

EXPLORING THE INFLUENCE OF DEMOGRAPHIC FACTORS ON THE IMAGE-BASED CAPTCHAS

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Abstract

As information security is perceived as an important and vital aspect of the survival of any type of e-business, CAPTCHA tests (Completely Automated Public test to Tell Computers and Humans Apart), as such, are an indispensable element of any e-business software that requires identification of Internet users. CAPTCHA represents security measures applied to the Internet in order to prevent malicious automated programs. Turing test or CAPTCHA should be as easy as possible for humans, regardless of the personal characteristics of the respondents, and almost impossible for bots. Within this research was analyzed five different types of CAPTCHA tests. The aim of this paper is to examine whether there is a statistically significant difference between the answers of the respondents according to the next demographic characteristics: age, the level of education, and the experience in using the Internet. The experiment included 100 Internet users, that used a smartphone to solve different CAPTCHAs tests. The obtained results were statistically processed using software SPSS v.20.0. The obtained results can be useful for CAPTCHA designers and web administrators when making a plan for implementing this type of security mechanism.

Keywords: image-based CAPTCHAs, influence, internet users, demographic factors

INTRODUCTION

CAPTCHA as a security measure guards internet services against automated abuse from computer programs. This method prevents spam or bots. Also, using this artificial intelligence mechanism can prevent fake comments on posts, fake email addresses, or fake transactions and logins [1]. Many business models on the Internet only make sense if they are used by real users, and not special software designed to speed up a process, automatic exploitation, and the like. When using the CAPTCHA test the goal is to apart computers from humans, the proposed test should be hard for a computer to solve, yet easy for a human to answer. CAPTCHA system has the capability to tell whether the user is a robot program or a real human being [2].

On the market are exist different CAPTCHA tests have been and such as picture labeling, text recognition, object identification, speech recognition, or puzzle-solving [3], [4]. However, the usability of any existing type of

CAPTCHAs is far from satisfactory, because human users usually have to face boring and time-consuming engagement [5], [6]. Therefore, the aim of this paper is to examine whether different demographic factors of Internet users influence the response time to find a solution for the five different images-based CAPTCHAs. Accordingly, the obtained results can help web designers and administrators in defining the application of the adequate type of CAPTCHA. This is especially important for specific types of internet businesses that are closely related to a specific target group of end-users.

The rest of the paper is organized in the following way. Section 2 is based on the theoretical background of relevant scientific literature based on which research hypotheses are defined. Next, Section 3 represents the applied methodology. After that, Section 4 is focused on the discussion of obtained results, and finally, the last Section 5 is presented conclusion with recommendations and limitations of the research.

THEORETICAL FRAMEWORK AND DEFINITION OF HYPOTHESES

There are numerous articles in the literature that explore the concept of CAPTCHA tests [7]. Most of them deal with testing different types of CAPTCHA tests, as well as research on the usefulness and safety of tests [3], [8]. Image-based CAPTCHA tests require recognition and selection of images with a similar or an exceptional meaning, out of a sequence of images and may cause confusion, as the images can sometimes be interpreted as having different meanings [5], [8]. The usability of the text-based type of CAPTCHA was considered in terms of response time to find a solution for the with text and with number types of CAPTCHA [9]. This analyze is included multiple features, like age, number of years of Internet use, education level, response time in solving a text-based CAPTCHA, and response time in solving text-number-based CAPTCHA [9]. The differences between various CAPTCHA tests and examine how they affect user experience among populations with and without learning disabilities were investigated [10].

By analyzing the relevant scientific literature, the authors found that there is a literature gap, ie lack of research that analyzes the impact of demographic characteristics of respondents at the time of solving CAPTCHAs tests, which was the main motive for defining hypotheses and analyzing them. Based on that fact it was proposed the next hypotheses.

