Analyzing Effects of Time on Human Accuracy to differentiate CGI vs Photographic Portraits

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***Abstract*—The last decade has seen the most remarkable growth in the field of computer-generated imagery. These advances made it easier to create CGI(Computer Generated Imagery) images that highly resemble photographic images. However, despite these advances, the human observer's ability to differentiate the CGI and Photographic images is good. However, we propose that time can affect the accuracy of humans. In this paper, we describe an experiment to validate this claim and analyze the effects of time on human accuracy to differentiate CGI and photographic images. We find that with more time provided to analyze the image, the accuracy of the human participant to differentiate the CGI and photographic image increases.**

***Index Terms*—computer graphics, photo-realistic, photo forensics**

I. Introduction

The advancement in the computer graphic domain has enabled humans to create photo-realistic CGI images. The accuracy of the humans to differentiate the CGI and photographic images is good, but it can be improved with the help of some training[1]. This accuracy can be further pushed by introducing the parameters of incentives and the competitiveness among the humans[2]. The ability of humans to differentiate a CGI and photographic portraits has significant implication in both legal and scientific domain. Humans can be tricked to view morphed CGI images of a person. If the human fails to differentiate it as a CGI image, then it can have significant implications. For example, fake news most often uses the morphed CGI portraits of famous people. Humans inability to differentiate such morphed CGI images of a famous person can have serious consequences.

Since most of the digital content is consumed on mobile devices. It becomes necessary to monitor images and differentiate the morphed images to assure the credibility of the news[3].

But before any automated tools are used to detect these CGI morphed images, it comes down to the human's ability to detect such CGI images and differentiate them from actual photographic images.

While consuming the content on social media, tend to fall prey to the morphed CGI images due to failure at identifying such images.

This paper focuses on finding the minimum amount of time for a human observer to identify a CGI and photographic image with the highest accuracy.

Consider a legal court setting in which an image is used as a piece of evidence. If the judge is shown the image and if that image is morphed CGI images and the judge fails to identify the morphed CGI nature of the image, it can have serious consequence on the result of the legal case.

In term of the scientific front, we must understand how much time the human requires to identify the CGI image which the highest accuracy. It will open new pathways for researchers to understand human accuracy.

We begin by describing the experiment, which will help us analyze how the accuracy of humans to detect the CGI and photographic image changes with time. Next, we present the results of the experiment and then validate our hypothesis.

II. Methods

To conduct the experiment we first gather the set of 60 images, out of which 30 are photographic and 30 are CGI. We utilized the images from the verified source[1]. These images are matched for the brightness and contrast. The participants were asked to participate in this experiment on the voluntary basis. We conducted three experiments, in each experiments we used 20 images out of which 10 are CGI and other 10 are photographic.

A. Selecting Time Quantum

We want to analyze the accuracy of the human at identifying the CGI and photographic images concerning the varying amount of time. Therefore, we decided to test the accuracy of humans at 5 seconds, 10 seconds and 15 seconds.

B. Procedure of Experiment

- First the participant of the experiment was explained what a CGI and photographic images is.
- The participant was then given an answer sheet. The participant must write P in the answer sheet if they think that the image shown to them is a photographic image. Similarly, they have to write C in the answer sheet if they think that the image shown to them is CGI.

- An instructor was keeping an eye on the participant. The instructor has a stopwatch to count to keep the count of the time and change the image displayed to the participant.
- Each participant had to undergo all three experiments.
- The Fig. 1, 2, 3 are the set of images that we used for our experiment.

C. Experiment 1: 5 seconds

In this experiment 20 images were used out of which 10 were CGI and other 10 were photographic images.

- Instructor shows the image to the participant.
- Instructor uses the stopwatch to count how many second the participant gets to view the image.
- In this experiment the participant was asked to view each image for 5 seconds.
- After viewing the image for 5 seconds the participant was asked to write the respective answer of that image on the answer sheet. P if they think its photographic image and C if they think that image shown to them was CGI
- In similarly fashion all the answers of 20 images are recorded on the answer sheet.

