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Stress-related Characteristics of the Actualization of Subjective Experience in the Process of Information Concealment

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Abstract
Introduction. Many theoretical models explain differences in changes in physiological indicators during the implementation of lying and truth-declaring behaviors in polygraph tests. From our point of view, lies can be regarded as a special goal-oriented behavior provided by the implementation of corresponding functional systems – elements of subjective experience. At the same time, polygraph examinations are stressful due to the motivation for the test. We were interested in the characteristics of the actualization of subjective experience when the result of information concealment behavior is achieved under the above-mentioned conditions. **Methods**. The experiment used the modified version of the Block Test by V. V. Korovin in the form of the concealed information test. Heart rate registrations were carried out. Both entropy (as an indicator of rhythm complexity that reflects systemic subordination of behavior) and spectral indicators of rhythm (as a stress severity assessment) were calculated. The examinees were instructed to conceal information obtained at various stages of ontogenesis. **Results**. The study was carried out with the participation of 40 subjects who underwent polygraph examinations during their employment. We analyzed their heart rate entropy in the process of producing honest and false answers under stressful conditions. When information concealment behaviors are realized, entropy changes in different directions. However, this dependence has not been revealed for the new experience, apparently due to the process of temporary system dedifferentiation, i.e. the deactualization of comparatively new systems. **Discussion**. A polygraph test model based on the system-evolutionary approach was proposed. In the process of passing the test, there appears to be a formation of non-universal functional systems of 'lies', but rather those depending on the component of the experience to which this information belongs. Moreover, it is difficult to considerably improve information concealment behaviors of the examinees, due to the impossibility of rapid correction of behavior based on feedback.

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Keywords
polygraph, lie detection, information concealment, stress, system-evolutionary approach, heart rate, sample entropy, adaptation, stress regression, systemic dedifferentiation

Highlights
- From the system-evolutionary approach, the concealment of information is considered as a special goal-oriented behavior provided by the implementation of corresponding functional systems (FS) – elements of subjective experience.
- In stressful situations, when a false answer is given to a question related to the actualization of FS of greater differentiation, heart rate entropy decreases (compared to truth-producing behavior).
- When examinees conceal information associated with a less differentiated FS, entropy increases.
- Behavior changes during polygraph tests are difficult, which manifests itself in the absence of entropy differences among subjects with different number of polygraph tests and the absence of its dynamics during testing.

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Introduction
Despite the widespread use of polygraph testing, there is no generally accepted theoretical model that explains the differences in the recorded physiological indicators for true and false answers. Currently, there are more than 15 of such theories (for a cumulative analysis of theories, see: Obukhov & Obukhova, 2011; Isaichev & Isaichev, 2016; Mailis & Kholodnyi, 2021; Walczyk, Igou, Dixon, & Tcholakian, 2013; and many others) that explain specific phenomena but not regularities of the organization of information concealment behavior. There is a tendency in them to highlight the predominant role of a certain parallel (to the concealment behavior) proceeding psychic process or state (memory, attention, etc.) in the concealment behavior ensuring, which determines their low explanatory power. We believe that it is possible to construct a theoretical model for polygraph testing based on the system-evolutionary approach (P. K. Anokhin, V. B. Shvyrkov) and aimed at analyzing the integral behavior of an individual (Uchaev & Alexandrov, 2020).

From the point of view of systemic psychophysiology (Shvyrkov, 2006; Alexandrov, 2009, 2020; Alexandrov et al., 2018), the ontogenesis process can be understood as a sequence of systemogeneses, i.e. the formation of new functional systems (FS). In this case, the latter are understood as a complex of mutual cooperation of body elements to achieve a useful adaptive result (Anokhin, 1973). Each behavioral act is the organization of the relationship of the entire organism with the environment, but not of individual organs or brain structures with their own specific functions. The implementation of behavior is provided by FS actualization, which in turn form part of the

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individual experience. At the same time, the 'psychic' and 'physiological' aspects are considered different aspects of the unified systemic processes of the organization and implementation of FS (Shvyrkov, 2006; Alexandrov, 2009).

