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Efficiency of Printing Technologies of Graphically Protected Materials

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Abstract:

This paper attempts to make a hierarchical assessment of graphic protection in order to enhance its use. It was established that the most common types of approved protection are also the best known ones and that their implementation enhances protection efficiency on products which are often counterfeit. Printing offices, publishers and design authors will protect their high demand products which are subject to counterfeiting by optimizing printing technology, implementation expenses and efficiency of the protection system. By means of a system of questioning and data processing, we created a scale of values of protective graphic technologies, inks and graphic materials. A survey showed that a large number of examinees believes in the possibility of counterfeit ballot papers and a hypothesis was tested which proved that 95% of citizens think that protective graphic techniques should be used to prevent the counterfeiting of ballot papers. We therefore recommend the individualization of ballot papers and the implementation of invisible graphics. It has been proved that citizens would have more confidence in the democratic elections if guaranteed the protection of ballot papers, which would finally result in the increased number of turnouts.

Keywords:

Security Printing, Protective Graphic Technologies, Infrared Ink, Ballot Papers

1. Introduction

The implementation of contemporary advanced technologies is mostly visible when producing security documents. Safety features are also introduced with other products like admission tickets, tickets for the games of chance, member cards, packaging and all sorts of labels. The aim of this survey is to route product technology protection towards the types of graphic protection that are known, recognizable and acceptable to users.

Contemporary graphic technology selectively introduces protective elements on different securities and documents and at the same time expects performance and efficiency of protective elements on graphic products. In some cases it is necessary to implement protection while in others this may not be the case. Graphic protection used on securities is widely used. It is therefore necessary to broaden the discussion about graphic technology so that graphic protection could become more purposeful. Knowledge that people have about graphic protection should be a guideline to the graphic profession when defining the levels of its implementation. At the same time, graphic protection which is best known to people or which they trust should be implemented in most cases while those that are less known should be used rarely.

An analysis displaying a level of counterfeit awareness and knowledge of graphic protection on print products of specific purpose has also been conducted. The result of the research is an objectively examined opinion of the chosen population group which provides quality foundation for short-term and long-term changes in the implementation of graphic protection. The understanding of graphic protection, as well as its implementation was also examined in certain groups (of experts, medium acquainted to non-expert), which always precedes graphic interpretations of usual inks, paper, print and printing machines.

Citizens are more cautious as they are informed through media on an everyday basis of criminal actions involving false banknotes, documents and all sorts of identifications (Figure 1).

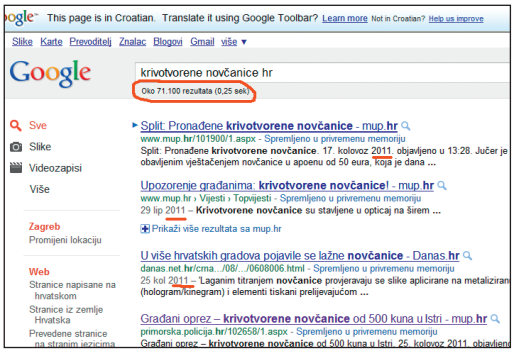

Figure 1. Google search

2. Analysis and results

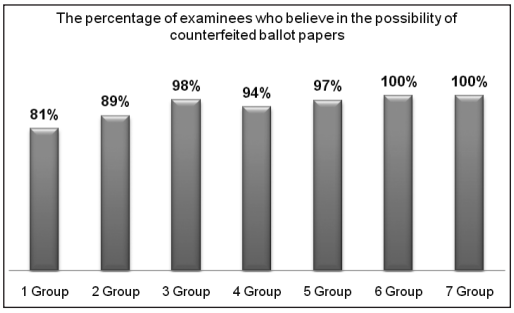

Figure 2. Shows the percentage of examinees who believe in the possibility of counterfeited ballot papers.

It could be concluded that a large number of examinees (>90%) believes in the possibility that printed ballot papers have been counterfeited (Figure 2). The possibility of counterfeiting ballot papers exists because they are printed in black colour with serial numbers as the only means of protection. Ballot papers have serial numbers from number 1 to the last number of the total of ballot papers. A certain amount of ballot papers is defined with serial numbers for every city and county. This enables an effective movement control of printed ballot papers during their distribution to the polling stations. During voting voters are unable to see the serial number of the ballot paper. The members of the elective committee are obliged to distribute the ballot papers to voters facing them down. By means of a Z-test for proportions of equal parts among mentioned groups were examined according to examinees' answers on whether or not they believe in the possibility of counterfeited ballot papers. The conducted test determined a level of significance of *0,95*. Tested hypothesis were:

The null hypothesis:
(Groups have equal answer proportions)

$$H_o : p_i = p_j$$

Alternative hypothesis:
(Groups have different answer proportions)

$$H_a : p_i \neq p_j$$

$i,j = 1,\ldots,7$

Test statistic for empirical z-proportion is:

$$z = \frac{\hat{p}_i - \hat{p}_j}{\sigma_{\hat{p}_i - \hat{p}_j}}$$

Test results are shown in table 1.

