Gaze vs. Mouse in Games: The Effects on User Experience

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Abstract: The possibilities of eye-tracking technologies in educational gaming are seemingly endless. The question we need to ask is what the effects of gaze-based interaction on user experience, strategy during learning and problem solving are. In this paper we evaluate the effects of two gaze based input techniques and mouse based interaction on user experience and immersion. In a between-subject study we found that although mouse interaction is the easiest and most natural way to interact during problem-solving, gaze-based interaction brings more subjective immersion. The findings provide a support for gaze interaction methods into computer-based educational environments.

Keywords: eye tracking, gaze input, user experience, immersion, problem-solving

Introduction

Eye-tracking is becoming cheaper, more robust, and easier to apply. Many believe that it eventually may become a next-generation human computer interface. For example, eye-tracking devices may become an input technique in educational applications such as program visualization [3]. What is not very well understood, however, is how eye tracking input affects learners. What are the effects of gaze-based interfaces on users' search and problem solving, is just one of the important questions which we need to answer before implementing gaze-based interfaces on a larger scale.

Gaming, also, is a potential application for eye-tracking educational systems, due to its massive popularity, user base, and positive cognitive effects on problem solving. De Aguilera and Mentiz [1] claim that *"video games [fully integrated into the everyday lives of millions of young people] are a vital part of contemporary culture"*. Previous attempts to employ eye-tracking in computer games have shown a great potential in first-person-shooter and role playing games. In addition, games are fun and it has long been recognized that learning is easier when having fun [2]. Several factors can influence the "enjoyability" of a game. Brown and Cairns [5] believe that more immersion – defined as *"the degree of [user] involvement with the game"* – brings more fun in gaming. Therefore, it is important to evaluate immersion and user-experience in educational games.

Amory et al. [2] found that learners preferred games which involved strategy and problem-solving. From an educational perspective, problem-solving is one of the important skills that learners need to acquire. Hence, problem-solving games have long been recognized as an educational experience that can enhance a learner's problem-solving and planning abilities. We studied the effects of input modality on various factors in a problem-solving game. In this paper we present a study of the effects of input in problem-solving games on user experience and immersion; we compare gaze-based input with the conventional mouse.

1. Gaze Input

1.1 Gaze as a Computer Input

Gaze input is concerned with using the eyes to point at- and select objects on the screen. It is achieved using an *eye tracker* which measures the position of the eyes as a user looks at the screen. Gaze input techniques can be summarized into two main categories: direct selection (*gaze-based* and *gaze-augmented input)* and *non-command* based interaction.

Gaze-based input solely uses the eyes to interact with the computer. Gaze-based selection can be achieved either by continuously looking at a screen object until it is activated, or by looking at the object and then blinking/winking or gazing at an off-screen target (eye gestures) [7, 10]. Gaze-augmented input, on the other hand, uses the eyes to complement a manual pointing device, such as a mouse or keyboard. Selection can be achieved by looking at a screen object and than engaging the input device [7] or by using the eyes to position the cursor near the intended screen object, while pointing is achieved with the mouse (e.g. MAGIC pointing [11]). In non-command based interaction the interfaces monitors the user's eyes and responds appropriately *"without the user explicitly giving a command"* [8].

Gaze input has several advantages: the eyes can move fast, it is a natural means of selection thus making it easy to learn, and it reduces fatigue due to reduced physical movement during selection. There are, however, several problems associated with eye gaze input. The eye's structure and jittery movements place constraints on the size of interaction objects. Additionally, the constant 'on-ness' of the eyes raises a Midas Touch problem; every time a user shifts his/her gaze an object is activated [7].

