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## Abstract

*With the advances of technology, gaze is becoming increasingly an attractive and viable interaction method in games. In particular, gaze is likely to provide a natural way of interaction in some games. However, little work has been done to design games that use gaze as an interaction method and test users' reactions to it. Additionally, despite the fact that Generation Y and Baby Boomers form a sizable population of gamers, little work has been done to see if users' generation can influence the experience of gaze interaction in a game. To address this need we developed a gaze-enabled memory game. We then compared the experience of the newly developed gaze-enabled game between Generation Y and Baby Boomer users.*

## 1. Introduction

With the advances in manufacturing high quality eye tracking devices [3], gaze is becoming increasingly an attractive and viable interaction method in video games. In particular, gaze is likely to provide a natural way to interact with certain types of games. However, little work has been done to design and test games that use gaze as an interaction method. Additionally, little work has been done to see if Generation Y (born between 1977 to 1994) and Baby Boomer users (born between 1946 to 1964) react to games that use gaze as an input differently. While it is commonly assumed that games appeal mostly to younger users, research shows that Baby Boomers also like to play games [12]. In fact both Generation Y and Baby Boomers form a good portion of gamers in US; about 32% of gamers in US are between the age of 18 and 34 and 26% of US gamers are 50 or older [6, 7, 12].

Given that consumers spend billions of dollars on games annually [6,7], and that both Baby Boomers and Generation Y form a sizable and powerful consumer segment in the US market [1,8,10,16,18], understanding the needs and preferences of these two generations can provide valuable insight for game developers in particular and the game industry in general.

To examine possible differences in gaze interaction experience between Baby Boomer and Generation Y users, we first designed and developed a game in which gaze can provide an intuitive and natural interaction method. Next, we evaluated the interaction experience of the newly developed gaze-enabled game between the two user groups.

## 2. Background

For sighted people, vision is the primary sensory input. Because only a small area of our eyes (fovea) can see objects accurately, we move our eyes constantly to direct them toward objects we like to see with our fovea. Eye tracking studies show that our foveal gaze is an accurate measure of attention to objects [3]. Because we naturally look at objects that we like to attend to, gaze can serve as a natural method for selecting objects that we wish to activate or control on a computer screen.

In addition to selecting objects, gaze can also be used to activate objects on a computer screen. For example, we can activate an object by looking at the object for a certain amount of time. Another way we can use eye movements to activate objects is by blinking, i.e., closing both eyes for a short period of time (longer than a natural blink).

In this study, we used both gaze and blink to interact with the game. We also combined gaze with mouse click, a familiar and commonly used method of activation, in our investigations. These various ways to interact with objects on a screen allowed us to design and test three different gaze-enabled interaction methods for our game. All of the gaze-enabled interaction methods in our study used gaze to select an object. To activate an object we used either gaze, blink, or click. We explain these methods in more details in the next section.

## 2.1 The Memory Game

The game developed for this project was a gaze-enabled version of Simon, a single player memory/puzzle game. To play this game, a user is required to remember and repeat a sequence that is played by the computer. First, the computer plays a sequence by highlighting a series of colorful squares and their corresponding sounds and then the player repeats the same sequence. If the player succeeds, the computer generates a harder sequence, which includes one more square to remember. If the player fails to repeat the computer generated sequence, the player can restart the game or exit it if he/she does not wish to continue the game. The image in Figure 1, demonstrates a screenshot of the game.
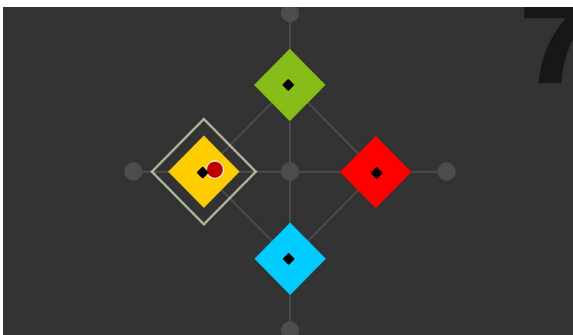


**Figure 1: Sample screen shot of the gaze-enabled Simon game. The red dot in the yellow square shows a user's gaze point during the gameplay**

Players can interact (select and activate) with an object in three different ways:

1. Use gaze to both select a square and activate it (Gaze & Gaze interaction method).

2. Use gaze to select a square and blink to activate it (Gaze & Blink interaction method).

3. Use gaze to select a square and click to activate it (Gaze & Click interaction method).

We used Tobii x30 eye tracking system with Tobii SDK to develop the gaze-enabled interaction methods for the game. Our game was developed on the PC platform.