D. Experiment 2: 10 seconds

In this experiment, we increased the image viewing time of the participant to 10 seconds. Thus, the participant had to view each image for 10 seconds. The rest of the experiment was done similarly to experiment 1.

E. Experiment 3: 15 seconds

In this experiment, we increase the image viewing time of the participant to 15 seconds. Thus, the participant had to view each image for 15 seconds. The rest of the experiment was done similarly to experiment 1.

III. Results

We evaluated the answer sheet of each participant. We did a separate evaluation of each experiment, consider experiment 1. In this experiment, we calculated the number of images correctly identified out of 20 total images. We the calculated number of photographic images correctly identified our of 10 total photographic images. Similarly, we calculated the number of CGI images correctly identified out of 10 total CGI images. We did a similar type of calculation for experiment 2 and 3.

Below is the Evaluation for the Answer Sheet of the participant in Fig 4

TABLE I: Evaluation of Experiment 1 for Participant in Fig. 4

Experiment 1: 5 seconds		
Total Images(T)	Photographic Images(P)	CGI images(C)
15/20	10/10	5/10

In the similar fashion we calculated the results of Experiment 2 and 3 of the participant in Fig. 4

For each participant in the experiment, we calculated the above tables.

TABLE II: Evaluation of Experiment 2 for Participant in Fig. 4

Experiment 2: 10 seconds		
Total Images(T)	Photographic Images(P)	CGI images(C)
14/20	9/10	5/10

TABLE III: Evaluation of Experiment 3 for Participant in Fig. 4

Experiment 3 : 15 seconds		
Total Images(T)	Photographic Images(P)	CGI images(C)
15/20	7/10	8/10

Now to find more insights from the gathered data. We decided to find the accuracy of the participants.

A. Average Accuracy Calculation

To calculate the average accuracy of participant in a experiment we used the following formulae.

- Average Total Accuracy
  For participant i, Let T_i be the number of images correctly identified out of 20 total images.
  We have total n participants
  i ranges from 0 to n
  Average Total Accuracy = $\frac{\sum_{i=0}^{n} T_i}{n}$
- Average Photographic Accuracy
  For participant i, Let $P_i$be the number of photographic images correctly identified out of 10 total photographic images.
  We have total n participants
  i ranges from 0 to n
  Average Photography Accuracy = $\frac{\sum_{i=0}^{n} P_i}{n}$
- Average CGI Accuracy
  For participant i, Let $C_i$be the number of CGI images correctly identified out of 10 total CGI images.
  We have total n participants
  i ranges from 0 to n
  Average CGI Accuracy = $\frac{\sum_{i=0}^{n} C_i}{n}$

B. Average Accuracy Results

TABLE IV: Average Accuracy Results of Experiment 1: 5 seconds

Experiment 1: 5 seconds		
Avg. Total Accuracy	Avg. Photographic Accuracy	Avg. CGI Accuracy
14.66	8.93	5.73

TABLE V: Percentage Accuracy of Experiment 1: 5 seconds

Experiment 1: 5 seconds		
Avg. Total Accuracy	Avg. Photographic Accuracy	Avg. CGI Accuracy
73.33	89.3	57.3

IV. Hypothesis

We visualized the data obtained from the participants in the form of a bar graph. The graph in Fig 5a) shows the accuracy comparison between the three experiments. Looking at the graph, we can find a few trends.

