

Modeling of media influence on personal information security

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Abstract

With the development of information influence technologies, the problem of personal protection from media information is becoming increasingly important. To study this phenomenon, it is necessary to create realistic models that would give an opportunity to evaluate the influence of information from the media on human behavior. The existing socio-cognitive and statistical models are too generalized and therefore cannot have practical application. The most convenient for research are the models of conformal human behavior, which can connect the position of the media and the behavior of a person depending on this position. On the basis of the conformity model, the authors of the article propose a simple probabilistic model on which they study the nature of media influence on individual behavior. The input parameters of the model are the a priori attitude of the individual to a certain social phenomenon, the degree of independence of the individual's thinking, the position of alternative media in relation to the specified phenomenon, and the degree of the individual's trust in the media. The authors of the article provide a formalized description of the concept of personal information security, as the difference between the deviations of an individual's position under the influence of alternative media. The main means of counteracting the negative influence of the media on personality is the mechanism of changing information flows between two alternatives. The authors determine the appropriate proportion of media change to achieve a given level of personal information security, depending on the position of the individual. Simulation of various scenarios of media flow management confirms the adequacy of the applied model and indicates that a person with a high level of independence, with a well-thought-out media change technology, is able to resist most informational influences and, thereby, ensure their own information security at a given level.

Keywords

media information, information security, personality, personal information security, conformism, information influence

1. Introduction

With the development of technologies, media information has become a powerful influence on a person's personal security. Cyberattacks, identity theft, and other security breaches are becoming more common and people need to take preventative measures to protect both their personal information and their mental state. A person's ability to recognize and counteract the harmful effects of information increases his resistance to stress and promotes greater confidence in his own actions and decisions in conditions of constant information pressure. In this aspect, it is necessary to create realistic models that would make it possible to evaluate the influence of information from the media on human behavior. Such models can be a useful tool for analyzing individual security risks and

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vulnerabilities. This article examines the application of a mathematical model of personal security under the influence of media information.

2. Problem statement

Personal information security has become a pressing issue in the digital era with the rise of cyber-attacks, data breaches and other security threats. The impact of media information on personal security is widely recognized, and various forms of media are used to spread misinformation, influence individual behavior, and facilitate security breaches. To address these issues, many studies have investigated the relationship between media information and personal security of an individual. Previous research has highlighted the importance of personal security in the digital age and the role that media information plays in shaping it. However, there is a need to choose a mathematical model that could quantify the impact of media information on individual security.

3. Related works overview

The influence of mass media has long been a subject of study in world science [1–2]. But, reviewing the scientific literature, there are gaps in the authors' attempts to develop appropriate mathematical models.

In the article [3], the authors investigated the impact of social networks on privacy and security. The study found that social media users were more likely to engage in risky behavior, such as sharing personal information online, when they felt their privacy was at risk. Another publication [4] investigated the impact of the media on cyber security incidents. Research has shown that media coverage of cyber security incidents can increase the likelihood of similar incidents in the future. There are also publications devoted to the connection between media literacy and personal safety. In particular, in the article [5], the authors investigated the impact of media literacy on students' ability to prevent security breaches. The study found that students who received media literacy training were less likely to be victims of security breaches. At the same time, there is a need for a more complete understanding of the relationship between media information and individual security.

The article [6] summarizes the empirical data obtained as a result of sociological research and proposes a model of voter reaction to the influence of mass media during presidential election campaigns. The main element of the proposed model is the dependence of the number of votes cast for candidates at various stages of the presidential election on the amount of airtime allocated to them on state TV channels. Such an approach, although quite realistic, can only be applied after the elections are over.

In the article [7], the authors analyze the influence of mass media on the mass audience. Although the authors explore this topic in considerable depth, they do not provide a simple formalization for evaluating influence processes, which complicates the practical application of the media influence model. The authors of the publication [8] propose a probabilistic statistical approach for the development of heuristic mathematical models of human behavior based on its internal psychological analysis. However, for an adequate assessment of human behavior, it is necessary to rely on specific actions, and not on internal psychological analysis, the process and results of which are practically impossible to subject to qualitative and quantitative assessment.