1.2 Gaze Input in Games

A great potential exists for using gaze input in games, however only a handful of applications exists that actually make use it [10]. Shooting games, such as Luna Command [9], take advantage of the swiftness of the eye, by allowing players to use their eyes to aim at targets on the screen, while firing shots with the mouse. Gaze input in first-person shooter and first-person role-playing games (e.g. Quake2 and Eye Venture [6, 9]) is used to control a player's orientation as they explore the virtual world. Role-playing games such as Neverwinter Nights make use of the way people use their eyes to communicate in order to interact with objects, by controlling the movements of the virtual world avatar [9]. While problem solving games such as EyeChess make use of gaze-based interaction techniques to checkmate the Black King in three moves.

The Little Prince Storyteller is an example of a non-command-gaze-based storytelling game. The environment is shown as a revolving planet, with a number of

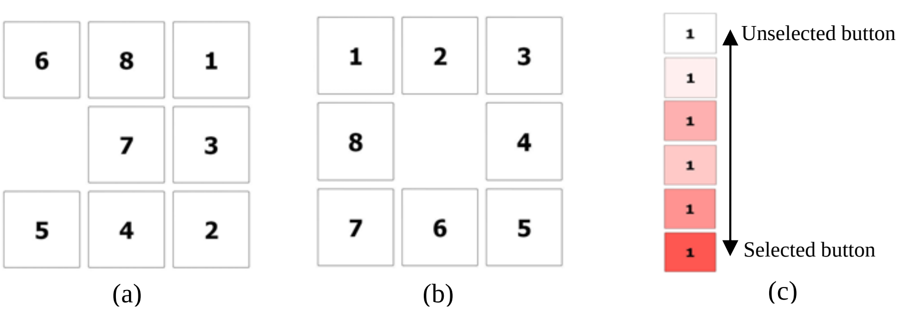

Figure 1: (a) 8-puzzle configuration at the onset of the game, tiles are shuffled. (b) 8-puzzle configuration once the puzzle has been completed. (c) Dwell-time button color animation, using hue volume to indicate amount of time left before selection or unselection.

objects on its surface. A narration is given about the planet and its contents, the narration's generality and specificity depends on the user's eye-movements and attention [4].

2. The 8-Puzzle

In this paper we study user interaction and problem solving strategies in the 8-puzzle. Because immersion and user experience are critical in educational problem solving games, we compare the user experience when using the conventional interaction technique (i.e. the computer mouse) to the experience when using gaze interaction.

To test the effects of input modality on user experience, we developed a version of an 8-puzzle tile rearrangement game. The puzzle consists of eight numbered tiles and one blank tile that are arranged in a 3x3 grid. The tiles are shuffled at the onset of the game (Figure 1a). The aim of the game is to arrange the tiles so that each tiles lies in its target position (Figure 1b).

In our implementation, the puzzle can be played using three interaction methods: mouse, gaze-augmented, and gaze dwell-time input. During gaze-augmented input, once a tile is gazed upon, it will immediately be highlighted green. The user can then select the tile by left clicking the mouse button; the mouse cursor is not displayed. During dwell-time selection, a user's gaze has to remain on that tile for 1 second in order for the tile to be selected. Color hue animation (Figure 1c) indicates the amount of time left before the tile is selected using hue volume – the longer the user looks at the button the more red it will turn. If the user's gaze leaves before the tile has been selected, the tile's color animates back to white. If the users gaze returns to the tile before the tile has turned white, the tile's color animation continues from the current color hue.

3. Gaze-Augmented, Dwell-Time, and Mouse Interaction 8-puzzle: An Experiment

A sample of thirty-six participants took part in the study (23 male, 13 female). All participants were computer literate and only 28% had prior experience with participating in an eye tracking study. Nine of the participants wore spectacles, one wore contact lenses, and the remaining 26 participants reported no visual impairments. Although all participants understood the logic behind solving the puzzles, the level of prior experience with the puzzle varied. A Tobii ET 1750 eye tracker was used for tracking the participant's eye movements and for gaze interaction.

The experiment was conducted in a laboratory. Participants completed a consent form and a short questionnaire to obtain their background information. Participants were then briefed on the rules of the 8-puzzle and interaction method to be used.

