not account for age-related ability changes (psychomotor, perceptual, and cognitive), and the relative inexperience of older adults with gaming, is an important barrier to gameplay [18, 19]. Video games are often designed by younger adults without consideration for the abilities and preferences of older adults.

This paper seeks to gain insight into older adults' perceptions of video game-based interventions to better understand barriers to cognitive intervention adoption and adherence, and the effective use of intervention gamification. Data were collected as part of the *Intervention Comparative Effectiveness for Adult Cognitive Training* (ICE-ACT) clinical trial (https://clinicaltrials.gov/ct2/show/NCT03141281). ICE-ACT aimed to test the impact of various interventions on cognition and everyday task performance [20]. Three intervention arms involved video gameplay. One group was asked to engage in BrainHQ training, which consisted of gamified neuropsychological tasks.

Another group was asked to engage in Rise of Nations training, a commercial complex real-time strategy game. Initial research has suggested that this game may improve cognition in older adults [21]. A control group played Sudoku, crossword, and word search computer programs. As part of this trial, a non-game training group completed online tutorials on driver safety and financial fraud avoidance (Instrumental Activities of Daily Living (IADL) training). As this intervention was not game-based, it is not a focus of the current paper. After each game interaction, participants rated the game experience and provided comments in a game diary. Of primary interest for the current paper, these data were analyzed to uncover older adults' experiences and challenges with this diverse set of video game and gamified interventions. Specifically, our first research question aimed to understand older adults' perceptions of the game or games they were assigned (perceptions of enjoyment, challenge, frustration, and motivation to perform well). A second research question aimed to better understand specific barriers (attitudinal and game mechanics-related) to gameplay for each game using open-ended diary responses.

2 Method and Results

A baseline paper for the ICE-ACT trial fully describes all research protocols, measures, and participant characteristics [20]. A brief summary is provided here.

2.1 Participants

In total, 230 participants were recruited from the Tallahassee, FL region, and randomized to different arms of the trial (M_{age} = 71.4, SD = 5.3). The sample was 58% female, largely White (82%), and fairly well-educated (91% with at least some college education). Random assignment resulted in 57 participants in the BrainHQ condition, 59 in the Rise of Nations (RON) condition, and 58 participants in the control condition (which played word and puzzle games). Another 56 participants were randomly assigned to the IADL training.

2.2 Game Experience

BrainHQ. Participants in the BrainHQ condition completed a subset of tasks within the BrainHQ cognitive training software suite. These tasks were: Double Decision, Freeze Frame, and Target Tracker. Double Decision is a gamified version of the Useful Field of View task, Freeze Frame is a gamified stop reaction time task, and Target Tracker is a gamified multiple object tracking task. Briefly, Double Decision presented short duration images containing road signs and vehicles and participants had to identify the vehicle and locate a peripheral road sign. Freeze Frame presented an image for participants to memorize, and then, they were shown a series of pictures. They were asked to make a response quickly if the image they saw was *not* the image they were asked to memorize, and withhold a response if it was. Target Tracker involved participants being asked to keep track of certain objects that moved randomly (e.g., fish swimming

in an ocean) among identical looking distractors. Tasks were gamified in the sense that they featured appealing graphics, performance feedback, and performance tracking.

Rise of Nations. Participants in the Rise of Nations condition played a real-time strategy game. In the game, players are positioned on a map with a small civilization and few resources. The task of the player is to collect resources from the map, build structures to expand their territory and advance their civilization, and develop and maintain a military force for offense and defense. Computer-controlled players are also on the map trying to accomplish the same goals. Players win when they control 70% of the map, capture their opponent's capital city, or lead in points by constructing world wonders for a sufficiently advanced civilization.

Control Condition. In the control condition, participants played a series of three puzzle games. The crossword game emulated a traditional set of crossword puzzles. Sudoku was a computerized version of the traditional number puzzle game. Finally, word search presented participants with a matrix of letters and participants had to locate a set of target words.

2.3 Equipment and Training

All participants were provided with a laptop with their assigned game or games on it to take home. They were also provided with a mouse. In the laboratory, participants were trained by study personnel on the use of the laptop, mouse, and their assigned game or games. Participants were also given written manuals related to equipment and game use.