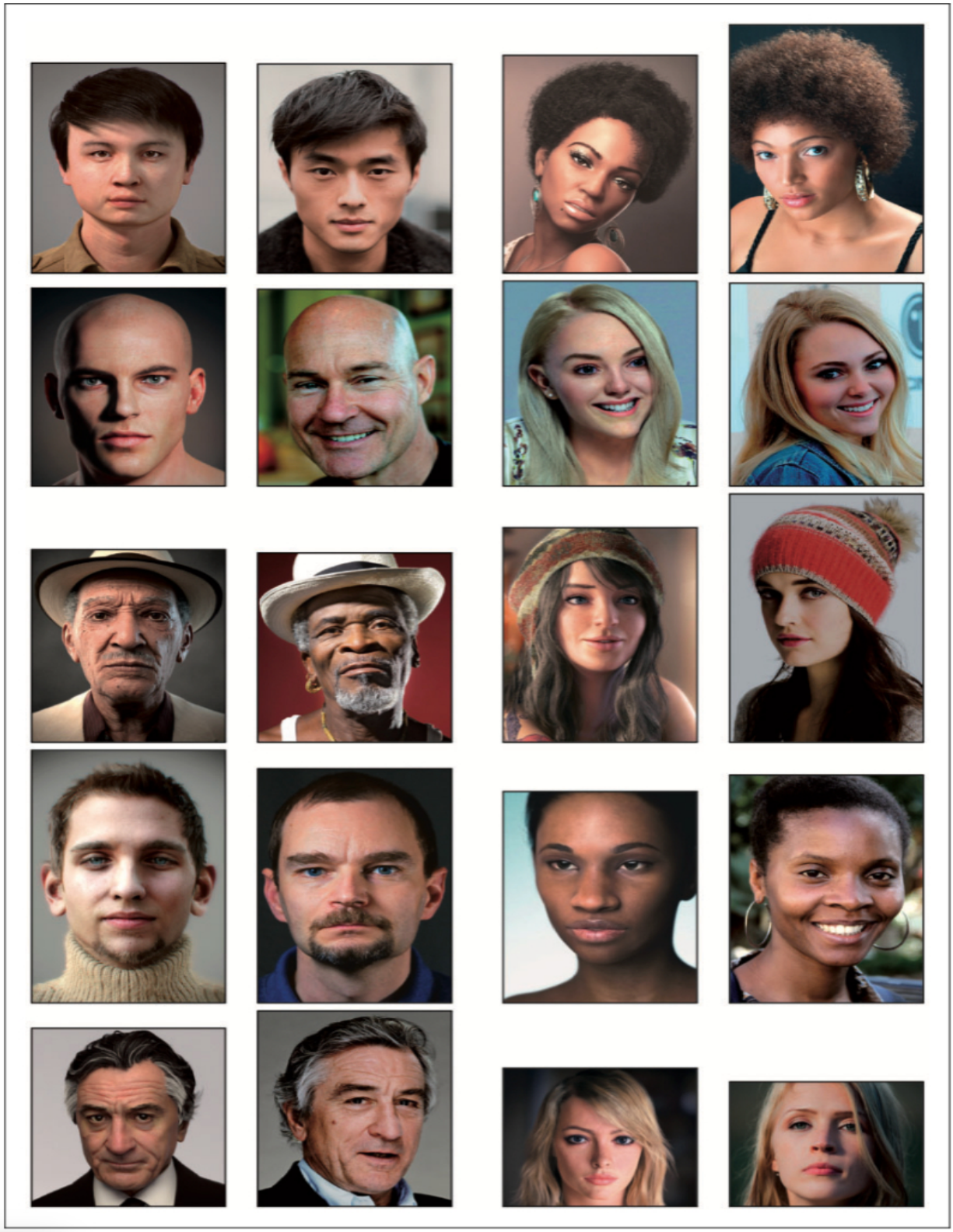


Fig. 1: Computer-generated images (first and third columns) paired with their photographic matches (second and fourth columns).