## 2.1 Generation Y and Baby Boomer users

Generation Y users are considered digital natives. This generation is accustomed to cutting-edge technology and has been playing video games since childhood [5,14,15]. Contrary to Generation Y, Baby Boomers entered into the digital world at a later age [5,14,15]. Because common experiences during formative years of childhood have a major impact in forming a generation's expectation of technology, they can affect the way people interact with a technology [14,15]. For example, studies show that Baby Boomers and Generation Y users exhibit significant differences when it comes to clicking links on a webpage and/or browsing the Internet [2,5].

While people are accustomed to focusing their gaze toward objects that they wish to attend [3], using gaze to interact with or control video game objects is certainly new to most users. Thus, users have to adjust to selecting and controlling game objects on a computer screen via gaze. Given that Generation Y users have been immersed in gaming their entire lives, it is likely that this younger generation can more easily adjust to this new gaze-enabled technology. As a result, the younger generation is likely to have a better interaction experience:

*H1) The experience of various gaze enabled interaction methods will be more positive for Generation Y than for Baby Boomers.*

Similarly, because Generation Y is grown up with computer technology, this generation has experienced the rapid advances in technology during childhood. Thus, this younger generation is accustomed to exploring or trying new technologies. Because of this, the involvement in the game is less likely to be affected by the newness of the interaction method in

our study for the younger generation. Hence, we assert that:

*H2) Game involvement will be less affected by interaction methods in the Generation Y group than in the Baby Boomers group.*

## 3. Method

Data, for 3 different types of interaction methods with the memory game (Gaze & Gaze, Gaze & Blink, and Gaze & Click), was collected from a total of 10 participants (3 male, 7 female), resulting in a sample of 30 sets of data. The participants ranged in age from 23 to 60 with 40% of participants belonging to the Baby Boomer generation and 60% to Generation Y. Each participant played the games 3 times, each time with a different interaction method. The interaction methods were assigned to the user in a random order.

## 3.2 Measurements

To compare the differences in gaze interaction experience between Baby Boomer and Generation Y users, we used interview questions adopted from the ImmersiveNess of Games (ING) instrument by Norman [11]. Because we were interested in examining differences in interaction experience between the two groups, we used only the items of ING that captured reactions to the interaction method. We then modified those items to match the interaction methods in our game. The interview questions in our experiment required users to report their subjective experiences of interaction methods on a 7-point scale. We measured interaction experience using the following items:

- *Perceived control* measured the degree to which users were able to control their interaction with the game. Higher scores indicated better control.

- *Perceived naturalness* measured the degree to which interactions felt natural to users. Higher scores indicated experiences that are more natural.

- *Frustration* measured the degree to which users experienced frustration when interacting with the game. The higher the score the more frustrated the user.

- *Likeability of the selection method* measured the degree to which users liked the way they selected

an object in the game. The higher the score the better the likeability of the interaction method.

- *Likeability of the activation method* measured the degree to which users liked the way they activated an object in the game. The higher the score the better the likeability of the interaction method.

To test whether the gaze-enabled interaction methods distracted users from the game play, we used the following item from the ING instrument:

- *Perceived involvement* measured the degree to which players felt that they were involved with the game. The higher the involvement scores the less distracting the interaction method.

## 3.3 Procedure

The experiment was conducted in a laboratory setting. Upon arrival, each participant engaged in a brief calibration procedure that lasted about 15 seconds. Participants were provided with a brief explanation of the game and a short practice for the gaze enabled interaction methods. Each participant played the game three times, each time with a different interaction method, which was assigned to participants in a random order. Users played each game until they were unable to remember the sequence to repeat. The experiment was not timed, each user played at his or her own pace. After each game users were interviewed by the same experimenter using the measures discussed in Section 3.2. Users rated their interaction experience during the interview after each game.