It is important that the formation of new FSs does not lead to the displacement of the old ones that have already been formed. They are accumulated and integrated into the already formed individual experience structure, including its partial reorganization. The set of all FSs available to an individual for implementation in behavior constitutes his/her individual experience. Thus, at the same time, the individual experience structure is the history of its formation from a lesser to a greater differentiation of the organism-environment relationship. Any implementation of behavioral acts is a simultaneous actualization of FS of different ontogenetic ages (Shvyrkov, 2006; Alexandrov, 2009; Alexandrov, 2018).

The advantages of using the systemic approach include the ability to consider the integral organization of human behavior in a polygraph testing situation, as well as the ability to use the language of system processes to describe particular phenomena. In this case, as previously noted in the literature, there is no need to highlight and focus on the leading psychic process or state that determines the information concealment behavior (Isaichev & Isaichev, 2016). Any FS fundamental architectonics (Anokhin, 1973) includes processes which characteristics can be compared to those that the authors of different theoretical models identify as the dominant ones. Furthermore, there is an opportunity for comparing the deliberate concealment behavior during the discussion of issues in the pre-test interview and during polygraph testing. It is possible to compare the similar behavior of humans and other social animals, whose behavior is considered by different authors as deception (Kuczaj, Tranel, Trone, & Hill, 2001; Osvath & Karvonen, 2012). In this case, we do not compare specific "functions" separately, but the dynamics of the course of the "isomorphic" system processes of the organization of the integral behavior in animals and humans (see, for example, Shvyrkov, 2006; Alexandrov, 2003).

Traditionally, polygraph testing is interpreted in terms of the stimulus-response paradigm. Thus, a polygraph examiner's question is considered as a stimulus, associated with it; changes in physiological parameters are considered as a response (see, for example, Ogloblin & Molchanov, 2004). From the standpoint of the systemic approach, an individual's behavior is the implementation of active interactions with the environment. In this case, the environment and the organism form the unity (Shvyrkov, 2004). From our point of view, the polygraph examiner's question should be understood not as a stimulus, but as the environmental component with which there is an active interaction. In a testing situation, an individual has certain goals, and considers the questions through the prism of achieving these goals. The distinct changes in the autonomic nervous system indices recorded by the polygraph are a reflection of the various organ activities that are included in the FS of the whole organism (see Bakhchina, Demidovskii, & Alexandrov, 2018), and formed to implement the question answering behavior. For example, there is a phenomenon in polygraph examination – 'reaction of expectation' (Ivanov, 2019, p. 29). It is a distinct change in the physiological parameters associated with the next expectation of subjectively significant questions. These changes are not passive 'reactions'; they represent the 'prestart integration' of FS components (Anokhin, 1973) for subsequent question answering.

At the same time, the intersystem interrelationship problem is still open. Information concealed during polygraph testing is the examinee's subjective experience component that reflects certain body-environment relationships, i.e. FS. From the perspective of the first person, its description is

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possible in the Russian language related to either behavior (see Kolbeneva & Alexandrov, 2016). United by the achieved results, commonality FSs are understood as experience domains (Alexandrov, 2018). They can be associated with approaching/withdrawal, sensory organs, etc.; each of the domains has its own degree of differentiation (Kolbeneva & Alexandrov, 2016). On the other hand, concealment behavior can be considered independently in the form of independent FSs that produce lies for one or another purpose.

Another special issue is the possibility of adapting to the polygraph testing procedure. The testing methodology does not imply direct observation by the examinee of changes in the dynamics of their physiological parameters. Separate test results can be reported with a delay, for instance, cumulatively, on the basis of several test results. Consequently, there is no opportunity to modify individual behavior to achieve the goal. In this case, the difficulty of directed adaptation (learning) to the polygraph testing procedure should be expected. It will be expressed in the absence of the opportunity to improve the corresponding subjective experience associated with the goal achievement formulated by the examinee on the basis of feedback.