H1: *It is observed a significant difference in the response time of respondents during solving CAPTCHA tests according to the age groups of respondents.*

H2: *It is observed a significant difference in the response time of respondents during solving CAPTCHA tests according to the level of education of respondents.*

H3: *It is observed a significant difference in the response time of respondents during solving CAPTCHA tests in relation to the experience in a time of Internet use.*

METHODOLOGY

Focusing on image-based CAPTCHA, this study conducted an experiment to study the effect of age groups, educations, and experience in using the Internet on the CAPTCHA tests. 100 Internet users were

recruited to take part in the experiment, where 44 of them were in the young group (aged 18-30), 43 of them were in the middle group (aged 31-40), and 13 in the older group (above 41 years). When is a word about the level of education 41 users have finished high school, 6 users have finished higher school, 53 has finished faculty, and 6 respondents are finished MSc. The last analyzed demographic factor in the research is the time experience in using the Internet. Up to 5 years of experience have 20 respondents, between 6-10 years have 71 participants, and more than 11 years have only 9 participants. The analysis included evaluations of five different types of image-based CAPTCHA: *Picture of the CAPTCHA*, *Animated character*, *Face of an old woman*, *Surprised face*, and *A worried face*. For testing defined hypotheses the one-way analysis of variance (ANOVA) was used to determine whether there are statistically significant differences between the response of Internet users and used image-based CAPTCHAs [11]. The software package SPSS v. 20 was used for testing defined hypotheses.

DISCUSION OF THE RESULTS

The results of the present study verified that Internet users in terms of the response time of CAPTCHA have differed significantly according to age groups, levels of education, and experience in using the Internet. The obtained results of the first analyzed hypothesis are depicted in Table 1.

Table 1. Influence of years of age of the respondents on the time of solving CAPTCHA tests

CAPTCHA test	Years of age	N	Mean	Std. Deviation	Sig.
<i>Picture of the CAPTCHA</i>	18-30	44	2.32	1.325	0.079
	31-40	43	1.93	1.183	
	>41	13	2.84	1.724	
<i>Animated character</i>	18-30	44	1.38	0.689	0.003
	31-40	43	1.12	0.391	
	>41	13	1.92	1.441	
<i>Face of an old woman</i>	18-30	44	1.27	0.659	0.008
	31-40	43	1.34	0.841	
	>41	13	2.15	1.573	
<i>Surprised face</i>	18-30	44	1.54	1.044	0.029
	31-40	43	1.63	1.001	
	>41	13	2.46	1.506	
<i>A worried face</i>	18-30	44	1.91	1.197	0.600
	31-40	43	1.76	1.192	
	> 41	13	2.15	1.463	

Based on the results presented in Table 1, there is a statistically significant difference in the CAPTCHA tests - *Animated character* ($p=0.003$), *Face of an old woman* (0.008), and *Surprised face* (0.029), while this is not the case with tests (*Picture of the CAPTCHA* and *A worried face*).

The results show that the CAPTCHA test - *Animated character* there is statistical significance, where $p=0.003$ which is less than the recommended value ($p<0.05$). The statistical significance here shows that the influence of age on the response time of solving the CAPTCHA test is not the result of a random sample, but is statistically justified. Based on the arithmetic means, it can be concluded that this type of CAPTCHA was answered the fastest by the respondents between 31-40 years (1.12 sec). Respondents between 18 and 30 needed slightly longer response time (1.38 sec), while the older group of respondents above 41 answered the slowest (1.92 sec). As the obtained results show that the respondents belonging to the middle age group of respondents solve the CAPTCHA *Animated character* the fastest, it can justify them by the fact that this group of respondents most often accesses orders that are protected by this type of protection (Internet trade, Internet banking, E-mail, and other forms of electronic business).

Then, there is the statistical significance of the CAPTCHA test - *Face of an old woman*, where $p=0.008$ is less than the recommended value ($p<0.05$). In this case, according to the comparison of arithmetic means, the fastest to solve this CAPTCHA test were the respondents aged between 18-30 years (1.27 sec). Then, the respondents who are between 31-40 years old (1.34 sec), which is not significantly different from the previous group of respondents, while in this case the slowest decision was made by the oldest respondents over 41. As the results were shown, the respondents who belong to the youngest group solved this type of the CAPTCHA test the fastest, hence we can connect this result with faster reactions and better perception of younger respondents compared to older ones, and it is logical to conclude that younger respondents solve faster these types of tests.

