

# Effects of Age Groups and Distortion Types on Text-Based CAPTCHA Tasks

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**Abstract.** Completely Automatic Public Turning test to tell Computers and Humans Apart, or CAPTCHA, is a security measure that guards a system from exploitation by the discrimination between a real human being and an automated computer program via the method of presenting to the unknown user the challenges that are hard for computer yet easy for human. Focusing on text-based CAPTCHA, this study conducted an experiment to study the effect of age groups and distortion types on the CAPTCHA task. Twenty-four participants were recruited to take part in the experiment, where twelve of them were in the senior group and twelve in the young group. Participants were observed to use three general steps: recognition, rehearsal, and motor response. With the inevitability of the security measure and the increasing population of senior netizens, this study has important implications for the design of CAPTCHA systems.

**Keywords:** CAPTCHA; age group; distortion.

## 1 Introduction

CAPTCHA, the acronym of “Completely Automatic Public Turning test to tell Computers and Humans Apart”, is a security measures that guards internet services against automated exploitations with abusive purposes [1]. The merit of a CAPTCHA system lies in the system’s capability to tell whether the user in question is a real human being or a robot program. A CAPTCHA process typically involves a session in which computer-generated questions are presented to users whose true identities are unknown to the system. Based upon the answers replied by the users, the CAPTCHA system determines whether the user in question is a human or not. To effectively tell computers and humans apart, the proposed questions have to be hard for computer to solve, yet easy for human to answer [2].

Among the techniques of breaking text-based CAPTCHA protection mechanism, Optical Character Recognition (OCR) programs is one of the commonly deployed

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methods to defeat the protection [3]. Generally, OCR programs recognize characters contained in an image via three steps [4]: (1) pre-processing of the image to make the image suitable for further processing, (2) segmenting the image into regions in which each region contains only one character, and (3) identifying the character in each region. To lower the success rate of character recognition by the OCR programs, CAPTCHA systems usually distort the images in certain ways to complicate the steps OCR programs typically employ. For example, a CAPTCHA system may warp the image or add extra elements (such as lines of various slopes, or circles of various radii) to counter the attacks of OCR programs. With the distortion, however, CAPTCHA questions may become difficult to solve even for human being, which may stress the user's cognitive system and vision system, and make a potential customer walk away [2, 5].

## 2 Method

Two groups of participants were recruited to take part in the experiment. The twelve participants in the senior group were between 50 to 56 years old with an average of 53.2 years, while the other twelve in the young group were between 23 to 24 years old with an average of 23.6 years. All participants had normal or corrected to normal visual acuity, and had normal color vision.

The experiment was a two-by-six mixed factorial design in which the two factors were age group (encoded as AGE) and CAPTCHA type (encoded as TYPE). The factor AGE was a between-subject factor with two levels, young and senior groups. The factor TYPE was a within-subject factor with six levels, each representing a kind of common CAPTCHA distortion.

The experiment was conducted by one experimenter in the settings mentioned above. A consent form with brief description of the study was given to each participant before the experiment could begin. Once the form was signed, the experimenter introduced the procedure to the participant and helped the participant familiarize oneself with the tasks involved. As described before, a participant had to finish six sessions to conclude an experiment. The first session was always the reference type (Type I), while the types of the latter five sessions were randomly determined for each participant. The participant could practice the kind of CAPTCHA stimuli in a practice session before a formal session began. Stimuli used in the practice and formal sessions underwent the same kind of distortion, but the texts of the two were different.

## 3 Results

Table 1 summarizes the means and standard deviations (enclosed in parentheses) of the dependent variables for distortion types and age groups (senior and young). The results of non-parametric analysis of the data revealed that the participants of two age groups differed significantly in terms of response time, error rate, and NASA-TLX score. Distortion type had significant effect on response time, error rate, CFF (Critical flicker fusion), and NASA-TLX score. Post-hoc analysis showed that Blot Mask and Line Mask were the hardest CAPTCHAs, while Thread Noise, Global Warp, and Geometry

Noise were on a par with Normal Type (no distortion). Dependent variables were also correlated to each other.

**Table 1.** Descriptive statistics of the dependent variables by types and age groups

Mean (SD)		Response time in ms	Error rate	CFF in Hz	NASA-TLX score
Normal	Senior	6694.56 (3177.19)	0.04 (0.04)	0.67 (0.69)	16.25 (2.14)
Text	Young	2755.03 (1131.92)	0.02 (0.03)	0.46 (0.4)	14.75 (3.49)
Blot	Senior	9960.46 (3645.76)	0.13 (0.06)	2.38 (0.61)	19.67 (2.31)
Mask	Young	4664.66 (1366.68)	0.07 (0.04)	2 (0.52)	17.25 (2.8)
Line	Senior	11974.85 (4385.73)	0.22 (0.06)	2.67 (0.39)	20.67 (2.02)
Mask	Young	6733.49 (2348.31)	0.23 (0.08)	2.63 (0.8)	19.08 (2.75)
Thread	Senior	6158.93 (2626.14)	0.05 (0.02)	1.29 (0.69)	16.92 (2.11)
Noise	Young	3072.86 (1358.78)	0.04 (0.03)	1 (0.74)	15.25 (3.05)
Global	Senior	6261.75 (2394.85)	0.06 (0.04)	1.54 (0.4)	17.25 (2.22)
Warp	Young	2707.77 (962.26)	0.02 (0.01)	1.33 (0.49)	14.92 (2.87)
Geometry	Senior	6104.62 (2082.41)	0.05 (0.04)	1.21 (0.58)	17.17 (2.69)
Noise	Young	2692.46 (1167.67)	0.01 (0.01)	0.96 (0.62)	14.83 (2.72)

## 4 Discussion and Conclusion

The results of the present study verified that participants of different age groups differ significantly in terms of response time, error rate, visual fatigue, and workload. In addition, some types of CAPTCHA design have significant impacts on the dependent variables. When designing a CAPTCHA system, one should take into account the basic steps users take during the interaction with such system. A CAPTCHA system may be so designed that the recognition step is as easy as an undistorted one for human users. Yet, not only distortion technique, but also the character set, that can impact the recognition and the rehearsal steps.

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