From the standpoint of systemic psychophysiology, heart rate variability (HRV) can be considered as a reflection of heart involvement in FS and related to the dynamics of the FS actualization. HRV reflects the coordination process of the activities of various components of the organism and depends on the characteristics of the system organization of the implemented behavioral act, including the degree of differentiation of the actualized set of systems (Bakhchina & Alexandrov, 2017; Bakhchina et al., 2018; Bakhchina, Arutyunova, Sozinov, Demidovsky, & Alexandrov, 2018).

One of the most common methods for assessing HRV in connection with the FSs actualization dynamics is the entropy analysis. It reflects the irregularity measure of the cardiac signal (sequence of RR intervals). In this work, we used the sample entropy indicator, which has a number of advantages, including the ability to apply to short sequences and noise resistance (Yentes et al., 2013; Bakhchina et al., 2018). On the other hand, HRV analysis can be used as a person's stress level indicator through the RR-interval sequence spectral analysis (Kovaleva, Panova, & Gorbacheva, 2013; Kim, Cheon, Bai, Lee, & Koo, 2018).

Polygraph testing is a stressful event (Ermakov, Vorob'eva, & Yatsyk, 2016, p. 158), which accordingly determines the manifestation of several phenomena. From a theoretical and empirical point of view, the relationship between the contribution to the behavior of comparatively younger and older FS changes in favor of the latter during stress. When the activity of highly differentiated (newer) systems is suppressed, the relative contribution of less differentiated (older) systems increases, which can be recorded by the relative changes in the entropy (complexity) of heart rate (Bakhchina & Alexandrov, 2017; Bakhchina et al., 2018). This condition is called regression or the temporary dedifferentiation of the system and is characterized by its reversibility (Alexandrov, 2016; Alexandrov et al., 2017).

Studies using the HRV analysis to detect concealment have been described in the literature (e.g., Sung & Pentland, 2005; Swee et al., 2020). However, in the available studies, only spectral indicators are used to differentiate the lie and truth states. These studies usually describe the information concealment behavior which is realized in a free conversation. In addition, a small number of studies have examined the impact of awareness of details of committed events on the effectiveness of testing. Bradley, Malik, & Cullen (2011) found that more information about the crime, which presumably corresponds to a higher degree of experience differentiation, facilitates lie detection by the polygraph examiner.

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The objective of our study was to analyze the dynamics of heart rate (HR) during the implementation of concealment behavior in information of varying degrees of differentiation by individuals undergoing a polygraph testing procedure under stress. As *hypotheses,* the following assumptions were stated: (1) behavior modification in the polygraph examination process is difficult due to the inability to adjust individual behavior using feedback; (2) when passing polygraph testing, HRV in the information concealment behavior mainly depends not on the differentiation of the systems that provide the newly formed concealment behavior, but on the differentiation of systems belonging to the concealed component of the experience.

Methods

The experiment used the common modification of the method in the polygraph test – concealment information technique (CIT). It involves presenting a number of homogeneous questions containing a particular feature of the event being investigated by the examinee (e.g., the amount of stolen money, the murder weapon, etc.) (Ogloblin & Molchanov, 2004). In the classical technique, the interval between questions usually does not exceed 20–30 seconds (Zhirnov, Pritulyak, & Alekseev, 2016), which is not very informative during HRV registration. The solution to this problem was found in the form of a block test (Korovin, n.d.). Thus, questions are asked without being mixed, which makes it possible to combine them into a single time period of analysis (Fig. 1).

Heart rate (HR) was recorded using the Zephyr sensor (HxM BT) and the special program for the registration of telemetric measurements (Polevaya et al., 2012) during the experiment.