The authors of [9] explore the concept of multi-model thinking, which involves using a set of models to understand complex phenomena. Multi-model thinking not only increases work efficiency, but also contributes to success in social life, which allows you to become real experts in assessing economic and political events. However, the use of the proposed models to formalize the impact of the results of social research turns out to be quite problematic.

A number of our previous works are devoted to the protection of people in social networks. For example, in [10] the security parameters of the personal data of an individual were investigated

depending on the topology and mutual influence of social network users. In [11–13], the dependence of information security of an individual in a social network on the influence of social engineering methods is considered. The work [14] examines the issue of taking information content into account. The publications [15, 16] analyze various methods of social control as a mechanism of self-organization, as well as the decision-making process in antagonistic digital communications. At the same time, the individual in all these works is considered as a passive receiver of information that does not change the line of behavior depending on the source of information. The issue of the impact of content on changing the line of behavior of an individual, namely its conformity, remains out of consideration.

The work [17] analyzes modern mathematical models of conformity, which are investigated by the methods of probability theory, game theory, and statistical physics. The work also provides numerous examples of social and economic situations that can be interpreted as manifestations of herd behavior. However, within the framework of this study, it is unlikely to be limited only to the variant of herd behavior, which requires the use of other approaches to building a model of media influence. The paper [18] investigated the construction of a model of the behavior of an individual who, when making decisions on certain issues, relies on both his own opinion and the attitude of surrounding subjects (team). Such an approach can be used to create a general model for evaluating the impact of media on individual behavior. Its advantages are simplicity and accessibility, as well as the possibility of expansion, since the author offers only a basis that can be supplemented with other aspects in the future.

The authors of the article [19] develop the model [18] and investigate the complex of mutual influences on the individual based on the solution of the problem of choice, within the team, which affects the individual's decision-making and evaluate the role of television in election campaigns. The state of information security of an individual under the influence of mass media is also investigated, the dependence of team members on the opinion of other participants and television is taken into account. This makes it possible to determine the conditions for ensuring a person's information security. In the following article [20], the author proposes a model of personal information security based on the concept of probabilistic control of conforming behavior. This approach makes it possible to explore different strategies for managing the influence of media information on a person and to choose an appropriate information management strategy that ensures the necessary level of information security of an individual.

There are other models of conforming behavior [21–22], which deeply explore the psychological features of a person in their relationship with the features of human character, but without taking into account the influence of media information. The disadvantage of such models is the complexity of their application for real assessments of information security.

So, from the conducted consideration, it can be concluded that currently the issue of formalization of the influence of the media on the behavior of individuals has been studied extremely insufficiently. The following shortcomings can be noted in the mathematical models proposed by various authors, in particular:

- Models using a probabilistic statistical approach are overloaded with internal psychological analysis of the individual, which is difficult to adapt to the influence of the media.
- Models of personal protection in social networks consider a person as a stable recipient of information without taking into account the degree of its relevance.
- Mathematical models of conformity and conforming behavior are the closest, although they need improvement for the possibility of using media information in them.

The purpose of this paper is to develop and explore a mathematical model that can provide a quantitative analysis of the relationship between media information and personal information security, allowing researchers to develop more effective strategies to promote individual security in the digital age.

4. Mathematical model of personal information security

In work [18], the author proposes a model of the behavior of a person who is under the influence of other people from his environment. The proposed model takes into account: initial beliefs of the individual; the degree of independence of her thinking and the influence of the environment on the personality. Thus, the specified model can be used as a basis for a general model for evaluating the influence of media on individual behavior. When developing a model of conformal behavior of an individual in [19], the basis is communication with other individuals. This is expressed in the application of appropriate probabilistic indicators of the influence of the environment on the individual and the reverse influence of the individual on the environment. In contrast to this approach, the individual's perception of media information has its own characteristics, in particular, the individual does not directly influence the mass media. In addition, an individual can perceive secondary influence, when information from the mass media is transmitted to the individual from other subjects in his environment. Therefore, the basic model of conforming personality behavior should be improved taking into account the identified features.