We made use of a between subject design. Participants were randomly divided into three groups-conditions, according to the input modalities. Participants completed three randomly ordered puzzles and each puzzle had a unique start configuration. Participant first had to complete a think-aloud task followed by a warm-up puzzle to orientate them with the interface and interaction sequence. Once participants were comfortable with the warm-up puzzle they started solving the three target puzzles.

Once a participant had completed all the puzzles under the specific condition, we allowed the participants from the gaze-augmented and dwell-time conditions to experience shortly the other mode of interaction. This aimed at providing participants the reference experience for answering the comparative questions after the study. Finally, the participants were administered a post-test questionnaire to obtain information about the user experience.

3.1 Results and Discussion

Table 1. Aggregated user experience and preference. Lower number indicates better result. * denotes significant difference in the responses.

Question	Dwell Time	Gaze Aug.	Mouse	X^2 (2)	p
1 Did you like this interaction?	1.83	1.67	1.83	.33	.846
2 How easy was it to control the game using this interaction?	3.17	1.92	1.42	13.5	.001*
3 How natural was it to use this interaction?	2.58	2.17	1.67	4.81	.090
4 How immersive did you find the game using this interaction?	1.83	1.75	2.50	7.44	.024*
Average rating	**2.35**	**1.88**	**1.86**	**8.11**	**.017***

Table 1 summarizes the results related to user experience and immersion. Users were asked to rate their experiences with the interaction method that they just have used. Ratings were made on a five-point likert scale. A rating of 1 indicated a strong agreement/preference (e.g., I like the interaction very much/very natural means of interaction), a rating of 3 indicated that the user had a neutral opinion of the interaction, whereas a rating of 5 indicated that the user strongly disagreed with the interaction (e.g. the game was very difficult to control using this interaction). The results were analyzed using a Chi-square (X^2) test. In addition we collected free-form comments of the users.

The first question, *"Did you like this interaction?"*, aimed at evaluating the subjective preferences of participants. Users of each of the input devices liked the interaction about same, with no statistical difference in the user responses. Participants under the dwell-time condition found the interaction to be fun and interesting. Most participants liked the colour highlighting and the 'eyes-only' interaction. Participants under the gaze augmented condition enjoyed the quickness of the interaction and felt that it provided *"faster response times than the mouse"*. The participants under the mouse condition liked the *"physical contact with the mouse"* as well as the fact that one could observe the puzzle without any interferences.

Based on the results from the second question, dwell-time interaction was found to be the most difficult to control the interface (and received the worst grade from all the questions and tools), followed by the gaze-augmented input and mouse. We believe that this may be a direct consequence of Midas Touch, where a tile would be accidentally selected during visual scanning. The differences in the responses were statistically significant. This is not a surprising finding, as computer users are accustomed to mouse interaction and gaze-based interaction is a novel way of interacting with computers.

A similar order of preference was found for the naturalness of the interaction (question 3): dwell time, although not requiring any manual efforts for moving a cursor, was found the least natural from the three input methods. Some participants felt that it was unnatural to both think/strategize and to select items at the same time. Gaze-augmented interaction received mixed responses, although most participants felt that the interaction was *"relatively straight forward"* and "*intuitive and easy*" to use; some users felt that the interaction initially required concentration due to the eye-hand coordination.

The results obtained from the last user experience question, that is, "*How immersive did you find the game using this interaction?*" clearly show that although the gaze-based interaction methods were not found the easiest and most natural, they were recognized as immersing the users into the game experience. The most immersive mode of interaction was the gaze-augmented input, followed by the dwell-time interaction. On the other hand, participants saw mouse interaction as being *"nothing special"*.