The study involved 40 participants aged 20 to 46 years (M = 25.03, Med = 23, SD = 3.84), 15 of whom were women. All participants had no complaints of physical distress or psychological discomfort. Before testing, each of them signed a written informed agreement to participate in the experiment.

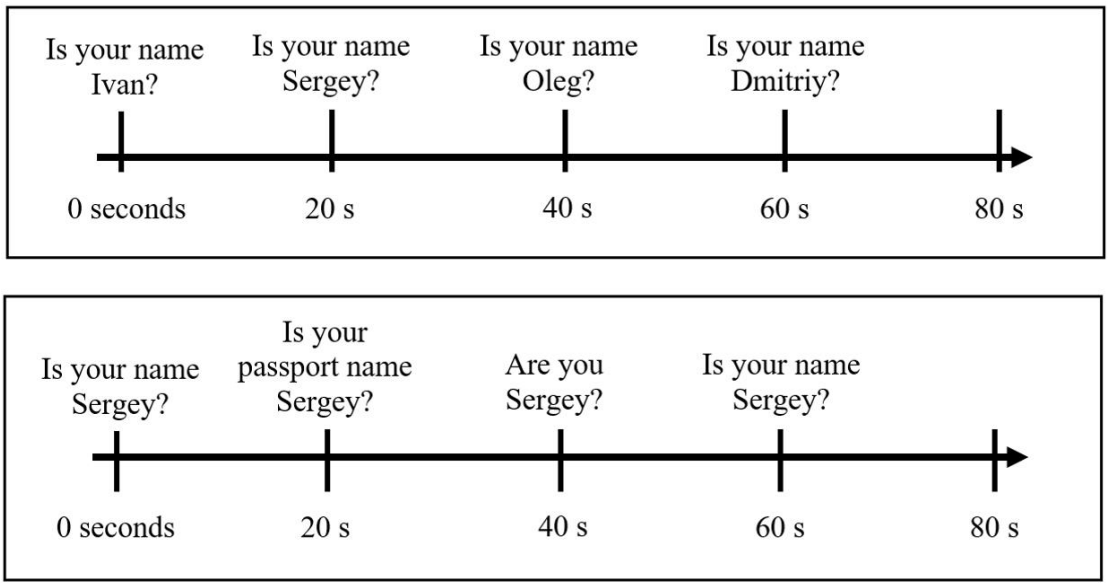

Figure 1. Classical (top) and block (bottom) versions for presenting questions to the examinee

This experiment was timed to coincide with a real polygraph test, which ensured ecological validity, as well as a certain level of stress, due to the motivation to pass the test. In the first stage of the study, the subject was familiarized with the polygraph examination procedure, information on the current state of health was collected, and the necessary documents were signed. The heart rate sensor was then installed; the examinee was interviewed about the events that were checked on the polygraph. Then, the testing was carried out according to the method described above.

During the experimental series, according to the instructions, the participant had to conceal the autobiographical information acquired at different stages of individual development. The choice of concealed information was due to its prevalence in real polygraph testing, for example, in 'stimulation' tests (Ogloblin & Molchanov, 2004). Furthermore, during the investigation process, the events of biography that took place in different periods of time are concealed. During the study, the examinee was instructed to lie when asked about his/her own name, year of birth, the type of school in which he/she studied, the mark in the school certificate, the name of the company for which he/she applied, and his/her age. In each case, a homogeneous series of questions was presented with one of them related to the examinee (Table 1). Before the test started, the examiner was told to lie only on the question related to him/her and to answer the others honestly. Information from a similar experience (e.g., name) was presented together. Each individual test consisted of three series of questions (one with lies and two without lies). For positional equalization, the questions in the tests were mixed and the order of presenting the test itself was changed for each subject.

