Audio, Color, and Form's effect on human reaction

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1 INTRODUCTION

Reacting to information quickly is important for users who wish to competently interact with modern computer games. The user must take in and process small amounts of information in a very short time and react accordingly in order to avoid negative outcomes. How this information is presented is a key component in ensuring user's actions and choices are able to matter. For example, in the series Street Fighter, 2 characters are pitted against each other in a titular street fight, one particular character has an attack that is commonly referred to as the "green hand"[13]. The green hand is visually identical to a different attack except for one key difference, the hand flashes green briefly before attacking. The opponent player has to react to the color of the hand in a very small window in order to avoid being hit, and the color is the only information they can see. This paper examines the relationship between human reaction time and either audio or visual cues with regards to efficiency in presenting users with usable information. By understanding the strengths of both mediums, we will be able to recommend possible approaches for quickly supplying critical information in HCI systems. Our goal is to establish if either choice has a stronger immediate effect in first time users being exposed to new information, this way we will be able to avoid users needing to develop muscle memory over long periods of time and can instead rely on already existing reactions.

1.1 Identifying features?

Color is the first identifying feature that could be a strong influence. A huge majority of information is presented in a visual medium, which means users become very adept at using their eyes to process information, but the question asked is without the added advantage of memorization and repeated exposure, does a user retain accurate reaction based off of visual stimulus.

The second identifying feature is an associated audio cue. Often times, audio is used as a "hit confirm" in computer games, which is to say, certain events and outcomes have a sound that plays to indicate something to a user. The advantage being that a user can hear something, even if they are paying active attention to something else whereas a visual cue relies on the user being able to actively see it. However, a noisy environment can obfuscate this as reliable information.

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These two features are often used in conjunction to give a user the maximum amount of information to react to rather than just one or the other. This study will separate the two in order to determine if there is a noticeable difference in the effect on reaction.

2 RELATED WORKS

Reaction speed with regards to information clarity has been studied in the past very thoroughly, but with a particular focus on its relation to gender, health, or hits relation and interaction with disabled users. With research beginning as early as 1989 [5] with the study of computer games potential positive impact on human reaction time. This study specifically found that reaction time was noticeably improved upon interaction with computer systems, though the study notes that any similar task requiring manual dexterity would likely show a similar impact. A particularly relevant portion of one study showed that "Variables significantly associated with reduced speed of task performance are...color defects and gender" [10]. Our studies focus on color in particular as a form of stimuli, so understanding that users with disabilities related to seeing color shows some precedent that color might be useful for reaction time. In a related study looking at visually impaired subjects, researchers Yu and Moeller found that a faster reaction time was often associated with an incorrect response [12]. This is very much relevant to our own study as we are not simply measuring the speed at which a user reacts but also the accuracy of their input. Something that is not discussed in our study but is still relevant is the influence of haptic feedback. One particular study by Peon and Prattichizzo found that vibration stimulus produced the fastest reaction time, besting both auditory and visual [6]. This study also researched the qualitative aspects of the three methods of stimulus and noted that "visual modality required more concentration...and that it was easy to go get distracted with it. Instead of being driven to react spontaneously one hat to that the decision"[6]. This finding could play a large role in our study as both of our methods of stimulus contain a visual element but only one has an additional auditory aspect. The combination of the two stimuli has been shown to have a significant positive interaction, notably that two forms of stimulus had improved reaction times when compared to any single form [9]. Something unaccounted for in our study is the in depth background of the participants. The only identifying features present in our study is age and biological sex, while other studies have shown careful attention to many potentially relevant traits such as left-or right-handed dominance, training conditions, physical background, and health conditions[2]. This means more than likely there will be a confounding variable going unaccounted for in our study, though with such a small pool of participants it becomes less certain. Additional research has focused specifically on visual reactions but with a focus on peripheral vision rather than direct focus, notable in Fischer and Rogal's study on hand eye coordination where subjects were told "Do not pay attention to the fixation point, just keep your eye on it"[3]. Others studies share reaction time as a tool of measurement but rather than the information being presented being the dependent variable, instead they focus on the method of input, comparing touch screen devices against classical mouse and keyboard setups[8]

3 USER STUDY

3.1 Methodology

Participants. Our research aims to determine which stimuli provides the fastest and most accurate response, auditory or visual. For this purpose, 15 participants (6 females and 9 males) were recruited on a volunteer basis. Their ages ranged between 25 and 63 and 8 expressed prior experience in reaction-based usage of computers, primarily in the context of playing games. Any other potential background factors have been excluded due to our inability to account for such a

variety of data in this small group of participants. The only exclusionary features that were accounted for were hearing disabilities and colorblindness which ruled out 2 additional potential participants. Each participant was tested once on the visual component and then the auditory component were only tested once to avoid memorization. Equipment. The reaction time java program was run on a Microsoft Surface laptop equipped with an AMD Ryzen Microsoft Surface Edition processor and 16 GB of ram.