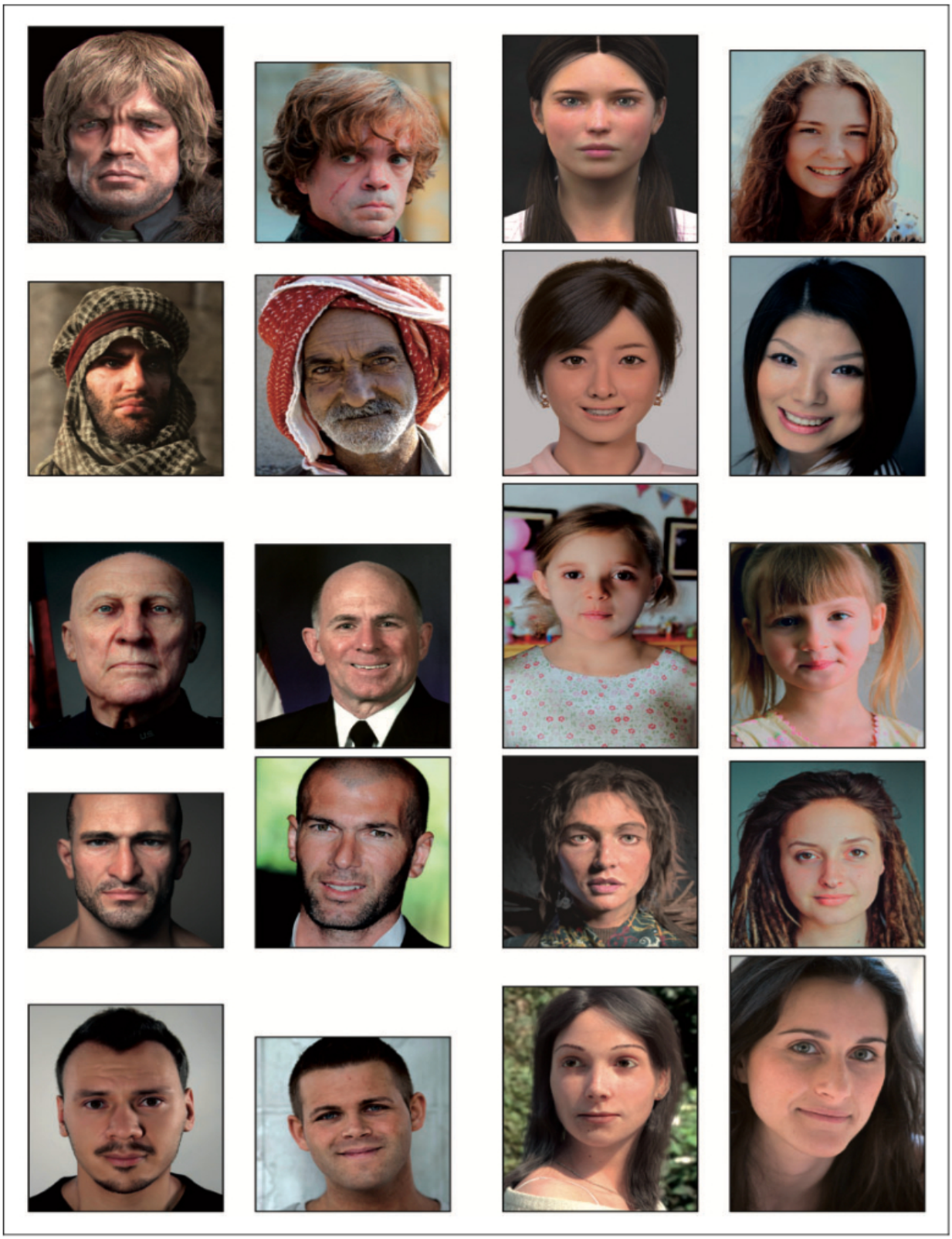


Fig. 2: Computer-generated images (first and third columns) paired with their photographic matches (second and fourth columns).