In addition to the mentioned types of CAPTCHAs, statistical significance also exists

when solving the CAPTCHA test - *Surprised face*, where $p=0.029$ is less than the recommended value ($p<0.05$). As in the previous case, the comparison of arithmetic means leads to the conclusion that the youngest age group of respondents solved this CAPTCHA test the fastest. Thus, respondents aged 18-30 solved the test at an average of 1.54 sec. It took the most time for respondents aged over 41 (2.46 sec). Based on the obtained results, it can be concluded that respondents who belong to the younger and middle age group, relatively quickly solve CAPTCHA tests, therefore, have a greater impact on the response time due to their better perception and resourcefulness, and experience in using the Internet in everyday life.

Based on all obtained facts, it was determined that there is a statistically significant difference in the response time of solving CAPTCHA tests in three types of CAPTCHA tests in relation to the age of the respondents, thereby confirming the hypothesis H1.

In Table 2 depicted results of the analysis of the impact of the level of education of the respondents on the time of solving CAPTCHA tests.

Table 2. Influence of level of education of the respondents on the time of solving CAPTCHA tests.

CAPTCHA test	Level of education	N	Mean	Std. Deviation	Sig.
<i>Picture of the CAPTCHA</i>	High school	41	2.61	1.531	0.081
	Higher school	6	1.83	0.983	
	BSc	47	2.02	1.188	
	MSc	6	1.50	0.836	
<i>Animated character</i>	High school	41	1.46	0.924	0.332
	Higher school	6	1.00	0.000	
	BSc	47	1.32	0.694	
<i>Face of an old woman</i>	MSc	6	1.00	0.000	0.012
	High school	41	1.78	1.235	
	Higher school	6	1.16	0.408	
	BSc	47	1.14	0.509	
<i>Surprised face</i>	MSc	6	1.33	0.816	0.115
	High school	41	2.02	1.369	
	Higher school	6	1.33	0.516	
	BSc	47	1.48	0.905	
<i>A worried face</i>	MSc	6	1.50	0.836	0.026
	High school	41	2.14	1.256	
	Higher school	6	2.83	1.602	
	BSc	47	1.55	1.099	
	MSc	6	1.66	0.816	

According to the obtained results of the ANOVA test, there is a statistically significant difference in the CAPTCHA tests - *Face of an old woman* and *A worried face*. Since another CAPTCHA test did not show statistical significance ($p > 0.05$), they are the result of a random sample and there will be no analyzed in the following.

In the CAPTCHA test - *Face of an old woman*, there is statistical significance between the examined variables, where $p = 0.012$ is less than the recommended value ($p < 0.05$), and indicates that there is a difference in the answers of the respondents in relation to their level of education. By comparing arithmetic means, the greatest influence on the response time has respondents with a BSc (1.14 sec), followed by respondents with a Higher school (1.16 sec). Respondents with the MSc solved slower than the previous two groups of respondents (1.33 sec), while respondents with High school solved the slowest (1.78 sec). As the number of respondents is only 6 respondents with an MSc degree, we will take their results with a grain of salt, because they are not representative. However, when we consider only respondents with High and Higher education, it notices that respondents with Higher education solve CAPTCHA tests faster. Given that respondents with a BSc degree have a wider interdisciplinary knowledge base on digital technologies and are familiar with the term CAPTCHA, the results are not surprising.

Also, the results of the ANOVA test from Table 2 show that there is statistical significance in the CAPTCHA test - *A worried face*, where $p = 0.026$ is less than the recommended value ($p < 0.05$). As in the previous case, we will ignore the results of respondents with an MSc education, since they are not representative due to the small number of respondents. The greatest influence on the response time, by comparing the arithmetic means, had the respondents with BSc education who solved the fastest the CAPTCHA test - *A worried face* (1.55 sec). The respondents who finished Higher school were solved this test slower (2.83 sec) than the respondents with High school (2.14 sec), which confirms the previous assumptions.

Based on the previous considerations, it can conclude that hypothesis H2 was confirmed. Table 3 shows the results of the ANOVA test, which analyzes the influence of the length of Internet use on the time of solving CAPTCHA tests.

