Measuring learning and fun in video games for young children: A proposed method

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ABSTRACT

As a student, educator, and researcher, I have long been interested in the learning opportunity that video games represent a corollary of a pedagogic awareness of the considerable benefit of applied and practical learning experiences.

The advent of low cost computing has increased ownership of personal computers in the last twenty years. A result of these decreasing costs has seen significant growth in household ownership of personal computing equipment for entertainment, education and enterprise. The increased ownership of personal computing equipment has also seen a significant increase of ownership and use of video games. The increased interest and use of video games for entertainment has seen a similar increase of interest in the use of video games for education.

In this paper, a proposed method is presented for obtaining a better understanding of the education potential of video games for young children.

Categories and Subject Descriptors

H.1.2 [**User/Machine Systems**]: Human Factors

General Terms

Human Factors

Keywords

Endogenous blinking; Game-based learning; Cognition; User engagement; eye gaze data

1. INTRODUCTION

There has been an increased interest in and about the potential educational benefits that video games may offer [4, 18, 23, 26]. However, while some progress is being made in terms of quantifying these claims [24], there is still some way to go to validate these claims. One of the challenges faced by researchers is finding reliable measures for learning and fun [see for example, 13]. While pre and post exposure surveys or assessments may provide researchers with indicators that some learning has taken place, this method may not be entirely reliable as it on the participants recollection of the experience [8]. Hassen [7] suggests that the ability of research participants to accurately recall or demonstrate that learning has taken place or how much fun was had is unreliable. Sim, MacFarlane, & Read [25] found a link between usability and fun, but no link between fun and learning. While, this is a noteworthy finding, it does suggest that further research is needed to qualify and quantify what learning is taking place while playing a video game and to further investigate the links between fun and learning. One of the biggest challenges has been finding accurate and reliable measures for fun and learning [8]. The scientific measurement of fun (or enjoyment) is also challenging [13].

This proposed research seeks to investigate some potentially more reliable tools that may assist in qualifying and quantifying if and how much learning and how much fun children have while playing a video game. Further, as the proposed methods require minimal intervention with the research subjects, this appears to be an appropriate system for researching children.

This research could benefit educational video game designers through ensuring the games they develop better meet the expectations of the developers, the children playing the game, their parents, and educators.

2. MEASURING LEARNING AND FUN

While some educators debate about the importance of fun (or enjoyment) in the learning process, there is a general consensus that an engaged learner will benefit more from the learning experience than a disengaged learner [4, 23, 26]. Therefore, it is important for developers of educational video games to make their product engaging. To understand what young learners find engaging, it is beneficial to understand what the antecedents of engagement are. From my own research and observations to date, the main two causes of frustration for young children playing video games are: usability and assumed user aptitude. By making a video game that is at the right level and is easy to use is an essential step to providing an engaging experience. Moreover, video games also need to provide a challenge, include some fantasy, and stimulate curiosity [11, 17].

The usability of a device is necessary for user acceptance and continued use [20]. Although humans make affordances [5] to use technology, the easier something is to use, the less affordance will need to be made [15]. However, young children typically have not learnt to make as many affordances as older children and therefore developers making products for this demographic need to ensure what they make is as easy to use as possible.

The assumed user aptitude is also important. According to Walker & Guajardo [28], Microsoft develops and tests their products in line with the ESRB ratings (3 to 6, 7 to 9, 10 to 12) [28]. However, there is a significant difference between the cognitive and dexterity capabilities of a three year old and a six year old [3]. Although beyond the scope of this proposal, this difference is worth considering when developing and evaluating video games and educational products for young children.

3.1 Measuring fun or engagement

Read and McFarlane [22] suggest that the Smileyometer may be appropriate for measuring fun for children aged over 9 years of age. My own experience suggests that despite their limitations, tools like the Smileyometer [27] may be useful for children aged seven and over. However, for younger children, this does not appear to be the most effective method. In practice, video game developers appear to be content using structured observation in a research laboratory or in the wild [13, 28]. The evidence collected includes observations of expressions of happiness (smiling) and expressions of frustration (sadness, anger, etc.), or an observation of how long the participant is focused on the given task (or "Eyes on Screen" [14]). However, while this may be a useful and potentially valid instrument for commercial video game developers, some academics (and practitioners) feel the need to use more scientific measurement instruments.