## 4. Results

Average scores for each measure were calculated and displayed by various charts to provide a summary of user reactions per interaction method per user group. Because visual representations of data through heat maps can serve as a valuable tool in understanding user experience [3] the background of the charts were color coded to denote low, medium, and high "ranges" for participants' average scores: low ($1 \leq$ scores $< 3$), medium ($3 \leq$ scores $< 5$), and high ($5 \leq$ scores $\leq 7$).

To examine differences in interaction experience between the two groups we first looked at the average ratings for perceived control. As expected Generation Y ratings for perceived control were higher than Baby

Boomers' ratings (Figure 1). While the perceived control ratings for the Gaze & Click interaction method by both older and younger users were in the high range, younger users rated this item more favorably (6.17) than older users (5.00). Younger users rated the Gaze & Blink interaction method in the high range (5.17) while older users' ratings for the same interaction method fall in the low range (2.25). Younger users rated the Gaze & Gaze interaction method in the medium range (4.17) while older users rated it in the low range (1.50).

In order to test whether the observed differences in perceived control were significant between the two groups we used a t-test. The results of the t-test showed that the differences in perceived control between the two groups for gaze enabled interaction methods were significant (p=0.001). Younger users' ratings for perceived control were significantly higher than Baby Boomers' ratings for the same item. These results are displayed in Table 1.
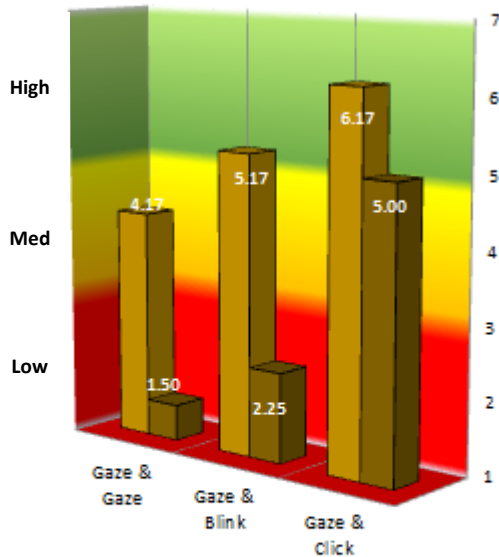
### Perceived Control
How much were you able to control your interaction with the game?



| | Gaze & Gaze | Gaze & Blink | Gaze & Click |
|---|---|---|---|
| Baby Boomers | 1.50 | 2.25 | 5.00 |
| Generation Y | 4.17 | 5.17 | 6.17 |

**Figure 2: Average and range of perceived control**

**Table 1: t-test, perceived control**

| User Groups | Mean | SD |
|---|---|---|
| Baby Boomers | 2.92 | 1.78 |
| Generation Y | 5.17 | 1.50 |
| df= 28, t Stat= 3.73, p=0.001 | | |

Next, we looked at the perceived naturalness scores (Figure 3). Again, as expected, Generation Y's ratings were higher than Baby Boomers' ratings for this item. While both user groups rated Gaze & Click interaction method in the high range, younger users rated this interaction method slightly better (5.67) than older users (5.00). Older users rated the naturalness of Gaze & Blink and Gaze & Gaze interaction methods in the low range (1.75 and 1.75) while younger users rated the naturalness of the same interaction methods in the medium range (3.83 and 3.83). These results indicated that younger and older users differed in how they perceived the naturalness of various interaction methods. A t-test verified that the observed differences in perceived naturalness of the gaze enabled interaction methods between the two groups were significantly different (p=0.018) (Table 2). Compared to older users, younger users found the gaze-enabled interaction methods significantly more natural.

The next item we looked at was the level of frustration users felt during their interaction with the game (Figure 4). Note that for this item the lower the number the better the score. Hence, the low frustration range was color coded with green and the high frustration range with red.

As we expected, frustration levels were lower in the younger user group. However, the differences between the two user groups were relatively small. As shown in Figure 4, both groups felt least frustrated when using Gaze & Click to interact with the game; the frustration level for Gaze & Click in both groups was in the low range (2.33 and 2.75). Both user groups rated their frustration levels for the Gaze & Blink (4.17 and 4.75) and the Gaze & Gaze interaction method (3.50 and 4.00) in the medium range. A t-test showed that frustration scores were not significantly different (p=0.52) between the two user groups (Table 3).