As in the basic model, we will assume that a person, making a decision on this or that issue, is guided by both his initial beliefs and the attitude of other subjects from his environment to this issue. As part of our review, collective opinion will include public opinion expressed in the mass media (Internet channels, social networks, television, radio, etc.). We'll look at events that can be presented in binary form, such as "support" or "don't support". The mathematical model [20] is based on two quantitative assessments of the individual's attitude to the new state:

- Personal a priori attitude to a new state (conviction of the individual), which is described by the probability of readiness of the individual to move to this state (A_{pr}) – before the influence of the media.
- Personal posterior attitude to the new state, which is described by the probability of the final decision to move to the new state (P_{post}) – after media exposure.

The probabilities A_{pr} and P_{post} describe exactly the informational component of the process of transition from the initial to the final state, as they are determined by the influence of the media on the individual. In the case when the individual is independent in decision-making, he may not be subject to such influence and then, obviously, his a posteriori attitude will coincide with the a priori $A_{pr} = P_{post}$.

Another characteristic that should be taken into account in the future is the degree of independence of the individual I_{nd} , which is defined as the probability that in a specific situation the individual behaves as independent. If $I_{nd} = 1$, then the individual's decisions do not depend on media influence. If $I_{nd} = 0$, then we have an absolute dependence, which means an almost instantaneous change of the initial beliefs of the individual under the influence of the media.

In contrast to the model of conforming behavior [21], in the following work, we will consider only the change in personality behavior under the influence of the media. So, as was mentioned, in a completely independent individual, the posterior probability $P_{post}^{I_{nd}=1}$ coincides with the a priori $P_{post}^{I_{nd}=1} = A_{pr}$, i.e. with his beliefs. The posterior probability for a completely dependent individual $P_{post}^{I_{nd}=0}$ can be determined based on the following considerations. We will assume that the influence of each i -th media on a given individual is determined by the number $E_{media[i]}$ – the probability that the individual will act as follows from the i -th message of the media. At the same time, we will also assume that such an influence of the i -th media message on this individual does not depend on the influence of other alternative media messages. This means that the individual will enter a new state with probability $P_{media[i]}$. Then the total probability of transition of a completely dependent individual to a new state will be equal to

$$P_{post}^{I_{nd}=0} = \sum_{i=1}^N E_{media[i]} P_{media[i]}, \quad (1)$$

where N is the total number of media messages (or sources); $\sum_{i=1}^N E_{media[i]} = 1$ [22] and all $E_{media[i]} > 0$, since a completely dependent individual is affected by any media message.

As you can see, $E_{media[i]}$ expresses the degree of influence of media on personality. On the other hand, taking into account $\sum_{i=1}^N E_{media[i]} = 1$, $E_{media[i]}$ can also be considered as a distributed level of an individual's trust in individual media, since, in any in any case, at least one source will influence the personality.

Thus, the posterior probability for an arbitrarily chosen individual can be obtained based on the formula for the total probability

$$\begin{aligned} P_{post} &= P_{post}^{I_{nd}=1} I_{nd} + (1 - I_{nd}) P_{post}^{I_{nd}=0} = \\ &= A_{pr} I_{nd} + (1 - I_{nd}) \sum_{i=1}^N E_{media[i]} P_{media[i]}. \end{aligned} \quad (2)$$

Formula (2) is a model of the individual's behavior under the influence of the media in general, with the simplifications that have been adopted. Unlike the model of conforming behavior, this model takes into account the level of trust in the media and the peculiarities of the information exchange between the individual and the media.

Given the given parameters (A_{pr} , I_{nd} , P_{media}) from formula (2) it is possible to determine the posterior probability (P_{post}), which in vector form will have the form

$$P_{post} = A_{pr} I_{nd} + (\mathbf{U} - I_{nd}) \mathbf{E}_{media} \mathbf{P}_{media}, \quad (3)$$

where \mathbf{E}_{media} is a stochastic matrix ($E_{media[i]}$), I_{nd} is a diagonal matrix (I_{nd}), \mathbf{U} is a unit matrix, A_{pr} and \mathbf{P}_{media} are vectors with components A_{pr} and P_{media} , respectively.