Home-based training consisted of a recommended 20 h of game play. This was in the form of one hour of game play on five different days each week, over the span of four weeks. To minimize fatigue, participants were asked to complete two separate thirty-minute sessions in a day.

After each session, participants were asked to complete an online diary to provide input on their experience. Participants rated four statements on a Likert-scale (1 = strongly disagree; 7 = strongly agree). These four questions were: (1) I found today's session to be enjoyable; (2) I found today's session to be challenging; (3) I found today's session to be frustrating; (4) I was motivated to perform well on today's session. Then, participants were allowed to provide any additional comments in an open-ended response box. These questions are the main focus of this paper to provide insight into older adults' game preferences and game barriers and challenges.

2.4 Results

All available diary data were entered into the reported analyses below. Participants were asked to rate their enjoyment, challenge, frustration, and motivation after each game session (Fig. 1). Note that 4 represents the neutral point of the scale (Neither agree nor disagree). For enjoyment ratings, scores were close to this neutral point, suggesting a general lack of enthusiasm for the interventions. Participants, on average, did find the games challenging and motivating, but also slightly frustrating.

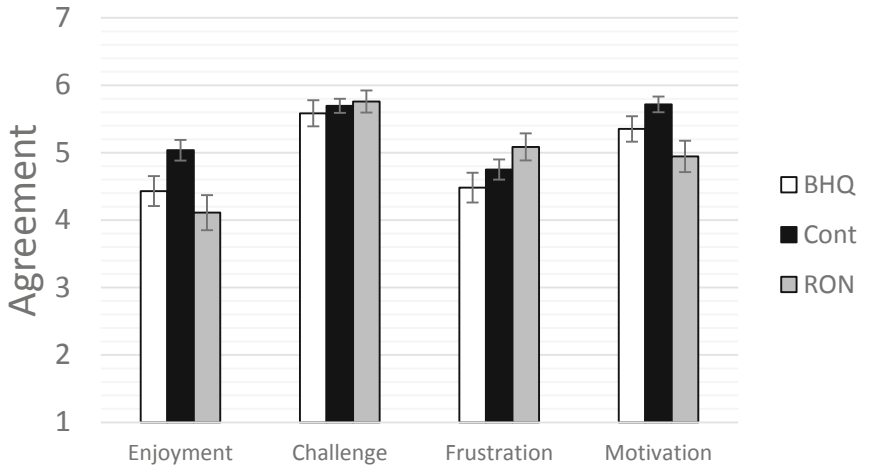

Fig. 1. Average agreement after game sessions to the four questions: (1) I found today's session to be enjoyable; (2) I found today's session to be challenging; (3) I found today's session to be frustrating; (4) I was motivated to perform well on today's session. 1 = strongly disagree; 7 = strongly agree. Error bars = ±1SEM.

The first set of analyses explored differences in game experience. Analysis of Variance (ANOVA) explored whether ratings differed between groups, and post-hoc tests with Tukey correction explored the nature of those differences. First, with respect to enjoyment, there was a significant main effect of condition ($F(2, 117) = 5.249$, $p < .01$). The control group, that played puzzle games, reported the highest enjoyment, and enjoyment was significantly higher in the control group compared to the Rise of Nations group ($p < .01$). There was no significant difference in game challenge between groups ($F(2, 117) = 0.319$, $p = .728$). There was a trend for frustration to differ between conditions ($F(2, 117) = 2.439$, $p = .092$), with this trend being associated with greater frustration being reported by the Rise of Nations group compared to the BrainHQ group ($p = .076$). Finally, there was a significant difference in reported motivation ($F(2, 117) = 4.801$, $p < .05$), driven by greater reported motivation to perform well during sessions by the control group compared to the Rise of Nations group ($p < .01$).