## Perceived Naturalness
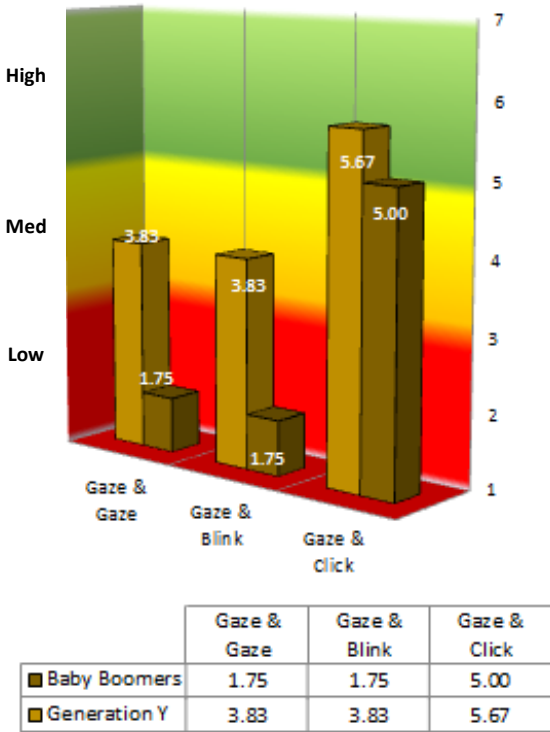### How natural did your interactions with the game seem?



| | Gaze & Gaze | Gaze & Blink | Gaze & Click |
|---|---|---|---|
| ■ Baby Boomers | 1.75 | 1.75 | 5.00 |
| ■ Generation Y | 3.83 | 3.83 | 5.67 |

**Figure 3: Average and range of perceived naturalness**

**Table 2: t-test, perceived naturalness**

| User Groups | Mean | SD |
|---|---|---|
| Baby Boomers | 2.83 | 1.95 |
| Generation Y | 4.44 | 1.54 |
| *df= 28, t Stat= 2.52, p=0.018* | | |

Next, we looked at how the two user groups liked the way they interacted with the game. Figure 5 displays the average scores for Baby Boomers' likability of the selection and activation methods. Figure 6 displays the same data for Generation Y users. As expected (see Figures 5 and 6) Generation Y's ratings for the likability of gaze as selection and/or activation methods were higher than Baby Boomers' ratings for the same items. Baby Boomers' ratings for

gaze as a selection/activation method were mostly in the low range (1.50, 1.75, 1.75, 2.50, 4.00) while only one of Generation Y's ratings for gaze as a selection/activation method was in the low range (2.83, 3.33, 3.33, 4.17, 4.67, 5.33). The observed differences in likeability ratings between the two groups were verified via a t-test. Generation Y liked gaze as a selection or activation method significantly more (p=0.004 and p=0.043) than Baby Boomers liked gaze as a new way to select and control game objects (Table 4 and Table 5).

## Frustration
### How frustrated did you feel when interacting with the game?



| | Gaze & Gaze | Gaze & Blink | Gaze & Click |
|---|---|---|---|
| ■ Baby Boomers | 4.00 | 4.75 | 2.75 |
| ■ Generation Y | 3.50 | 4.17 | 2.33 |
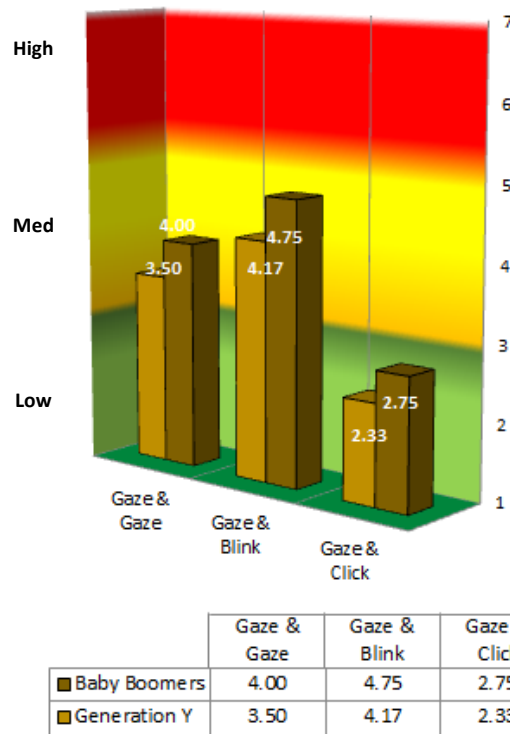
**Figure 4: Average and range of frustration**