Personality is constantly under the influence of various media. It is logical to assume that some media will incline a person to certain decisions, other media, which have an alternative focus, to alternative decisions. Thus, as can be seen from the previous discussion, the value of P_{post} for an individual under the influence of different media will vary from some maximum value of P_{post}^{MAX} to a minimum value of P_{post}^{MIN} .

Taking into account the above statements, in general, the model of personal information security can be formulated as follows

$$\Delta P_{post} = P_{post}^{MAX}(t) - P_{post}^{MIN}(t) \leq L_{im}, \quad (4)$$

where $P_{post}^{MAX}(t)$, $P_{post}^{MIN}(t)$ – respectively, the maximum and minimum value of P_{post} during the specified time period t ; L_{im} is some pre-set spread value of P_{post} .

That is, it will be possible to talk about the information security of an individual when condition (4) is met, namely: the a posteriori probability P_{post} of the individual's transition to a new state under the influence of the information channel of information influence will remain within certain limits relative to its a priori probability A_{pr} .

5. Simulation and discussion of results

To keep P_{post} within the given limits L_{im} of the individual, depending on the initial beliefs of A_{pr} , the degree of independence I_{nd} and the level of trust in the channel of information influence E_{media} , it is necessary to have one's own strategy for managing media influence. To simplify understanding, we will consider a person who is under the influence of two alternative media. In many cases the entire set of media messages can be divided into two opposite groups: "agree" or "disagree"; "positive" or "negative", etc. Thus, it is possible to group all the media into two opposite groups regarding some

high-profile event, which one of the groups will support, and the other will be in opposition to the first.

For example, we will consider the scenario of an election campaign, when various media support "their" presidential candidates, while leveling the ratings of their opponents. So, let's take 2 alternative media: Media 1 and Media 2, which broadcast information about the same Candidate X. Media 1 determines the support of the Candidate X at the level of 0.9 (that is, believes that such a candidate will win 90% of the vote in the elections). Media 2 determines the support of the same Candidate X at the level of 0.1 (believes that this candidate will win only 10% of the vote in the elections).

The individual has his own opinion about Candidate X, which is expressed through his initial beliefs A_{pr} . Also, an individual has his own degree of personality independence I_{nd} , which will determine his ability to be influenced by the media. An individual has the opportunity to choose between Media 1 and Media 2 in order to stay with his beliefs A_{pr} as long as possible (this is the essence of personal information security – to stay with his own views as long as possible without being influenced by the media). With this approach, the key strategy for ensuring the informational security of the individual will be the change in media exposure between the two alternatives, which will satisfy formula (4). We will provide separate graphs and comment on possible options for implementing the "media change" strategy.

Fig. 1 shows that in the case ($A_{pr} = 0.9, I_{nd} = 0$), when the individual supports Candidate X at a level that coincides with Media 1, then keeping him in a state of information security is quite a difficult task as Media 2 will sway him to its side. As soon as Media 2 sways the individual to its side, the individual changes the source to Media 1 and now Media 1 will sway him to its side. All this happens due to the degree of independence of such an individual is zero ($I_{nd} = 0$) and therefore any information polarizes his P_{post} , that results $\Delta P_{post} = 0.8$, which is the maximum value and indicates the absence of any information security for such an individual.

Consider the case when the individual's initial beliefs differ from the position of Media 1, for example, with $A_{pr} = 0.8$, and his resistance to informational influence is sufficiently high ($I_{nd} = 0.8$). In this case, it can be seen that any influence of Media 2 leads to a change individual's beliefs to the contrary, but such an influence can be compensated by four inclusions of Media 1 and at the same time the individual is able to ensure $\Delta P_{post} = 0.16$ (Fig. 2).

In the case when $A_{pr} = 0.2, I_{nd} = 0.8$, the picture will be symmetrical, because in this case our individual is inclined to the position of Media 2, and at the same time, each influence from Media 1 can be compensated by four influences from Media 2. As in the previous case, the level information security for an individual is provided at the level of $\Delta P_{post} = 0.16$ (Fig. 3).

