

# AUGMENTED REALITY GAMES AND ACCESSIBILITY

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*ABSTRACT: With the rapid growth of the gaming industry, it is vital to focus on whether or not all games being produced are accessible to players with disabilities. Players with physical disabilities struggle to use game dynamics designed for individuals with full visual-motor coordination. As well, players with mental disabilities have not been considered in the research of accessibility of video games. Augmented reality (AR) games, which integrate computer-generated images and interactions into real world context, are riddled with physical tasks as a part of game dynamics. This study looks at whether the social interactivity dynamics of the AR game, Ingress, are accessible to players with physical and mental disabilities. A chi-squared test was run comparing the observed and expected player responses to 7 questions evaluating their social interactivity in the game. The null hypothesis, was not rejected because of a high p-value of 0.3481. Due to this lack of significant difference between observed and expected responses, I conclude that the AR game Ingress has adequate accommodations for players with mental and physical disabilities. Further research can help conclude if Ingress can be used as an example for further game development.*

*Keywords: Augmented Reality, Physical Disability, Mental Disability, Visual-Motor Coordination, Accessibility*

## Introduction

A disability is a physical or mental condition that limits an individual's movements, senses or activities. These limitations can obstruct an individual's ability to perform daily life and leisure activities (Bierre, 2005). 97% of children and adolescents in the US spend at least an hour everyday playing video games (Granic, 2014). Logically, the gaming industry has placed an importance on providing accessible games for those hindered by such ailments (such as hearing and vision impairments). In doing so, adaptable software has been designed to make game play more accessible, such as alternative pointing devices, on-screen keyboards, speech recognition, screen readers, and screen magnifiers (Bierre, 2005). In other cases, games have been designed specifically as therapeutic techniques for players who have developmental disabilities (DD). Exergames, which incorporate physical activity into game

play, have shown to improve visual-motor coordination within adults with DD, through exercises and repetition which improves their aimed-limb movement (Caro, 2018).

Although interest in accessibility is growing within the game industry, the interaction between disability and social interactivity within games is unstudied. As well, we do not have a clear understanding of the accessibility of video games for players with mental disabilities. This study aims to provide insight into the augmented reality game Ingress, and whether social interactivity between players is limited for those with disabilities. It is key to focus on augmented reality games because they require a level of physical activity and social interaction that can be restrictive for a large portion of players. Our sample includes both players with mental and physical disabilities.

**Materials and Methods**

Data on the answers to the 7 questions used to evaluate player social interactivity and disabilities of the players, was taken from an online survey distributed on platforms, such as reddit, and at events for gamers. Of the population of gamers who play Ingress, a sample of 2546 people were taken. From that sample, we selected participants who provided legitimate answers to all 8 questions totaling to 2476 subjects. Of these, 2315 subjects reported no disability, 138 reported having a physical disability, and 23 reported having a mental disability.

Figures 1 and 2 were used to run the statistical test. A chi-squared test was ran in Excel using the proportions of responses from non-disabled players to calculate the expected responses in disabled players. These were then compared to the observed responses from disabled players, to determine if there is a significant difference. A significance level of  $\alpha=0.05$  was used for this test. My research hypothesis was that players with disabilities have statistically significantly lower player interactivity levels, than those with

no disability. Meaning there are significantly lower ‘yes’ responses from those with disabilities, to the questions, compared to those without disabilities. The null hypothesis was that there is no statistically significant difference in the expected and observed responses from disabled players. At any  $p$ -value greater than  $\alpha$  we fail to reject this hypothesis.

**Results**

A chi-squared test was performed to determine if there is a significant difference in Ingress player social interactivity between players with a disability and those without. The results of this test yielded a  $p$ -value of 0.3480992, indicating the probability of acquiring these results by random chance if the statistical null hypothesis is correct is 0.3480992. Therefore, I fail to reject the null hypothesis, concluding there is not a statistically significant difference in player social interactivity between the two groups. Figure 3 displays the clear lack of difference in proportion of answers to the 7 questions about social interactivity between abled and disabled players.