Table 3. Influence of years of experience of respondents in using the Internet on the time of solving CAPTCHA tests

CAPTCHA test	Years of experience	N	Mean	Std. Deviation	Sig.
<i>Picture of the CAPTCHA</i>	Up to 5	20	2.85	1.565	0.050
	6-10	71	2.09	1.289	
	Over 11	9	1.77	0.833	
<i>Animated character</i>	Up to 5	20	1.75	1.208	0.016
	6-10	71	1.26	0.608	
	Over 11	9	1.00	0.000	
<i>Face of an old woman</i>	Up to 5	20	2.10	1.293	0.001
	6-10	71	1.25	0.750	
	Over 11	9	1.22	0.666	
<i>Surprised face</i>	Up to 5	20	2.35	1.460	0.012
	6-10	71	1.56	1.010	
	Over 11	9	1.33	0.500	
<i>A worried face</i>	Up to 5	20	2.50	1.317	0.016
	6-10	71	1.78	1.206	
	Over 11	9	1.22	0.440	

Based on the obtained results, it can be concluded that statistical significance was determined in all five analyzed CAPTCHA tests according to the length of Internet use. The results of the ANOVA test shown in Table 3 indicate that statistical significance exists in the CAPTCHA test - *Picture of the CAPTCHA*, where $p = 0.050$. This type of CAPTCHA test the fastest was solved by respondents who used the Internet for more than 11 years (1.77 sec), followed by respondents who used the Internet in the interval between 6-10 years (2.09 sec). While the most time for solving this CAPTCHA test was needed to respondents who have been using the Internet for less than 5 years (2.85 sec).

There is a statistically significant difference in the CAPTCHA test *Animated character* where $p = 0.016$ ($p < 0.05$), which indicates that there is a difference in the answers of the respondents in relation to the length of Internet use. Based on arithmetic means, it can be noticed that respondents with more than 11 years of experience in using the Internet solve this type of CAPTCHA test the fastest (1.00

sec), on the other hand, respondents with the experience less than 5 years need more time to solve this test (2.85).

Additionally, the difference in the answers of the respondents also can be noticed in CAPTCHA's Face of an old woman, where $p=0.001$ ($p<0.05$). By comparing the arithmetic means, it can be noticed that the CAPTCHA test is solved by two groups of subjects at approximately the same time, that is respondents who use the Internet between 6-10 years (1.25 sec) and respondents who use the Internet for more than 11 years (1.22 sec). On the other hand, respondents with less than 5 years of experience needed 2.10 second to solve this test.

The results of the ANOVA test show that statistical significance also exist in the CAPTCHA test - Surprised face, where $p=0.012$ ($p<0.05$). This type of CAPTCHA test was solved the fastest by respondents who used the Internet for more than 11 years (1.33 sec), followed by respondents who used the Internet between 6-10 years (1.56 sec). The most time to solve this test was needed by respondents who have been using the Internet for less than 5 years (2.35 sec).

Also, a statistically significant difference was shown in the CAPTCHA test - A worried face, where $p=0.016$ ($p<0.05$). The respondents with more experience in using the Internet needed less time to solve this test (1.22 sec), while the respondents with less experience (up to 5 years) were needed more time to solve this test (2.50 sec).

Considering the obtained results, it can be concluded that respondents who have more years of experience in using the Internet solve the analyzed CAPTCHA tests faster than respondents who have less experience in using the Internet, which confirms hypothesis H3.

CONCLUSION

CAPTCHA is now almost a standard security technology, and has found widespread application in commercial websites. To counter the automated attacks of computer programs, very often the security of the CAPTCHA test relies on image distortion techniques and the use of non-words to test the fact whether the remote user is a human or the computer user.

In this research, the ANOVA test was used with a 95% confidence interval to test all considered hypotheses [11]. The obtained results showed that exists a significant difference between the time of solving CAPTCHA tests according to the age of respondents, level of educations of respondents, and experience in using the Internet, which indicates that all tested hypotheses in the research are statistically significant and accepted. The contribution of this study is reflected through an innovative approach to the analysis of demographic parameters that affect the response time of image-based CAPTCHAs, which contributes to a better understanding of the usefulness of CAPTCHA tests from the point of view of end-users [10].

The distinction between the demographic characteristics of the users of CAPTCHAs in this study provides useful implications for future CAPTCHA designs. As pointed out in the Discussion, researchers found that respondents who longer use the Internet easier to solve different CAPTCHA tests as opposed to respondents who have less experience. Because of the importance of image-based CAPTCHAs in securing websites and services, challenges to their security posed by advances in machine learning algorithms need to be further investigated in some next research.

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