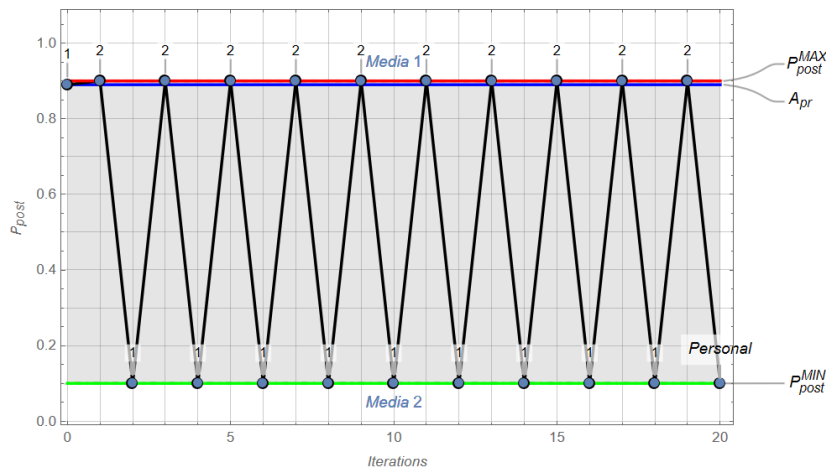


Figure 1: Simulation results at $A_{pr} = 0.9, I_{nd} = 0$.

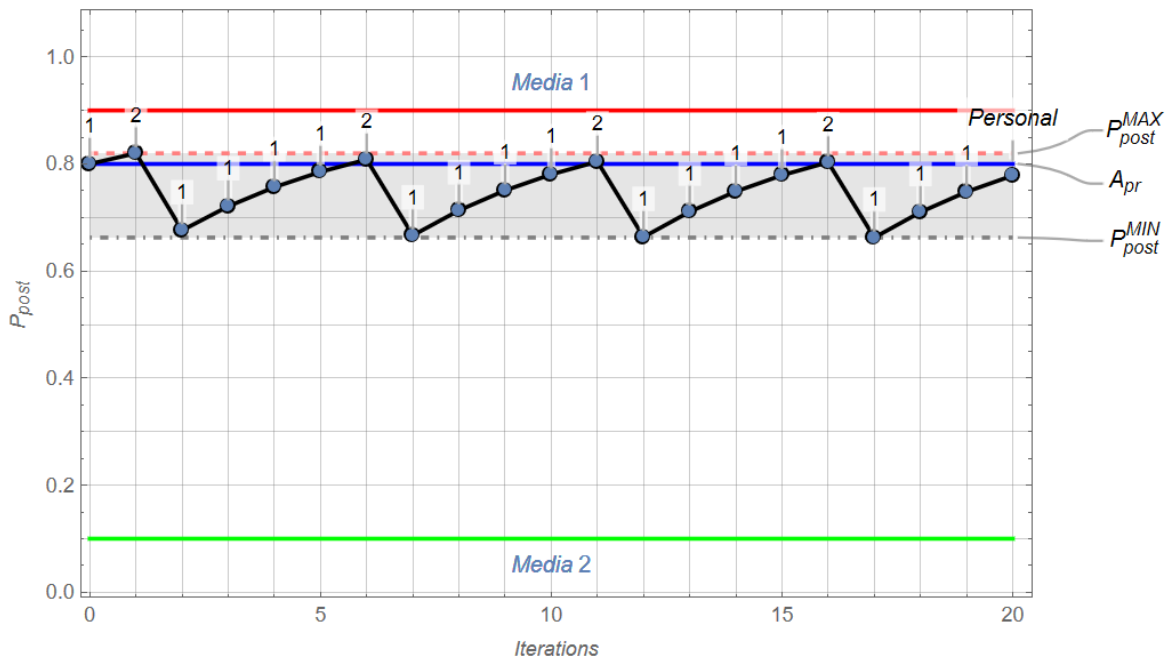


Figure 2: Simulation results at $A_{pr} = 0.8, I_{nd} = 0.8$.

According to general logic, an increase in $I_{nd} \xrightarrow{\text{yields}} 1$ will lead to a decrease in $\Delta P_{post} \xrightarrow{\text{yields}} 0$, which will indicate the achievement of information security of the individual. So, with $(A_{pr} = 0.7, I_{nd} = 0.9)$ you can see that $\Delta P_{post} = 0.08$. At the same time, the individual on average needs to change media in a ratio of 2:1 in favor of Media 1. That is, one inclusion of Media 2 can be leveled by 2–3 inclusions of Media 1 (Fig. 4).