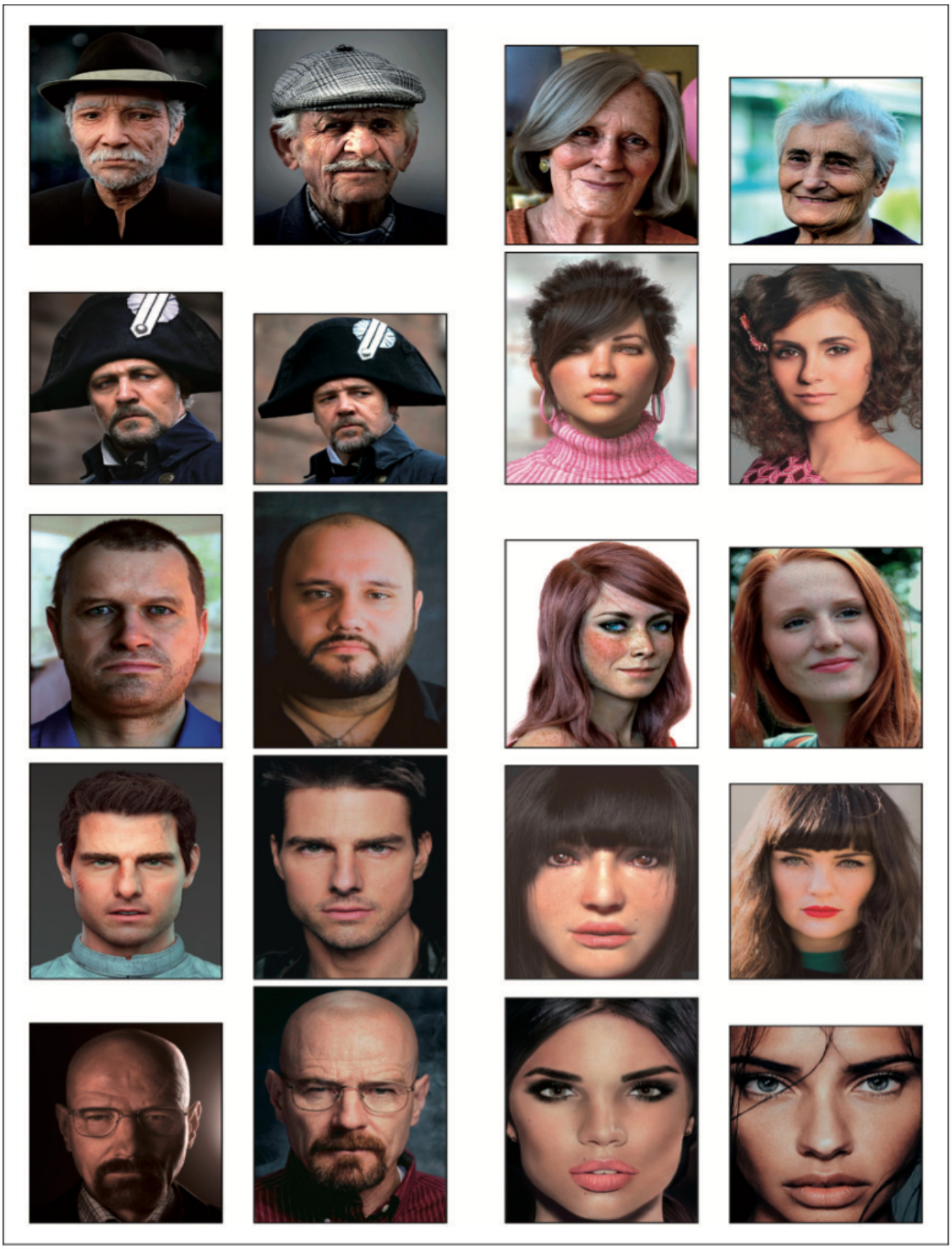


Fig. 3: Computer-generated images (first and third columns) paired with their photographic matches (second and fourth columns).