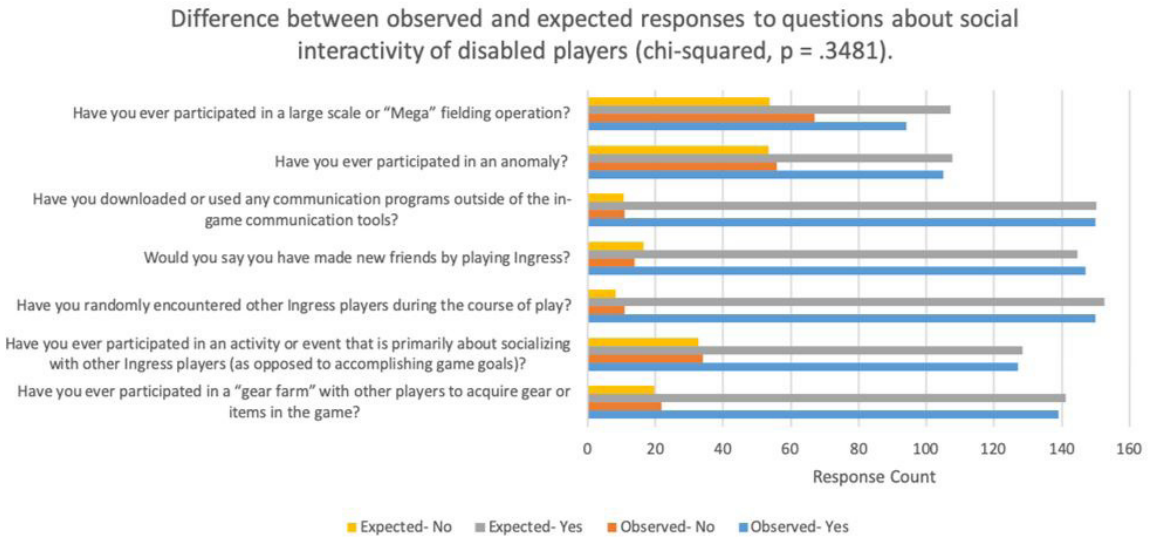
**Figure 1.** Table of count and proportion of responses to 7 questions on social interactivity of abled players.

	Q1	Q2	Q3	Q4	Q5	Q6	Q7
<b>NO DISABILITY</b>							
<b>Count</b>							
Yes	2031	1844	2195	2077	2160	1547	1541
No	284	471	120	238	155	768	774
Total	2315	2315	2315	2315	2315	2315	2315
<b>Proportion</b>							
Yes	0.87732181	0.79654428	0.94816415	0.89719222	0.93304536	0.66825054	0.66565875
No	0.12267819	0.20345572	0.05183585	0.10280778	0.06695464	0.33174946	0.33434125

**Figure 2.** Table of observed and expected responses to 7 questions on social interactivity of disabled (mentally and physically) players.

	Q1	Q2	Q3	Q4	Q5	Q6	Q7
<b>DISABILITY</b>							
Observed- Yes	139	127	150	147	150	105	94
Observed- No	22	34	11	14	11	56	67
Total	161	161	161	161	161	161	161
Expected- Yes	141.248812	128.243629	152.654428	144.447948	150.220302	107.588337	107.171058
Expected- No	19.7511879	32.7563715	8.34557235	16.5520518	10.7796976	53.4116631	53.8289417

**Figure 3.** Comparison of proportion of abled and disabled Ingress players and their social interactivity in the game based on 7 questions. Chi-squared test concluded there is not a statistically significant difference between the groups ( $p$ -value = 0.3481).



## Discussion

From the results of the chi-squared test, we failed to reject the null that there is no statistically significant difference in social interactivity levels of Ingress players with and without disabilities ( $p$ -value = 0.3481). These results suggest adequate accommodations in AR games for players with mental and physical disabilities. Currently, Ingress is allowing players with disabilities to engage fully in the social dynamics of the game. This is vital for future game development, as awareness to the lack of accessibility within the game plays a key role in guiding developers in their work. By creating links between the questions posed in this study to actual components of gameplay, we can narrow the focus of future research.

Problems posed by a lack of accessibility within games include lacking proper feedback responses, the ability to determine in-game responses, and the ability to use input devices required for game play (Yuan 2011). The latter of these problems stems from the lack of suitable assistive technologies and alterability of game dynamics (Bierre 2005). The available assistive technologies are often either designed

for disabilities but not games, or designed for games but not disabilities (Bierre, 2005). It is very possible that the results of our study were affected by the use of outside assistive technologies, not created specifically for Ingress. Some responses mentioned the use of assistive technology, but no question directly asked about the use of outside assistance, therefore analysis of such phenomena cannot be done with this data. In this case, Ingress itself may not be adequately accessible, but there may be technologies that pair with the game to close the gap of inequality. With further study and identification of the use of assistive technology with Ingress, game developers can begin to understand how to create games that pair with already existing technology, and which technologies are important to AR gameplay accessibility.

We must acknowledge the unequal sample sizes between groups, with 2,315 abled players and 161 disabled players. It is possible the disproportionate number of disabled players is responsible for the lack of significance in results. As well, the data for this study was gathered using convenience sampling methods.

Meaning players with more severe limiting disabilities may not have been truly accessed. Thus, these results have limitations to the population in which they can be generalized. With further sampling, we could determine more conclusively if the difference in social interactivity is significant.

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