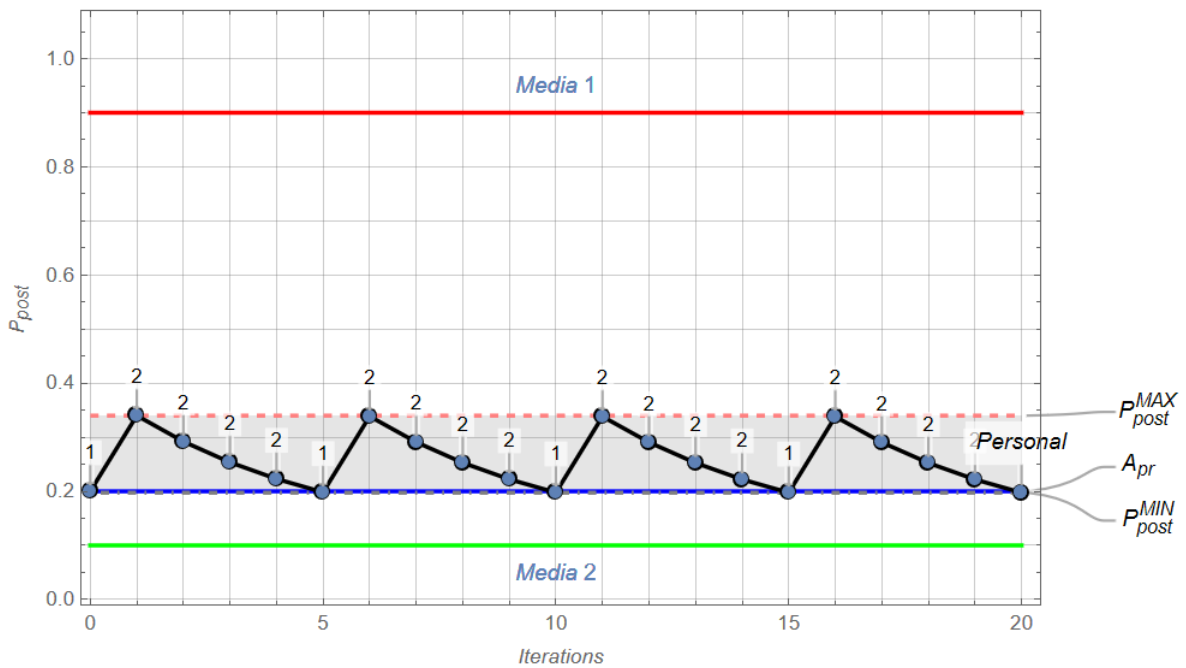


Figure 3: Simulation results at $A_{pr} = 0.2, I_{nd} = 0.8$.