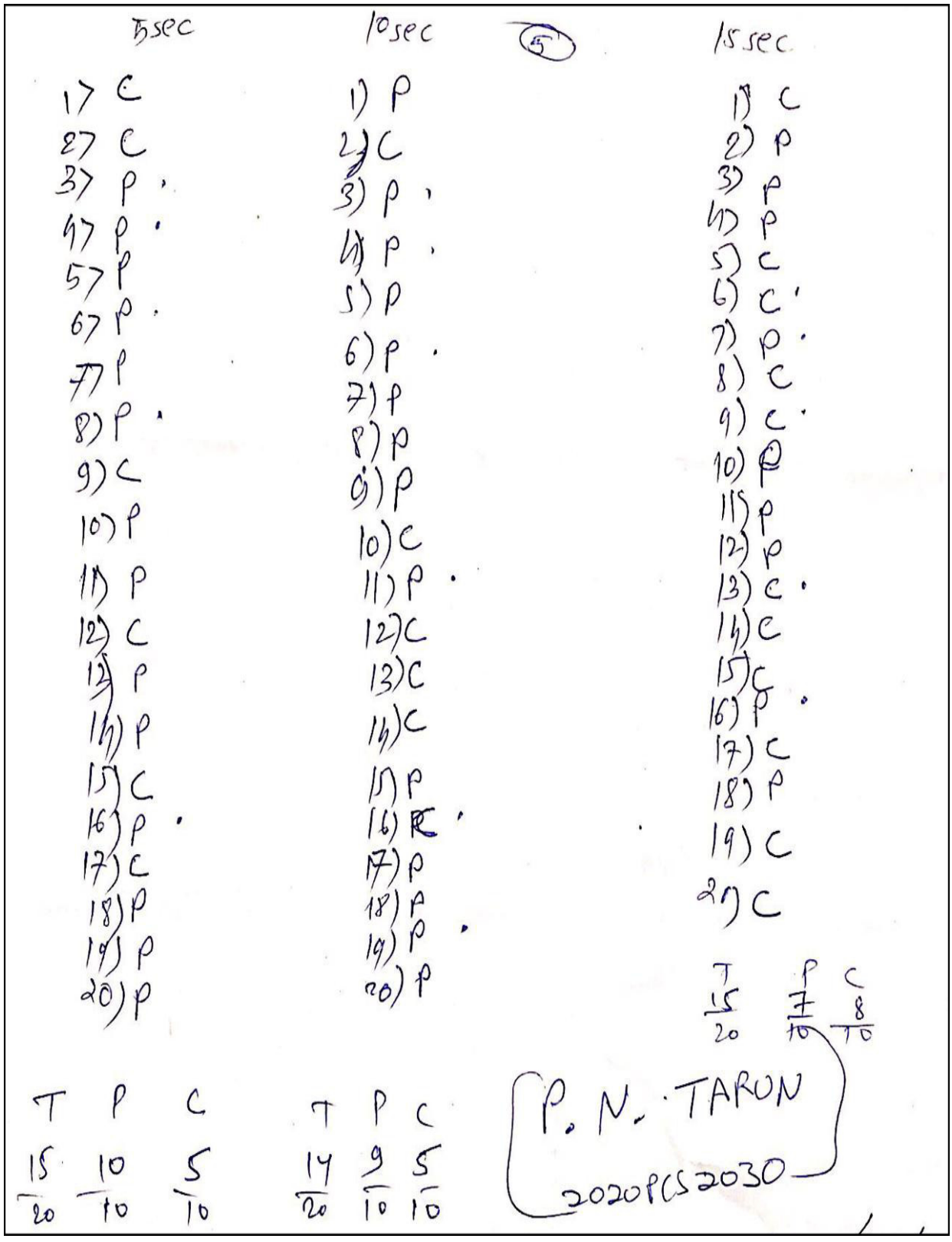
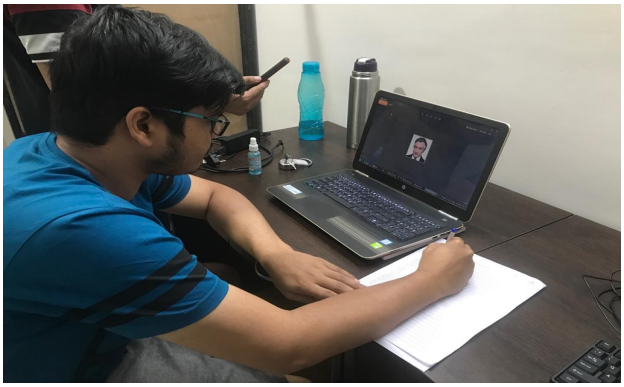


Fig. 4: Answer sheet of participant.

Fig. 5: Graph showing trends in accuracy of participants.



(a) Participant 1

(b) Participant 2

Fig. 6: Participants taking part in experiment.