Table 1
Questions presented to the examinees during the experiment

Concealed experience	False answer	Honest answer	Honest answer
Year of birth	Were you born in 1990?	Were you born in 1985?	Were you born in 1980?
Name	Your name is Ivan, isn't it?	Your name is Sergey, isn't it?	Your name is Oleg, isn't it?
School mark	Do you have an 'excellent' chemistry mark on your school certificate?	Do you have a 'good' chemistry mark on your school certificate?	Do you have an 'average' chemistry mark on your school certificate?
School type	Did you study at the lyceum?	Did you study at the cadet corps?	Did you study at high school?
Place of employment	Are you applying for the 'Alliance' company?	Are you applying for the 'ProTek' company?	Are you applying for the 'Invest' company?
Age	Are you 30 now?	Are you 35 now?	Are you 40 now?

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The sequences of RR-intervals were used to analyze the HRV – calculated intervals between two adjacent R-waves of cardiocomplexes. The following sequences were obtained for each subject: the conversation about the biography and one topic tested on a polygraph, false answers to 6, and true to 12 questions (2 questions in 6 series). Those that contained artifacts were excluded from the resulting records. The analysis of the questions with honest answers was carried out cumulatively by calculating the arithmetic mean, which is a standard procedure for processing polygrams (Popovichev, 2011).

Data processing and statistical analysis were performed in the MATLAB R2020a and IBM SPSS Statistics 23.0 programs. The Lomb–Scargle method was used to calculate the spectral indices and the sample entropy was used as the entropy index (Richman & Moorman, 2000) with the following input parameters: dimension = 2; filtering factor = 0.5*σ. For normality checking, the Kolmogorov–Smirnov and Shapiro–Wilk tests were used. The Spearman correlation coefficient was used to analyze the relationship between parameters. To assess the differences between the samples, Student's t test and the Mann–Whitney U test were used. The results were considered significant at $p < 0.05$.

Results

According to the results of the analysis, we found that all subjects were under stress. For this, the sequence of RR intervals was divided into windows (width: 100 s, shift: 10 s), for each of which the spectral indices were calculated. The criterion for the presence of stress was a simultaneous increase in the ration of low- and high-frequency activity (LF/HF) with a decrease in the total spectrum power in at least three consecutive windows (Shishalov et al., 2013).

For each testing stage, the sample entropy and LF/HF were calculated. There was a significant inverse correlation between them (some of the data are presented in Table 2). In other words, when stress increases, the entropy of the heart rate decreases.

The study involved participants who underwent polygraph testing for the first time (n = 27) and two or more times (n = 13). Comparison of entropy between the indicated groups for each of the testing stages did not reveal their significant differences (Table 2). Thus, the HR complexity was the same for subjects who had different quantitative experience in passing a polygraph test.

Furthermore, we analyzed the sample entropy dynamics throughout the testing. The cardiointerval sequence for each subject was divided into windows (width: 100 s, shift: 10 s); the entropy indices were calculated for them. An approximate straight line was then constructed, which was described by the coefficient function $y = kx + b$, where the coefficient k reflects the angle of its slope. The average value of k was found to be $–4{,}357*10^{–5}$, i.e., almost zero. The comparison of indicators for the first and last questions regardless of their type ($t = –0.055$; $p = 0.956$), as well as for those where there was an instruction to lie ($t = –1.333$; $p = 0.193$) and without it ($t = 1.249$; $p = 0.219$) did not reveal significant differences between them. Thus, the HRV of the subjects did not change considerably during the tests.

Pairwise comparison of questions revealed differences in entropy indices for questions with instructions for true and false answers related to early experience ($t = 2.371$, $p = 0.024$ and $t = –2.338$, $p = 0.025$, respectively), as well as for true answers related to a relatively early experience (relative to the verification date) ($t = 2.135$, $p = 0.045$), but not for false ones ($t = –0.538$, $p = 0.597$). Similarly, no dependence was found for the late experience ($t = 0.776$, $p = 0.447$; $t = –0.169$, $p = 0.868$). This means that the HR complexity is significantly higher with true answers

to the year of birth compared to the name or the school mark compared to the school type. However, lies about the year of birth are characterized by less complexity than lies about the name. For other pairs of questions, including late experience, no differences were found.