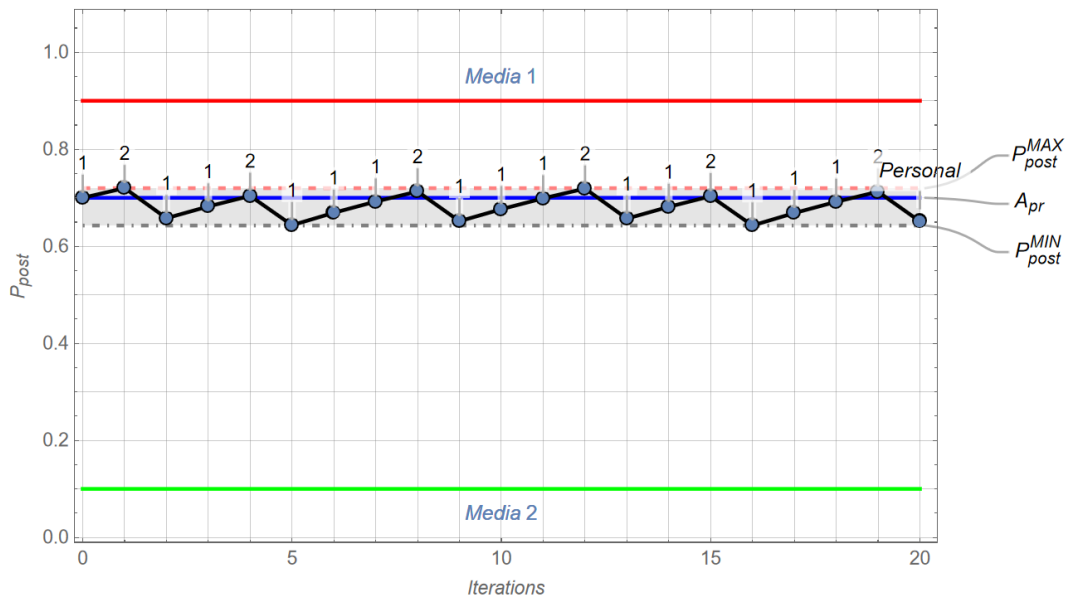


Figure 4: Simulation results at $A_{pr} = 0.7$, $I_{nd} = 0.9$.

The general dependence of the information security of the individual ΔP_{post} on A_{pr} and I_{nd} is shown in Fig. 5, where it is shown that with the increase of I_{nd} , the values of ΔP_{post} decrease almost linearly and reach 0 when the value of $I_{nd} = 1$.

At the same time, ΔP_{post} almost does not change with a change in the a priori beliefs of the individual A_{pr} . In general, this corresponds to the logic of common sense, since the individual's resistance to external informational influences depends mainly on his internal (innate) qualities or character traits, and not on the position he occupies in relation to some event. Individual fluctuations of ΔP_{post} values, which can be seen in Fig. 5, due to the fact that the indicated indicators are obtained as a result of simulation.

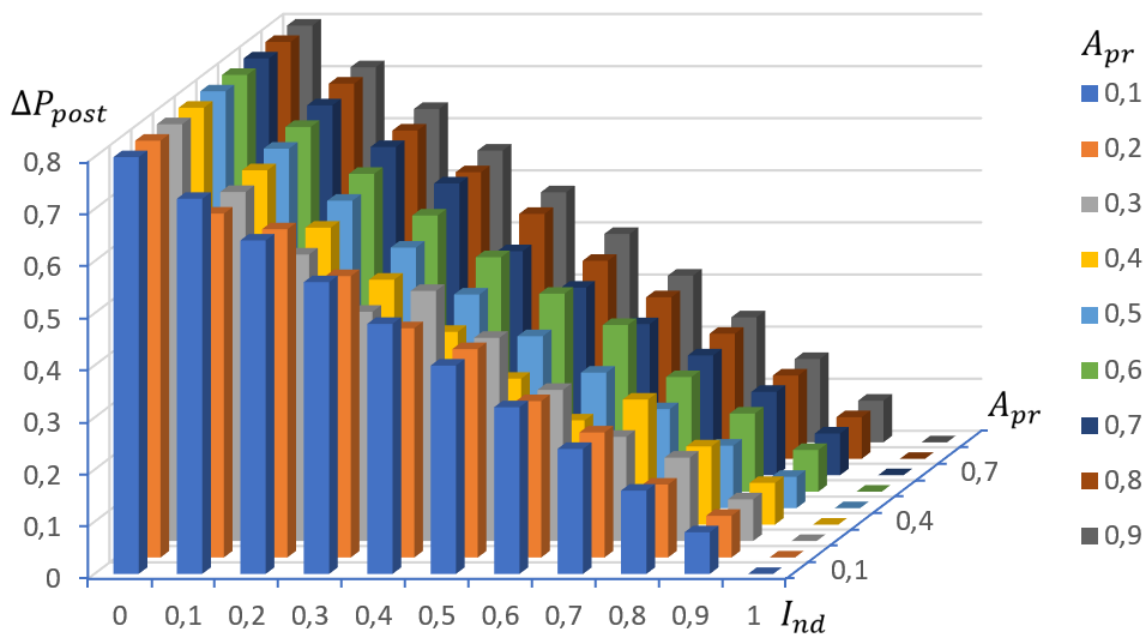


Figure 5: Dependence of personal information security ΔP_{post} on A_{pr} and I_{nd} .