Next, we present data related to the open-ended question at the end of the diary entry. A rater was given categories in which they could rate participant diary comments, and was informed that comments may contain multiple ideas and clauses, and was instructed to rate each clause independently. The enjoyment category related to thoughts on positive experiences with the intervention (e.g., "The game is addictive!"; "fun"; "I'm liking the bubbles more!"). The frustration category related to negative experiences (e.g., "Not fun and frustrating"; "A little frustrating"; "glad it is over"). The challenge category contained thoughts on game difficulties and challenges to overcome (e.g., "Still trying to learn what I'm doing in this game!"; "Always find the crosswords challenging"; "The cars are VERY close in shape"). The boredom category contained expressions of poor motivation and lack of interest (e.g., "this is so boring";

"the crossword puzzles are lame"; "gets boring tracking the balls etc. in the last exercise"). Figure 2 depicts the proportion of comments made that fell into each category.

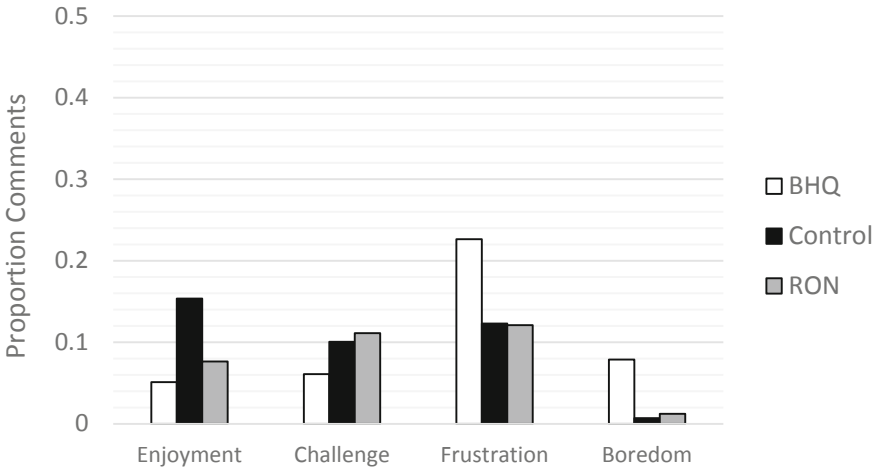

Fig. 2. Proportion of all diary entry clauses that related intervention enjoyment, challenge, frustration, and boredom.

Similar to the quantitative results, the control condition had the most comments that were positive. However, unlike the quantitative data, there were many more comments relating to frustration in the BrainHQ condition, and this condition also inspired the most comments related to boredom. More comments related to frustration may be due to the fact that this intervention was the most adaptive, and increased in difficulty as participants increased in their skill level. Other tasks, by not being as adaptive, may have allowed participants a greater sense of mastery. In a sense, the Brain HQ may have offered the least variability in game play (the same three basic exercises), which may explain the comments related to boredom. It is important to note, though, that this intervention limited their experience to three out of many BrainHQ tasks. Compared to other groups, the BrainHQ group was more likely to mention eyestrain ("The Double Decision game causes a great deal of eyestrain"; My eyes got tired doing 1 h together"; "as task continued my eyes started to fatigue"; "eyes got very tired").

The quantitative data from the Rise of Nations group suggested a trend toward greater frustration, and a lack of game motivation. The qualitative data were explored to gain insight into these patterns. In the Rise of Nations group, some participants reported being averse to the violent and war-related content of the game ("I STILL sense that the game's program tilts toward having to look for a military win. This goes against my utopian grain!!!""; "I'm not into this level of aggression"; "Men groaning… blood splatting…shooting civilians…women screaming…Seriously? Folks play this for entertainment?"). Many negative comments related to confusion related to the complexity of the game (e.g., "So much to learn to perform well in this game"; "it was trial and error…there is so much to remember and understand") and lack of gaming

experience (e.g., "Overload of information for someone not familiar with "Gaming Conventions"!"; "Don't normally play games and didn't feel comfortable doing it!"). Although the intervention provided in-lab training, and support materials for home-based training, the complexity of the game and its many rules appeared to present a learning challenge. It should be noted that although participants reported less enjoyment on average with the Rise of Nations game, some participants enjoyed the game and noted very positive comments ("Having fun building and making money"; "enjoyed game"; "Am surprised to be enjoying the game more now that I'm finally getting the hang of it!").