With the given level of significance, the answer YES means that the hypothesis that specimens were chosen from equally basic sets is accepted. The answer NO signifies the rejection of the null hypothesis. It is evident that the results from other groups are different from the results of the basic group. Differences in shares are relatively small.

By merging the groups we get a specimen value $n = 521$ (Table 2).

We are testing the hypothesis of the proportion of examinee sets. Appointed hypothesis are:

The null hypothesis: $H_o : p \geq 0.90$

The alternative hypothesis: $H_a : p < 0.90$

The empirical test statistic is determined by the formula:

$$z = \frac{\hat{p} - \hat{p}_0}{\sigma_{\hat{p}}}$$

Test value is $z = 0.599$ Critical value that separates the area of accepting null hypothesis from the area of rejecting the null hypothesis is $z_{0.05} = -1,65$.

Empirical z–proportion is higher than the lower theoretical (critical) value, i.e.

$$z_{0.05} = -1,65 < 0,0599$$

The null hypothesis is therefore accepted at the given level of significance. We have determined that, with the given level of significance, more than *90%* of citizens believe in the possibility of counterfeiting ballot papers. These figures impose on the graphic profession the important task of creating, respectively choosing and applying a more efficient protection of all kinds of securities and documents with a specific purpose which are widely used.

A very high percentage of examinees believe that graphic protection should be approved in order to prevent any counterfeiting of ballot papers. (Figure 3).

Two sample z-proportion tests investigate the equality of proportions among mentioned, according to the answers of examinees when asked whether they would approve the

Table 1. Results for Z-proportion test on equal parts among groups of examinees according to the percentage of positive answers when it comes to believing in the possibility of counterfeited ballot papers

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7
Group 1	-	YES	NO	NO	NO	NO	NO
Group 2	YES	-	NO	YES	NO	NO	NO
Group 3	NO	NO	-	YES	YES	YES	YES
Group 4	NO	YES	YES	-	YES	NO	NO
Group 5	NO	NO	YES	YES	-	YES	YES
Group 6	NO	NO	YES	NO	YES	-	YES
Group 7	NO	NO	YES	NO	YES	YES	-

Table 2. Group answers to the question: Do you believe in the possibility of counterfeiting printed ballot papers?

	Yes	No
Total	473	48
In percentages	0,91	0.09

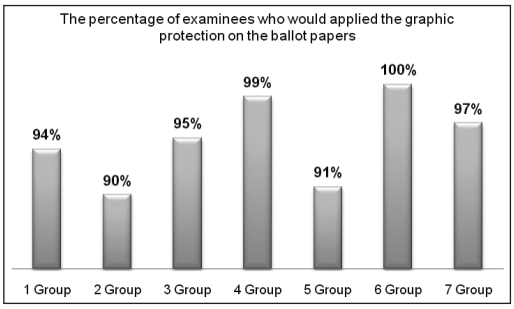

Figure 3. Depiction of percentages of positive answers per groups for application of techniques of graphical protection that would prevent all kinds of counterfeiting of ballot papers.

implementation of graphic protection techniques which would prevent the counterfeits of ballot papers. The investigation was conducted with the significance of *0,95*. The Z-test was conducted with a level of significance *0,95* for all possible combinations for all groups.

Results of other groups do not differ significantly from the results of the control group, nor do most groups significantly differ between themselves according to the answers to most questions.

Conducted hypothesis showed that 95% of citizens believe in the approval of implementation of graphic technology techniques which should prevent any kind of ballot paper counterfeiting.

By merging the groups we get a set value of n = 521.

We are testing proportion hypothesis of the basic set by means of one sample z-test of proportions with the level of significance α = 0,05. Hypotheses of the test are:

The null hypothesis: $H_o : p \geq 0.95$

The alternative hypothesis: $H_a : p < 0.95$

The empiric z-value is z = -1,194. The empiric z-value is greater than the lower (critical) value i.e.

$z_{0.05} = -1,65 < -1,194 = z.$

the null hypothesis is therefore accepted at a given level of significance. According to this test we may conclude that with the level of significance of 0,95 more than 95% citizens would apply the graphic protection on ballot papers.

The examinees consider to a great extent that the public proclamation of applied and guaranteed graphic protection on ballot papers would significantly influence personal trust in the democratic processes. (Figure 4).

Table 3. Z-test proportion results on equal parts among groups of examinees according to the percentage of positive answers for implementation of graphic protection techniques which would prevent any ballot paper counterfeiting

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7
Group 1	-	YES	YES	YES	YES	NO	YES
Group 2	YES	-	YES	NO	YES	NO	YES
Group 3	YES	YES	-	YES	YES	YES	YES
Group 4	YES	NO	YES	-	NO	YES	YES
Group 5	YES	YES	YES	NO	-	NO	YES
Group 6	NO	NO	YES	YES	NO	-	YES
Group 7	YES	YES	YES	YES	YES	YES	-

Table 4. Group results that answer the question: Would you approve implementation of graphic protection techniques which would prevent ballot paper counterfeiting?