3.2 Measuring Learning

Measuring learning is challenging as there is a variety of definitions of what is learning. Moreover, as learning is a cognitive process, it is difficult to observe or measure if, what, and how much learning has taken place. Therefore, proxy measures (observations or measures of learning acquisition) of learning help gather evidence of the learning process.

However, the methods of measuring fun or learning are less than precise and therefore, it is worth considering alternative methods to provide more reliable approaches.

3. MEASUREMENT TOOLS

The introduction of physiological measurement tools has led to advances in understanding human behavior and cognition. One innovation has been the use of eye tracking technologies that are transparent to research participants (see SMI [9] or Tobii [10]).

By tracking the movement of the retina, these devices can provide detailed information about what the participant is looking at, how long they look at it, and the 'path' of each scan [6]. These tools provide potential measurement techniques for identifying where participant is looking while playing a video game. There is a close connection between what a subject is looking at and what they are thinking about [6, 12]. Where users look on the screen, how long they look, and how many times they look at that particular object can not only provide an indicator what the user thinking about, but it can also indicate where the user was having difficulty with that particular part of the game. The duration the eyes are fixed on a particular object can also potentially indicate the amount of processing that is taking place [17]. In order to process information on a screen the eyes fixate on areas that are surprising, significant, and or important [16]. Through identifying these gazepoints (the cumulative fixation time), it is possible to map these against the reference image (see figure 1) and ascertain the sequence of eye movements and areas of interest or attention [21].

From the evidence to date, it appears that these tools when combined with participant observation or feedback can provide reliable indicators of cognition.

Figure 1. Gaze Plot Data [2].

The Gaze Plot Map (figure 1) can also provide scanpaths which are "defined by a saccade-fixate-sequence on a display" [6 p. 635]. The scan path sequence and duration can provide insights into search behavior [6]. That is, the areas with the larger dots on the screen indicate areas of interest. These areas of interest can be either where the participant had difficulty understanding or using, or where areas the participant was fascinated with.

Another indicator of human cognition is when the eye blinks [19]. If someone blinks his or her eyes this is either a reflex or startle action (a response to something physically about to invade the eye or the eye is dry), a voluntary action (resulting from a decision to blink), or an endogenous action (due perception, a reaction, or information processing). Endogenous blinks are typically the lowest in amplitude and the shortest in duration (see figure 2) [27, p. 3].

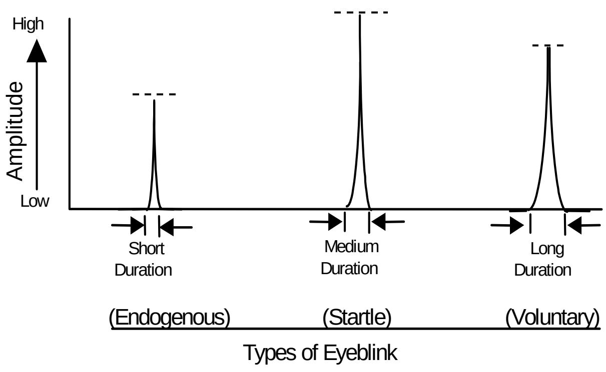

Figure 2. Endogenous blinks [27, p. 3].

In the past, eye blinks have been measured using an eye blink electrooculogram which requires the use of electrodes that are placed on the extra-ocular muscles of each participant (see figure 3). With an electrocardiogram, it is possible to identify the duration and amplitude of each blink while the subject is performing a set task that requires cognitive activity [27]. While this practice appears to produce reliable data on the amplitude and duration of the blink as well as eye movements, it appears reasonably intrusive for the participant and is unlikely to yield a substantial amount of data from a statistically significant sample of young children.

Figure 3. Electrooculogram electrode placement [27, p. 4].

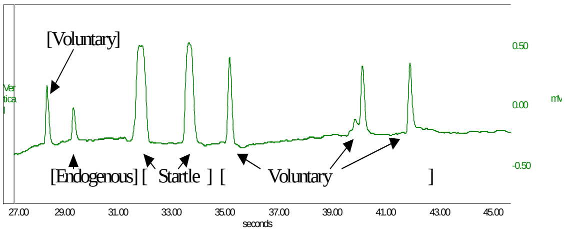

Figure 4. Actual Electrooculogram (EOG) for eye blinks [27, p. 3].