Participants used a Logitech Bluetooth keyboard and mouse for entering in both reaction times and participant identifying information. Procedure. Before beginning the trial, each participant was placed in a quiet room apart from the other participants and given a consent form to review and sign. They were instructed to review the questions presented on the laptop and fill in the categories. They were then instructed to review the on-screen colors or sounds associated with the cardinal directions and continue doing so until after they felt comfortable in their ability to recognize the identifying feature. When being tested on the audio version of the program, participants were told to adjust the volume of the computer to their preference before beginning. Participants were then left alone in the room and told to click the begin prompt when they were ready. After doing so, participants would be presented with a symbol and an accompanying identifying feature dependent on which version of the program they were testing on. They would have 3 seconds to input one of the four directional keys on the keyboard before the program displayed the next image.

After viewing all images, the participant would be instructed on screen to exit the program and leave the room. Each participant's accuracy and average speed was recorded using the computers system clock. Failure to input a key in the 3 second time frame was recorded as an incorrect input. Each time a participant would enter a key, the program would log the correctness of that particular input as well as the individual speed of reaction for that image. At the end of the trial, the program would record the average total speed of all inputs. The program began by asking the user to input their name for organizational purposes, age, biological sex, and which version of the program they were currently being tested on. Participants were given a standard QWERTY keyboard and were displayed the symbols and sounds associated with the 4 cardinal directions before beginning the experiment. The participant will have those 3 seconds to input one of the four cardinal direction keys and the program will record their entry as being correct or incorrect as well as the amount of time it took to input a key. Additionally, the program will record any lack of input as being an incorrect input.

Equipment. The reaction time java program was run on a Microsoft Surface laptop equipped with a AMD Ryzen Microsoft Surface Edition processor and 16 GB of ram. Participants used a Logitech Bluetooth keyboard and mouse for entering in both reaction times and participant identifying information.

Procedure. Before beginning the trial, each participant was placed in a quiet room apart from the other participants and given a consent form to review and sign. They were instructed to review the questions presented on the laptop and fill in the categories. They were then instructed to review the on screen colors or sounds associated with the cardinal directions and continue doing so until after they felt comfortable in their ability to recognize the identifying feature. Participants who were in the audio recognition group were instructed to adjust the volume to their preference. Participants were then left alone in the room and told to click the begin prompt when they were ready. After doing so, participants would be presented with a symbol and an accompanying identifying feature dependant on their group. They would have 3 seconds to input one of the four directional keys on the keyboard before the program displayed the next image. After viewing all images, the participant would be instructed on screen to exit the program and leave the room.

Data Collection. Each participants accuracy and average speed was recorded using the computers system clock. Failure to input a key in the 3 second time frame was recorded as an incorrect input. Each time a participant would

enter a key, the program would log the correctness of that particular input as well as the individual speed of reaction for that image. At the end of the trial, the program would record the average total speed of all inputs

Program Functions. The program began by asking the user to input their name for organizational purposes, age, biological sex, and which group they have been sorted into. Participants were given a standard QWERTY keyboard and the program displayed the symbols and sounds associated with the 4 cardinal directions before beginning the experiment.

The participant will have those 3 seconds to input one of the four cardinal direction keys and the program will record their entry as being correct or incorrect as well as the amount of time it took to input a key. Additionally, the program will record any lack of input as being an incorrect input.

As the user inputs directional keys, the program records the correctness of their entry and keeps track of their total correct answers. Additionally it records the time the user took to enter a key measured from when the image is displayed. It averages the reaction speeds and after all 20 images have been reacted to it writes the users inputted information, total correctness, and average reaction speed to a .txt file titled "exampleuser.txt"

3.2 Image components

Participants were shown one of 4 symbols with an associated color or sound depending on their group, the program then performed a countdown from 3 before transitioning to the next symbol.

The symbols themselves are a representation of human hands pointing either up, down, left, or right in reference to the computer monitor being used.

Fig. 1. This single image was altered to point in the four cardinal directions up, down, left, and right

The sounds associated with images are 4 distinct noises, the volume of which could be freely adjusted by the participant before beginning the trial. The colored images were either red, blue, green, or black to ensure that there is sufficient contrast between the symbols and minimal ambiguity is present.

3.3 Results

Our results show that a significant number of participants reacted noticeably faster to auditory stimulation compared to visual stimulation and after performing ANOVA on the results, we were left with a p-score of .0178 which is less than .05 meaning the use of audio or visual does have a significant impact on reaction time which is consistent with the Shelton Kumar paper testing pure reaction time without accounting for accuracy [11].