**Table 3: t-test, frustration**

| User Groups | Mean | SD |
|---|---|---|
| Baby Boomers | 3.83 | 2.37 |
| Generation Y | 3.33 | 1.85 |
| *df= 28, t Stat= 0.65, p=0.52* | | |

## Baby Boomers' Likeability of the Selection/Activation Method

How much did you like the way you selected/acivated an object in the game?
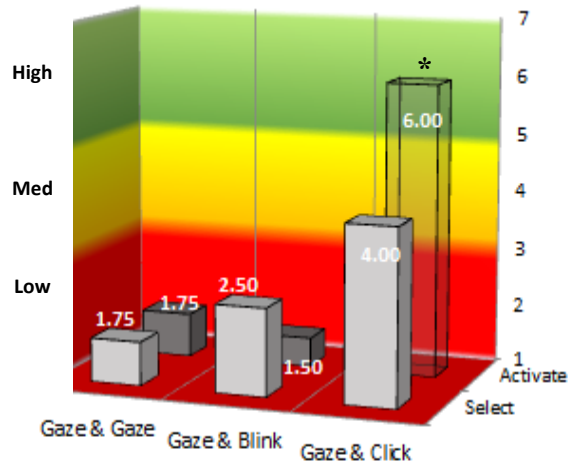


*This column represents reactions to mouse click

|  | Gaze & Gaze | Gaze & Blink | Gaze & Click |
|---|---|---|---|
| □ Select | 1.75 | 2.50 | 4.00 |
| ■ Activate | 1.75 | 1.50 | 6.00 |

**Figure 5: Average and range of perceived likeability of selection/activation method for Baby Boomers**

## Generation Y's Likeability of the Selection/Activation Method

How much did you like the way you selected/acivated an object in the game?



*This column represents reactions to mouse click

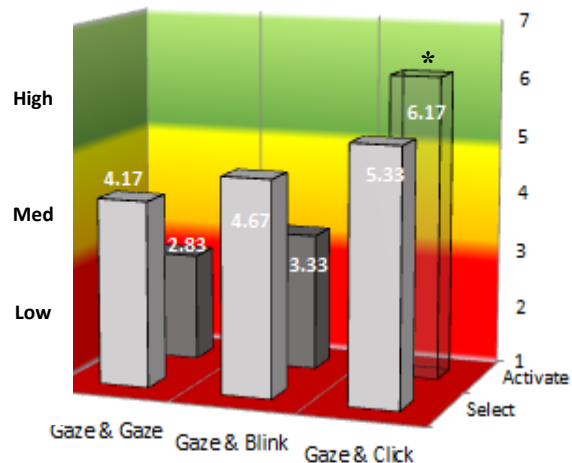|  | Gaze & Gaze | Gaze & Blink | Gaze & Click |
|---|---|---|---|
| □ Select | 4.17 | 4.67 | 5.33 |
| ■ Activate | 2.83 | 3.33 | 6.17 |

**Figure 6: Average and range of perceived likeability of selection/activation method for Generation Y**

The above results, as predicted by H1, show that overall Generation Y's ratings were more positive than Baby Boomer's ratings for perceived control, perceived naturalness, frustration, and likeability of the gaze-enabled selection/activation methods. However, we found significant differences between the two generations only for perceived control, perceived naturalness, and likeability of the gaze-enabled selection/activation methods. We did not find significant differences in how the two groups experienced frustration. These results together suggest that of the two users groups, younger users had a significantly better interaction experience.

In order to test whether the interaction methods used in our study distracted Baby Boomers more than it distracted Generation Y participants from focusing on the gameplay, we compared average scores for perceived involvement with the game between the two groups (Figure 7).