Table 2

Spearman correlation coefficients for entropy and LF/HF; Mann–Whitney U test for groups of examinees with different number of polygraph tests

	Biography discussion	Topic discussion	Truth about the name	Lie about the name	Truth about the year of birth	Lie about the year of birth
r	–0.493**	–0.720**	–0.689**	–0.452**	–0.707**	–0.608**
U	137	114	164	148	122	86

*Note: "**" indicates the significance at the p < 0.01 level.*

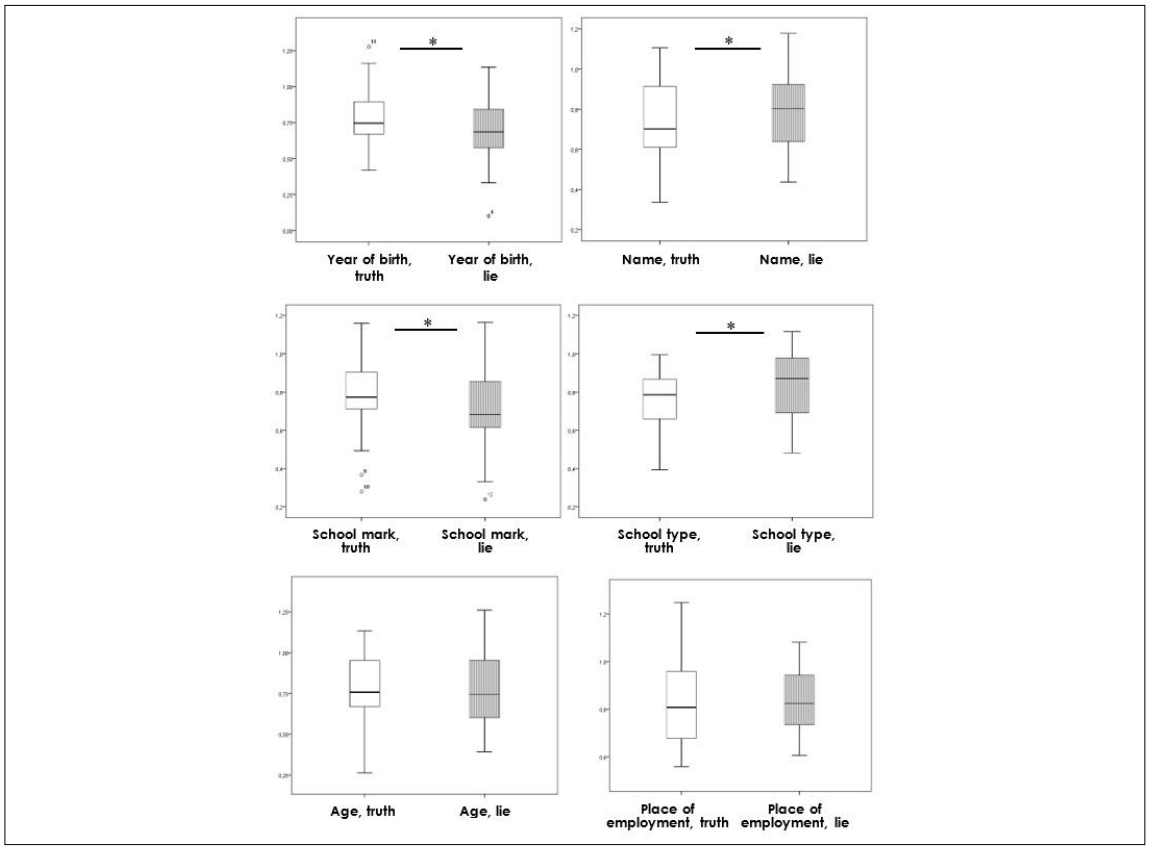

Figure 2. Entropy indices for true (no shading) and false (shaded) answers in tests for experiences acquired at early, relatively early, and late ontogenesis stages (upper, middle, and lower rows, respectively) and belonging to different experiences (numbers on the left, text on the right)