	Audio	Visual	Total
Number of participants	15	15	30
Mean	268.133ms	294.0667	281.1
Std.Dev	36.6545	15.6455	30.6711

Table 1. Reaction Time Results

Additionally, the male reaction time was consistently lower than the average female reaction time across both stimuli. This again is consistent with the findings in a study specifically designed to test for a difference along biological sex lines [4].

Source	Sum of squares	DoF	MS	P-score
Between-Treatments Time	5044.03	1	5044.033	6.361
Between-Treatments Correctness	0.133	1	0.133	0.05858

Table 2. Anova

The lowest score for both the audio and visual sections was 16 correct entries and the highest for both was a perfect 20 entries. The average correctness varied between the two tests with correctness using audio being 18.0 and visual correctness being 18.133. Using ANOVA on our correctness results however shows a p-value of .05858 which is greater than .05 meaning the influence of these two stimuli on correctness is unlikely to be significant.

	Audio	Visual	Total
Number of participants	15	15	30
Mean	18	18.133	18.067
Std.Dev	1.4639	1.5523	1.484

Table 3. Correctness Results

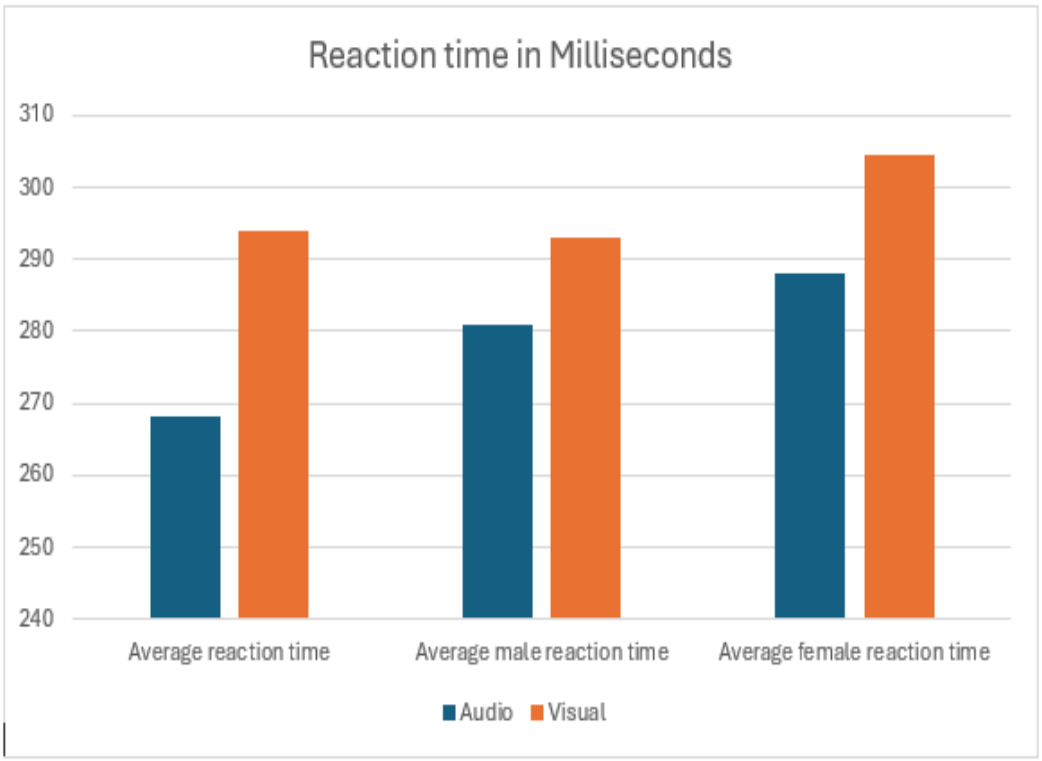

Fig. 2. This single image was altered to point in the four cardinal directions up, down, left, and right

4 DISCUSSION

In the present study, it has been observed that auditory based reaction times are significantly faster than those of just visual. This compared to the results of previous studies indicates a consistent pattern of audio reactions being faster[5, 7]. Additionally, the finding that female reaction times are slightly slower than male reaction times holds true as well [4], though the bias towards males data in our study may very well be playing a part in this particular result. It should also be notes that the visual stimuli aspect of our study focused on objects of different color, and according to an earlier study there is a quantifiable difference in reaction speed depending on the color of the light be used which could be influencing our outcome as the color red is noted as eliciting faster reaction times[1].

5 CONCLUSION

There are significant differences the reaction time of a purely visual system when compared to a visual and auditory one. Further research into the possible confounding variables would be a logical next step, accounting for participant background and further separating the two types of stimuli. Focusing on a solely audible cue rather than one paired with a visual aid tested against a single color visual would help to understand if the color of the visual as well as the compounding stimulus influence reaction speed at all.

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