**Table 4: t-test, Likability of the selection method**

| User Groups | Mean | SD |
|---|---|---|
| Older users | 2.75 | 1.54 |
| Younger users | 4.72 | 1.78 |
| *df= 28, t Stat= 3.13, p=0.004* | | |

**Table 5: t-test, Likability of the activation method**

| User Groups | Mean | SD |
|---|---|---|
| Older users | 1.63 | 0.92 |
| Younger users | 3.08 | 1.73 |
| *df= 18*, t Stat= 2.18, p=0.043* | | |

*This analysis includes only gaze enabled activation methods, hence, the data for the activation method in the Gaze & Click interaction method (i.e., reactions to Click) was not included here.*

## Perceived Involvement

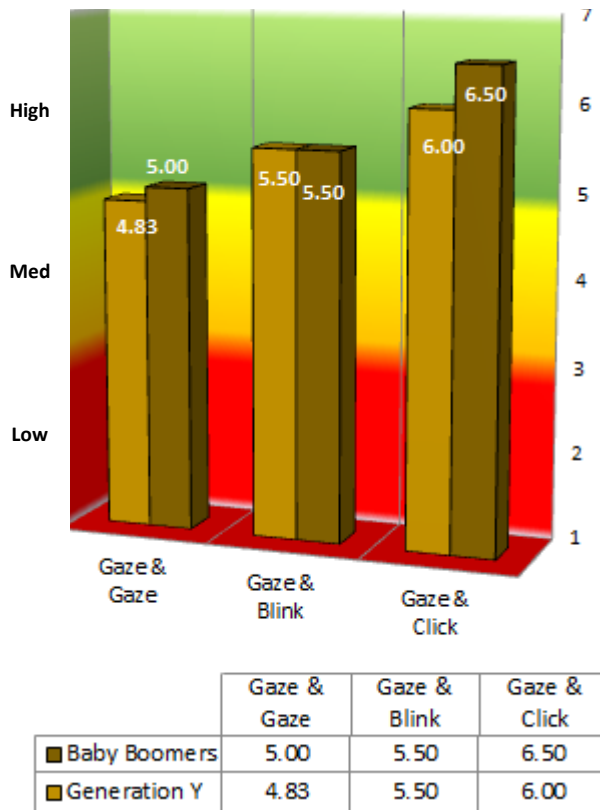How involved were you in the experience of playing the game?



|  | Gaze & Gaze | Gaze & Blink | Gaze & Click |
|---|---|---|---|
| Baby Boomers | 5.00 | 5.50 | 6.50 |
| Generation Y | 4.83 | 5.50 | 6.00 |

**Figure 7: Average and range of perceived involvement**

**Table 6: t-test, perceived involvement**

| User Groups | Mean | SD |
|---|---|---|
| Older users | 5.67 | 2.20 |
| Younger users | 5.44 | 1.42 |
| *df= 28, t Stat= 0.35, p=0.73* | | |

While Generation Y's scores were mostly higher than Baby Boomers' ratings, contrary to our expectation, the two groups showed little difference in their perception of involvement. As shown in Figure 7, the average scores for Gaze & Click and Gaze & Blink interaction methods were in the high range in both user groups (6.00, 6.50 and 5.50, 5.50 respectively). While the average ratings of Baby Boomers for the Gaze & Gaze interaction method was in the high range (5.00) and the average value of this score was in the medium range for the younger users (4.83), the differences between these two scores were quite small.

Additionally, the results of the t-test showed no significant differences (p=0.73) in involvement between the two groups (Table 6). Interestingly, both user groups reported high levels of involvement with the game. The high ratings by both groups suggest that the gaze interaction methods did not have a major negative impact on younger and older users' involvement with the game. The non-significant results of the t-test indicates that the two groups did not differ majorly in how they perceived to be involved in the gameplay.

## 5. Discussion

To examine possible differences in interaction experience between Baby Boomers and Generation Y, we compared user reactions to three different gaze-enabled interaction methods for the Simon memory game that was prototyped in our lab.

The results of this study, supporting our first hypothesis, show that overall the younger generation had a significantly better gaze interaction experience than the older generation. Younger users reported significantly better scores for their experience of control, naturalness, and likeability of gaze as an interaction method. While younger users reported lower frustration levels than older users, the ratings between the two groups, was not significantly different. These results are consistent with prior research that show generational differences can affect a user's experience of technology [5].

Contrary to our expectation, the results did not show significant differences in involvement with the game between the two user groups. Both groups reported relatively high levels of involvement. While, these results do not support our second hypothesis, they are good news for game developers that intend to incorporate gaze in their products. These results indicate that gaze enabled interactions are neither distracting to younger nor to older users.