The average values of A_{pr} for different values of I_{nd} are shown in Table 1. As can be seen, sufficiently low values of $\Delta P_{post} < 0.2$ are observed at high values of $I_{nd} > 0.7$, which once again confirms the conclusions made earlier.

Table 1

Average values of ΔP_{post} depending on I_{nd}

I_{nd}	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
ΔP_{post}	0.80	0.70	0.61	0.52	0.45	0.37	0.29	0.23	0.15	0.08	0.00

As can be seen from the previous discussion, in order to remain with his beliefs, the individual must manipulate the information from the media by timely changing Media 1 to Media 2 and vice versa, when these media force the individual to change his beliefs, moving away from their initial value. Therefore, an interesting question is how often it is necessary to change sources of information to ensure information security? To investigate this issue, let's turn to the developed model again and determine the ratio of media change depending on A_{pr} and I_{nd} . The results of the study are shown in Table 2.

As can be seen from Table 2, at low values of I_{nd} , the change of media is carried out uniformly in an equal proportion between Media 1 and Media 2. When I_{nd} increases, in order to minimize ΔP_{post} , the individual must more often choose the media that is closer in position to the beliefs of the individual himself. Otherwise, the minimum ΔP_{post} is not ensured. In the case when the individual does not have clear initial beliefs $A_{pr} \approx 0.5$, the media change is carried out proportionally evenly (in our example 10/10).

Table 2

Dependence of the need to change the media on A_{pr} and I_{nd} to reach the minimum ΔP_{post}

A_{pr}	0.1		0.2		0.3		0.4		0.5		0.6		0.7		0.8		0.9		
I_{nd}	Media		Media		Media		Media		Media		Media		Media		Media		Media		
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	
0.0	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
0.1	2	18	10	10	10	10	10	10	10	10	10	10	10	10	10	10	13	7	
0.2	1	19	7	13	10	10	10	10	10	10	10	10	10	10	13	7	15	5	
0.3	1	19	7	13	10	10	10	10	10	10	10	10	10	10	13	7	16	4	
0.4	1	19	7	13	10	10	10	10	10	10	10	10	10	13	7	16	4		
0.5	1	19	6	14	7	13	10	10	10	10	10	10	13	7	14	6	17	3	
0.6	1	19	5	15	7	13	10	10	10	10	10	10	13	7	15	5	17	3	
0.7	1	19	5	15	7	13	10	10	10	10	12	8	13	7	15	5	18	2	
0.8	1	19	4	16	6	14	8	12	10	10	12	8	14	6	16	4	18	2	
0.9	1	19	4	16	6	14	8	12	10	10	12	8	14	6	16	4	19	1	
1.0	1	19	3	17	5	15	8	12	10	10	12	8	15	5	17	3	19	1	

6. Conclusions

In order to ensure the personal information security of an individual, it is necessary to solve the problem of assessing changes in his behavior under the influence of information from the media. At the same time, the main goal will be to achieve such an indicator of independence of the individual I_{nd} , which would, with any efforts of the media, make it possible to ensure that the resulting value

of the posterior probability P_{post} remains within the given limits of L_{im} relative to the initial beliefs of the individual A_{pr} . The main mechanism for achieving such a state is the control of the flow of information coming to the individual from the media.

The model of personal information security studied in this work is based on the concept of managing information from the media with probabilistic control and evaluation of the individual's behavior under the influence of the media. This makes it possible to explore various scenarios of managing the media's information impact on a person and to choose an appropriate information flow management technology in order to ensure the necessary level of its information security ΔP_{post} .

Simulation of various scenarios of media flow management confirms the adequacy of the applied model and indicates that a person with a high level of independence, with a well-thought-out media change technology, is able to resist most informational influences and, thereby, ensure their own information security at a given level.

Future research can refine the model by integrating machine learning to predict behavior dynamics under media influence and analyze content in real-time. Expanding the model to include cultural and social factors will enable more personalized strategies for managing information flows, improving individual information security.

Declaration on Generative AI

The authors have not employed any Generative AI tools.

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