	Yes	No
Total	489	32
In percentages	0.94	0.06

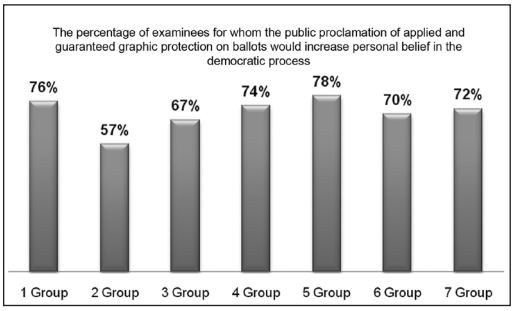

Figure 4. Histogram depiction of applied and guaranteed graphic protection on ballot papers would significantly influence personal trust in the democratic processes shown according to different groups.

Two sample z-tests with the level of significance of *0,95* examine the equality of proportions among the test groups. Testing is carried out with the significance of *0,95*. The results are shown in the table 5.

In this group, with the given level of significance of *0,95*; test values belong to the same basic set.

By merging the groups we get 358 affirmative answers and 163 negative answers per set of n = 521 examinees.

We are testing proportion hypothesis of the basic set by means of one sample z-test of proportions with the level of significance α = 0,05. Hypotheses of the test are:

The null hypothesis: $H_o : p \geq 0.70$

The alternative hypothesis: $H_a : p < 0.70$

The result of the empiric z-value is $z = -0,648$.

Critical value that divides the area of accepting the null hypothesis from the area of rejecting the null hypothesis is $z_{0.05} = -1,65$. The empiric z-value is greater than the lower (critical) value i.e.. $z_{0.05} = -1,65 < -0,648 = z$. It is determined that with the level of significance of 0,95 more than 70% of citizens believe that the application of guaranteed graphic protection on ballot papers would significantly influence personal trust in the democratic process.

There is a correlation of ranks with the groups among variables of knowledge of all graphic protections (grouped on paper, in print and in ink) and portions of answers to the first three questions (Table 7). Spearman's coefficients which show the level of rank correlation among the values were computed.

Table 5. Results of proportion Z-test on equality of proportion among the groups and according to the percentage of affirmative answers from examinees for whom the public proclamation of applied and guaranteed graphic protection on ballot papers would significantly influence personal belief in the democratic process.

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7
Group 1	-	NO	YES	YES	YES	YES	YES
Group 2	NO	-	YES	NO	NO	YES	YES
Group 3	YES	YES	-	YES	YES	YES	YES
Group 4	YES	NO	YES	-	YES	YES	YES
Group 5	YES	NO	YES	YES	-	YES	YES
Group 6	YES	YES	YES	YES	YES	-	YES
Group 7	YES	YES	YES	YES	YES	YES	-

Table 6. Group results that answer the question: Would the public proclamation of applied and guaranteed graphic protection on ballot papers significantly influence personal trust in the democratic process?

	Yes	No
Total	358	163
In percentages	0.69	0.31

Table 7. Spearman's coefficients of rank correlation

Percentage of affirmative answers to questions:	Do you believe in the possibility that ballot papers could be counterfeited?	Would you approve applying graphic protection in order to prevent counterfeiting ballot papers?	Public proclamation of graphic protection on ballot papers would significantly effect personal belief in democratic process?
Percentage of examinees acquainted with graphic protection	$\rho = 0{,}598$	$\rho = 0{,}500$	$\rho = 0{,}393$
Strength of rank corr.	Mid (strong) positive corr.	Mid (strong) positive corr.	Weak positive corr.

There is a significant link between the knowledge of graphic protection and the belief in the possibility of counterfeiting. (Table 7). The examinees better acquainted with graphic protection would to a greater extent approve the implementation of anti-counterfeiting graphic protection. Moreover, the examinees who demonstrated a better knowledge of graphic protection consider that the application of guaranteed graphic protections would raise their personal trust in the democratic processes.

3. Conclusion

The technology of printing plays the key role in the creation of a safe, protected and controlled graphic product. Those protections are implemented that the target group knows most about. Users trust the protections which they are best familiar with. Those kinds of protections are mostly used on securities, documents and other graphic products.

This survey proves that the implementation of safe and secure protection on ballot papers will not only contribute to the raising of citizens' trust in the democratic processes, but it would also prevent possible counterfeits and the misuse of ballot papers. In this paper we tested a hypothesis which stated that the majority of examinees believed that an implementation of some sort of technical graphic protection should be approved in order to prevent potential counterfeits. We are introducing the individualization of ballot papers with controlled, protective infrared ink, which will be used to print the numeration. The innovation of a displayed solution is the introduction of the infrared effect which can be applied without further expenses and will easily be detected.

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