The results revealed other interesting similarities and differences between the two groups as well. Both groups reported that Gaze & Click provided the best interaction experience and the highest level of involvement. Both groups experienced little frustration during the Gaze & Click interactions (their ratings were in the low range). Both groups rated perceived control, naturalness, and involvement with the game for this interaction method in the high range. The results showing that Gaze & Click provided a positive interaction experience in gaming for both groups are consistent with prior research that suggests the

combinations of gaze and other input methods are likely to provide a more positive experience for users [13].

The gaze only interactions, Gaze & Blink and Gaze & Gaze, were moderately frustrating for both user groups. Observations during the experiment and post task interviews revealed that most participants did not find blinking as an intuitive way to activate objects on the screen. Similarly, most of the participants in the study did not like activating an object in the game by merely looking at it. This was because, this interaction method require users to avoid looking at things that they do not wish to activate. Because many eye movements are involuntary, adjusting to this method of interaction for the gaze-enabled version of the Simon game may require more practice for some people. Future studies are needed to see whether changing the gaze duration, changing the size of the game objects, and/or changing the arrangement of the game objects on the screen can improve users' experience of gaze as an activation method in this game.

Both groups reported similar frustration levels for gaze only interactions, however, they rated perceived control of these interaction methods differently. As shown in Figure 1, perceived control ratings for Gaze & Gaze and Gaze & Blink were in the low range for Baby Boomers and in the medium and high ranges for Generation Y. The frustration levels experienced for these interaction methods were in the medium range for both users groups (Figure 4). In other words, while Baby Boomers were less successful in interacting with the game objects using their gaze they reported the same level of frustration as Generation Y users who were able to control the game with their gaze more successfully. These results together suggest that baby Boomers were more patient about learning to use gaze enabled interaction methods. The results are consistent with prior research that shows Baby Boomers are far more patient than Generation Y when viewing webpages [5].

While both groups liked the Gaze & Click interaction method, they differed in how much they liked the gaze only interactions (Gaze & Gaze and Gaze & Blink). Generation Y's ratings were substantially more favorable for these interaction methods than Baby Boomers' ratings. Generation Y rated the likability scales in the high range and/or in the high end of the medium range. Baby Boomers' ratings for the same items were in the low range. Interestingly enough Baby Boomers still reported high involvement with the game for these interaction methods. Again, this behavior is consistent with prior

research that shows Baby Boomers tend to be patient users [5].

The results of this study have important theoretical implications because they extend both gaming and gaze control research in the area of interaction experience [9,14,17]. The results also extend HCI research that focuses on the impact of generation on user experience [5].

From a practical point of view, the results provide insight for designing appealing games, particularly for those games that use gaze as an input. The results suggest that the combination of gaze and mouse click may provide a positive user experience for gaze enabled PC games for both younger and older users.

## 6. Limitations

As with any laboratory study, the results of our research are limited to the task. For example, we focused on interaction experience without requiring users to achieve a certain level of performance. Expecting users to achieve a desired score within a given time may affect the interaction experience results obtained in this study. Long-term exposure to gaze interaction may also change the results. For example, through practice users can learn to activate objects in the game more effectively using blink and/or gaze. This in turn, can improve their experience of Gaze & Blink and/or Gaze & Gaze interaction methods.

We used only three different gaze interaction methods. The combination of gaze with other input methods (e.g. voice command) may yield different results. While small sample sizes are not unusual in game studies, having a small pool of participants to test the interaction experience of the game was yet another limiting factor in our investigation. Future studies, with larger sample sizes, examining different game settings, using different gaze interaction methods are needed to increase the confidence in the generalizability of our results.

## 7. Conclusion

The results of this study have important theoretical and practical implications. The results provide evidence that older and younger users, at least initially, are likely to react differently to gaze-enabled interaction methods. In general, gaze-enabled interaction methods provided a better experience for

younger users. Neither group was distracted by the gaze-enabled interaction methods (both groups were similarly involved in the gameplay). Both groups reacted positively toward the Gaze & Click interaction method and rated this interaction method higher than the other interaction methods. These results suggest that gaze and click together can serve as a suitable interaction method for controlling puzzle games on PC platform for both Generation Y and Baby Boomer users. Hence, the results provide useful insight for game developers and interaction designers. The results also provide insight for studies that focus on experience design, and/or generational differences in gaming and/or usage of other technologies.

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