We compared the relative preference by asking the participants in the dwell-time and gaze conditions (24 participants in total, 12 each) to compare the preferences in the just experienced input modality to the mouse-based interaction. The mouse was the preferred interaction mode for a majority of the participants (67%) playing with the dwell-time interaction. On the other hand, in the gaze-augmented condition, five users preferred the gaze-augmented input over the mouse, while three participants felt that there was no difference between the two modalities. When the users were queried on which interaction sequence they found *easier to use*, the majority of participants, in both the dwell-time and gaze-augmented conditions, felt that mouse was easier to use – a finding supporting the results from Table 1. Three participants under the gaze-augmented condition, however, felt that there was no difference between the two interaction modalities.

In summary, dwell-time based interaction received generally the worse feedback. The gaze-augmented interaction, however, was in overall found at to be least as good as the mouse interaction. Comparing the two gaze-based conditions, gaze-augmented modality received a better feedback, was more preferred to the mouse than the dwell-time and was found to be slightly easier to use. On the dimension of immersion, gaze-augmented problem-solving was found to be subjectively perceived the best.

4. Conclusion

Immersion, fun, and user experience are recognized to be important factors in any game genre, including educational gaming. We studied the effects of input modality on these factors in a problem-solving game.

Not surprisingly, we found that novel input methods received worse feedback on the dimensions of easiness and naturalness than the computer mouse did. All three input methods were found to be about same when considering how users like/dislike them. More importantly, however, we discovered that users feel more immersed with the problem-solving game when using either of the two gaze-based input methods than when using a conventional mouse. This result is a promising one, taking into consideration the role of immersion in gaming, and in educational gaming especially. We propose that gaze-augmented interaction can increase immersion in the educational problem-solving games.

References

[1] De Aguilera, M. and Mendiz, A. (2003). Video games and education: (Education in the face of a "parallel school"). *Computers in Entertainment.* 1, 1 (Oct. 2003), pp. 10-10.

[2] Amory, A., Naicker, K., Vincent, J., and Adams, C. (1999). The use of computer games as an educational tool: Identification of appropriate game types and game elements. *British Journal of Educational Technology* 30 (4), pp. 311–321.

[3] Bednarik, R., Myller, N., Sutinen, E., and Tukiainen, M. (2006). Analyzing Individual Differences in Program Comprehension. *Technology, Instruction, Cognition and Learning*, 3 (3-4), pp. 205-232.

[4] Bolt, R. A. (1982). Eyes at the interface. In *Proc. of CHI '82*. ACM Press, New York, NY. pp 360–362.

[5] Brown, E. and Cairns, P. (2004). A grounded investigation of game immersion. In *CHI '04 Extended Abstracts on Human Factors in Computing Systems*. CHI '04. ACM, New York, NY, pp. 1297-1300.

[6] Gips, J., DiMattia, P., Curran, F. X., and Olivieri, P. (1996). Using EagleEyes: An electrodes based device for controlling the computer with your eyes to help people with special needs. In *ICCHP '96: part I*. Munich, Germany. pp. 77–83.

[7] Jacob, R. J. K. (1991). The Use of Eye Movements in Human Computer Interaction Techniques: What You Look At is What You Get. In *Proc. of ACM Transactions in Information Systems*. pp. 152-69.

[8] Nielsen, J. (1993). Noncommand user interfaces. *Communications of the ACM*, *36*(4), pp. 83-99.

[9] Smith, J. D. and Graham, T. C. (2006). Use of eye movements for video game control. In *Proc. of the 2006 ACM SIGCHI* ACE '06, vol. 266. ACM, New York, NY, 20.

[10] Špakov, O. (2005). EyeChess: The tutoring game with visual attentive interface. In *G. Evreinov (ed.) Proc. of Alternative Access: Feelings and games 2005.* University of Tampere. pp. 81–86.

[11] Zhai, S., Morimoto, C., and Ihde, S. (1999). Manual and gaze input cascaded (MAGIC) pointing. In *ACM CHI '99.* New York, NY, USA: ACM Press. pp. 246–253.