Statistically significant differences are marked with "".*

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Further, we compared the sample entropy indicators for true and false responses with a similar differentiation degree. In the process of lying with instructions to conceal the year of birth ($t = -1.935$; $p = 0.049$) and the school mark ($t = -3.236$; $p = 0.003$) the entropy decreases. On the other hand, the complexity of HR increases during the lies about the name ($t = 2.649$; $p = 0.012$) and school type ($t = 2.340$; $p = 0.030$). In tests with concealed age ($t = -0.207$; $p = 0.837$) and place of employment ($t = 0.164$; $p = 0.872$), that is, for the relatively recently acquired experience, there were no differences in the realization of lie- and truth-related behavior (Fig. 2).

Discussion

We analyzed HR entropy in examinees who underwent polygraph tests in stress. The negative inverse correlation was found between the entropy and the LF/HF indices for each stage. According to the HRV spectral indicators, when the stress level increases, the entropy decreases significantly, which is the temporary systemic dedifferentiation that characterizes stress (Alexandrov et al., 2017; Bakhchina & Alexandrov, 2017).

According to the results of the experiment, there were no differences in entropy for each of the testing stages in those who had different experience of passing polygraph testing. Furthermore, the dynamics of the actualization of subjective experience of examinees almost did not change throughout the study. It is known that any FS fundamental architecture includes a feedback loop designed to reorganize the behavior to obtain the most favorable programmed result (Anokhin, 1973). Participants who undergo polygraph tests are not often aware of the individual test results and changes in physiological parameters are not available for direct observation. In this case, there is no opportunity to correct (improve) individual behavior due to the reduced feedback on the behavior result achieved.

When analyzing data related to a relatively early experience (year of birth and name), differences were revealed in the entropy indices for true and false answers (separately). A similar dynamic was found for true answers related to relatively early experiences. Questions related to the years of birth and the school mark, as well as the name and the type of school, can be grouped according to the fact that they reflect behavior associated with school experience. In turn, qualitative and quantitative characteristics are associated with FS of different subdomains of experience. The implementation of true answers to information expressed in quantitative values (numbers) clearly involves a greater number of heterogeneous FS. At the same time, in the case of lying about autobiographical information acquired early, the opposite trend is observed. The behavior associated with the concealment of the year of birth includes fewer FSs and is simpler (related to fewer behaviors) compared to the concealment of names.

This can be seen in more detail in the material of HR entropy comparing the implementation of lying and truth-declaring behaviors related to the information associated with FS of the same degree of differentiation. HR becomes more complex in the situation of concealing autobiographical information expressed by the text. On the contrary, when concealing numerical information, its complexity decreases. Thus, in a lie situation during polygraph tests HR entropy does not change in one direction. The relativity of changes depends on the initial differentiation of the experience that will be concealed (Fig. 2). Obviously, the concealment behavior associated with numerical information is simpler because it involves the realization of all available components of the indicated experience. It was also shown earlier that lying about school marks is one of the first concealing behaviors that develop in a child (Khazova, Mosina, & Us, 2016). Moreover,

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this dynamic is observed only with the actualization of early and comparatively early behavior systems. This was not revealed for new behaviors (Fig. 2). In a number of experiments conducted within the system-evolutionary framework, it was discovered that, in a stressful situation, the new experience is partially deactivated. In this case, the mechanisms providing behavior shift towards relatively less differentiated and older systems (Alexandrov, 2016; Alexandrov et al., 2017).

In general psychological practice, 'lie' and 'truth' usually represent a dichotomy and are opposed to each other (see Znakov, 2019). However, the study shows that the 'lie' in the polygraph testing process apparently does not represent a single 'universal' FS domain, which is realized in any deception situation. Statistically significant differences were recorded depending on the type of concealed information.