By calculating the quantity of endogenous blinks and combining this data with the gaze point maps, it will be possible to differentiate the areas of difficulty versus the areas of fascination. It is my belief that the areas of difficulty will be evident by the higher incidence of endogenous blinks.

4. THE PROPOSED STUDY

To further understand what learning is taking place and how much fun the participants have, a study will be conducted using an eye tracking device to track eye gaze behavior and monitor and measure the frequency of endogenous blinks.

This proposed research is based on the study conducted by Evens and Saint-Aubin [1] but will be conducted with participants aged 5 to 7 years old. The study by Evens and Saint-Aubin [1] involved children that were 48 to 61 months old. These children were read a contemporary story book that included both text and graphical illustrations. The purpose of this study was to investigate whether children were looking at the text or at the pictures during shared reading. This research used a SR Research EyeLink II, which consists of three cameras attached to a headband that is worn by the participant. This enabled the researchers were able to track both head and eye movement. The researchers found that the primary point of interest is on the graphic images and not on the text.

In this study, a portable tablet device and a desktop computer will be used to provide comparisons between the effectiveness of the two devices. The participants will be selected using a convenience sampling method from participating kindergartens and early year’s primary school students. Informed consent will be obtained from the school and the parents of the children involved. The observations will be conducted in a laboratory setting and the parents will be asked to sit the child on their knee while the observation is being conducted. To get a diverse range of children from different ethnic groups, the research will be conducted in New York, Sydney, and Auckland. The sample size for each study will be 10-15 children (based on Pagulayan [25]). The children will be asked to play two levels of the video game World of Goo (as used by Shute and Kim [30]). Before the game play starts, the child will be asked to watch a short cartoon which will be used to calibrate the equipment. The World of Goo was chosen because it is non-violent and according to Common Sense Media [35] there is the potential for participants to learn physics and engineering concepts and at the same time improve analytical thinking skills. The SMI Red500 eye tracking system [9] operates at 500Mhz and therefore appears to be capable of tracking eye gaze behavior and measuring the quantity and frequency of endogenous eye blinks.

Multiple exposures to two levels will enable the researchers to measure any improvements in performance as well as any changes in search behavior (the number of overall fixations on particular parts of the game), as well as any changes to the duration of fixations on any object (a possible indicator the child is struggling or is fascinated with a particular part of the game [12]). Moreover, the researchers will be able to observe and measure any reduction in endogenous blinks.

5.1 Observations

From observations thus far, the areas the user is struggling with are identifiable by the greater incidence of endogenous eye blinks and larger gaze points (the cumulative fixation time). Whereas the areas that the user is already familiar with or has learnt should have a lower frequency of endogenous eye blinks. This should also be supported by other behavioral signs of enjoyment (smiling, laughing, etc.) [27].

Furthermore, evidence of learning should be identified by the decrease in the frequency of endogenous eye blinks as the user reviews each learning point. From observations thus far, when a child tries to answer a problem the first time they generally spend more time fixated on that part of the screen and produce more endogenous blinks than when they answer the same question each subsequent time.

Although retained learning is dependent of the frequency of the learning and temporal delay between each review or application of the learning [28], this proposed method will potentially identify if any learning is evident from both single and multiple (two to three) exposures to a learning concept within a single (ten minutes) session. Although more exposures would be preferred, given the difficulty of getting young children (and their parents) to support this may be too difficult to manage.

When combined with structured observation, it is possible that the triangulation of these three methods will provide qualitative and quantitative data on both fun and learning. Moreover, because the techniques are non-invasive, these collection methods appear more appropriate for observing and measuring young children.

5. CONCLUSIONS

The study will provide some improved knowledge of what young videogame players learn while playing a video game. Moreover, it will provide a better understanding of the causes of player frustration and provide some suggestions for reducing these frustrations.

The outcome of this study will also provide a contribution to understanding of the learning that transpires while playing a video game and a debate of implications for formal education. The outcomes of this study will give guidance for the adoption of these technologies by educators and educational policy makers.

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