TABLE VI: Average Accuracy Results of Experiment 2

Experiment 2: 10 seconds		
Avg. Total Accuracy	Avg. Photographic Accuracy	Avg. CGI Accuracy
14.86	8.4	6.4

TABLE VII: Percentage Accuracy of Experiment 2

Experiment 2: 10 seconds		
Avg. Total Accuracy	Avg. Photographic Accuracy	Avg. CGI Accuracy
74.33	84	64

TABLE VIII: Average Accuracy Results of Experiment 3

Experiment 3: 15 seconds		
Avg. Total Accuracy	Avg. Photographic Accuracy	Avg. CGI Accuracy
15.13	7.26	7.86

TABLE IX: Percentage Accuracy of Experiment 3

Experiment 2: 10 seconds		
Avg. Total Accuracy	Avg. Photographic Accuracy	Avg. CGI Accuracy
75.65	72.6	78.6

A. *Hypothesis 1*

The accuracy of differentiating/identifying the CGI and Photographic images of humans can change with time. From the Fig 5b) we see that as there is an upwards trend in increasing accuracy of the participants. Which justifies our hypothesis that the accuracy of the humans to differentiate the CGI and photographic images changes with time.

B. *Hypothesis 2*

There exists a time called IDEAL TIME, defined as follows. IDEAL TIME: The minimum amount of time which is taken by a human observer at which the differentiating accuracy is highest In Fig 5b), we see that the time does increase the participants' accuracy. However, if we look closely, we will see no significant increase in the accuracy at 5second to 10 seconds. On the other hand, we see a higher jump in participants' accuracy during the third experiment. So we can say that humans should see an image for at least 15 seconds to gain their highest accuracy. So the IDEAL time is 15 sec.

V. Observations

- In the graph Fig 5b) we see that there is an increase in accuracy of the participants with the increase in time. We can say that when humans are allowed to analyze an image for more time, they tend to achieve higher accuracy in identifying CGI and photographic images. The minimum time the humans should view an image to perform with higher accuracy is 15 seconds.
- In the graph Fig 5c) we see that accuracy of detecting photographic images is decreasing; this is happening because the participant earlier has bias towards photographic images. However, as the experiment progresses, they get more time to analyze the images, and their bias towards the photographic images gets reduced.
- In the graph Fig 5d) we find a rapid increase in the detection of the CGI images when more time is provided. We see that the participant's accuracy increases with more time when identifying the CGI images. As participants get more familiar with the CGI images, their accuracy increases with time.

VI. Participant Feedback

After the completion of the experiments we asked the participants following three questions.

- How did you differentiate/identify the CGI or photographic image?
  - Participants said that to identify the CGI images, they looked at facial features such as eyes, skin tone, symmetry of the face. To identify the photographic images, they looked for the imperfections in the photos and facial marks or scars.
- Which images where difficult to identify ?
  - According to most participants it is difficult to identify a CGI image of old people.
- Does having more time to analyze the images help?
  - We had received mixed opinion for this question. While most participants said they benefited from the

more time, it allowed them to analyze the image in detail. On the other hand, some participants said they depended on their natural instinct to identify the images. For such participants, 2-3 seconds was enough to form an opinion about an image. Those participants who took were forming an opinion in just 2-3 seconds performed poorly since some images needed meticulous analysis.

VII. Discussion

We did the first of its kind experiment to analyze the effects of time on human accuracy to identify CGI and computer-generated images. With the data we gained, we can firmly conclude that humans cannot differentiate CGI and photographic images in 5 seconds or 10 seconds with higher accuracy. For humans to perform at higher accuracy, they need to spend at least 15 seconds on an image to identify whether CGI or photographic. We believe that humans should critically analyze the image when dealing with essential images and take more time. The experiments proved our hypothesis to be accurate, which states that time affects human's accuracy. Also, the hypothesis of IDEA time holds at 15 seconds. In this paper, we successfully defended our hypothesis and showed our finding via graph. Our experiments also show that humans have a bias toward photographic images. In the coming years, human accuracy will be challenged as computer graphic technology keeps advancing.

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