The problem of the existence and interaction of the 'system of lie' and the 'system of truth' was previously raised in the literature (Isaichev & Isaichev, 2016). The authors postulate that in the information concealment process during polygraph testing, there is a conflict between two 'systems' – the automated behavior strategy or the need to modify behavior (if the situation is assessed as threatening). Therefore, two (usually opposed) activities should be mentioned as groups of behaviors aimed at achieving many different results in two different ways – concealment and truth-declaring. The achievement of behavior results of both groups is provided by a variety of FSs. Differences in these groups are found not only between lying and truth-declaring behaviors, but also for the behavior within each of these groups. Truth-declaring is a set of different behaviors recorded in memory. From the point of view of the subject, most of them may not be specifically classified as 'truthful'. Lying have many results which achievement is guaranteed by various methods of deception. As a rule, these behaviors are classified as distortion or information concealment by the subjects. Further research can be directed towards the experimental development of these descriptions, for example, by comparing the brain activity in situations of 'similar' lies that involve various goal achievements.

At the same time, information concealment behavior (which is associated with the formation of special systems to achieve specific new results) is not completely new, but is based on individual experience, as any behavior is the implementation of many systems of different ages (Shvyrkov, 2004; Alexandrov et al., 2017). Although being formed in the process of testing on a polygraph (and possibly in a number of situations before it), at the first encounter with a polygraph testing situation, the individual is very likely to have lying experience in a situation of social interaction (conversation).

In the process of passing polygraph tests, the formation of the FS does not seem to occur for the implementation of concealment behavior as such. It depends on the characteristics of that experience subdomain to which the behavior belongs (for which achievement the lie is used). This may also explain the presence of distinct changes in physiological parameters in testing in a situation of question significance due to any other reason besides concealing: for example, in the case of interviewing an innocent person not willing to reveal real criminals. Polygraph testing has its own motivational characteristics in contrast to indicator registration under other conditions. However, these findings are related to concealment behavior that occurs in different stress situations. For a more detailed consideration of the subject of the study, the data obtained under control (non-stress) conditions are required.

In addition to the general functional definition of testing using a polygraph as a procedure for registering a number of physiological parameters under controlled conditions (Ogloblin &

Molchanov, 2004), there are others, depending on the theoretical model on which its authors base on. In this case, testing is defined as a procedure for testing memory, attention, motives, etc. (Obukhov & Obukhova, 2011; Isaichev & Isaichev, 2016; Mailis & Kholodnyi, 2021). Therefore, it is possible to consider a polygraph examination as a procedure for testing individual experience, aimed at comparing the dynamics of this experience in two situations – truth or lie to achieve results. Moreover, during passing the test, both the urgent formation and implementation of the tested (specific for a given situation) relationship between the organism and the environment take place, as well as the diagnosis of such relationship experience in the past. And as indicated above, it is probably difficult to change the current relationship generated by the tests.

The data obtained in the experiment enabled confirmation of the hypotheses of the present study and the outline of the methods for subsequent studies. First, it is possible to record heart rate when performing similar behavior actions in a test situation, but without stress, for a more complete data analysis. It is also possible to analyze behavior when information related to other areas of experience is concealed, e.g., approach/withdrawal (see Kolbeneva & Alexandrov, 2016). Furthermore, similar experiments were carried out in the form of 'blind' experiments to increase the environmental validity of the method. In this case, the polygraph examiner does not know the concealed information in advance (Ogloblin & Molchanov, 2004), including the ability of the examiner to select the information to be concealed independently (see Kireev, 2017).

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A. V. Uchaev contributed to the design development, conducted the experiment, carried out statistical data processing, interpreted the findings, and prepared the draft of the manuscript. **Yu. I. Alexandrov** suggested the idea of the study, contributed to the design development, conducted the experiment, interpreted the findings, and prepared the manuscript for publication.

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