3 Conclusions, Limitations, and Implications for Future Research

This paper presented data related to older adults' video game experiences in the ICE-ACT randomized clinical trial. As many cognitive interventions now take the form of gamified neuropsychological tests, or commercial and custom video games, understanding older adults' game motivations, preferences, and barriers to game play is important, as these likely impact adoption and adherence to these interventions. More broadly, the introduction of game elements is being considered to improve adherence to a wide variety of interventions aimed at improving health and encouraging healthy behaviors (i.e., gamification).

Our first research question related to older adults' perceptions of the game or games they were assigned (perceptions of enjoyment, challenge, frustration, and motivation to perform well). Traditionally, there has been a digital divide between younger and older adults, including large differences in the adoption of video games as a form of leisure activity [8, 18]. This divide likely impacted participants' game experiences in the trial. For the most part, participants did not rate their game enjoyment as high, though ratings were higher for puzzle games that were part of the control condition. Overall, participants tended to rate their game experiences as challenging, and slightly frustrating. Game preferences were generally consistent with a number of prior studies [13–16]. Enjoyment was higher for puzzle games, and lower for the most violent game (Rise of Nations, which often involved combat).

Our second research question related to specific barriers to gameplay. For Rise of Nations, the most complex game, participants reported difficulty remembering the many rules and procedures of the game. However, many novice gamers with little previous experience with real-time strategy games may encounter similar difficulties. Rather than relating to age per se, these challenges may instead simply reflect a lack of experience. It should be noted that the games older adults enjoyed the most in the study (word and number puzzle games) were likely the most familiar, as they have non-digital analogues.

Although older adults in the ICE-ACT study received training on their assigned game or games within the laboratory, and help manuals and instructions for home-based training, many still reported frustration and challenges, which highlights the relationship between learnability and usability. More training may have been beneficial, especially for Rise of Nations, in order to minimize difficulty in learning how to

master the game. Given that older people often rely more on help systems and error messages, it may be necessary to provide additional support aids and tutorials for older adults. Better game design and context-aware help within the game itself may be especially beneficial for older novice gamers. Adaptive support might include the option to turn this support off once it is no longer necessary. One general recommendation is that designers decrease the number of steps needed to complete a task and recognize that mistakes in any part of a serially organized sequence or process can affect the overall success or mastery of the game [22]. Just like all systems, video games and associated gaming technologies need to consider the needs, preferences, and attitudes of older adults in their design [18, 19]. This will help maximize engagement with, and adherence to, potentially beneficial game-based interventions.

Game design, however, presents a unique challenge compared to the design of other types of systems in that video games are *intended* to be challenging and slightly frustrating. That is, if a game is not challenging enough, the player will be bored and will likely disengage. However, if the demands of the game exceed the abilities of the player substantially, they will have a frustrating game experience, also resulting in disengagement. Good game design challenges players, but not too much or too little, resulting in a pleasant state known as "flow [23]." However, as a result of normative age-related changes in perceptual, cognitive, and psychomotor abilities, games that produce a flow state in younger adults might be too challenging for older adults (or novice gamers), and games that produce a flow state for older adults might not be challenging enough for younger adults. This suggests a benefit to carefully considering the range of difficulty options available to players, and having the ability to adjust game difficulty with more precision compared to typical options (easy, medium, hard) [24].

Some limitations need to be considered with respect to the data and analyses reported here. First, diary data are not available for participants who did not adhere to, or who quit, the study. Thus, data presented here may represent an underestimate of the difficulties some older adults experienced, and an overestimate of their enjoyment. Data are not available for participants who may have been so frustrated with their game, or who so disliked their game, that they dropped out of the study entirely. Second, diary questions asked participants to report their experiences with the training session. Some challenge and frustration may have come not from the game, but from their interactions with the provided technology and technical issues. For example, one participant in their diary noted a broken "U" key on their keyboard. These technical problems, unrelated to their assigned game, may have negatively influenced their ratings. Practical limitations relate to the presented analyses being based on the exploration of data from a completed study with a different purpose (to assess cognitive benefit). Much more can likely be learned in the future from studies designed specifically to understand older adults' long-term experiences with video games, including their perceptions of games and game training after extended game play, and human factors issues related to game play, using a more diverse set of video games.

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