

# Time Synthesis in Organization of Sensorimotor Action

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**Abstract:** *Time synthesis of sensorimotor action is reviewed as a process of a coherence setting action duration (expected duration), time sequence of required operations and significant changes in conditions. Aim: to experimentally set up the connection of time synthesis success and efficiency of realization sensorimotor action in changeable conditions. Hypothesis: successful time synthesis of the setting duration and the temporal sequence of operations in the mental organization of sensorimotor action in changing conditions is realized in accordance with the corresponding operational meaning and is allowed by anticipatory effects and an increase in the effectiveness of the action, materials and methods. An experimental study involved 152 male and female students. Participants of the investigation solved experimental tasks, implemented in a computer version, according to schemes of a simple visual-motor reaction and a choice reaction (separately and in combination), according to a scheme of sensorimotor action with a warning signal when the apperceptive scheme, setting duration and sequence of required operations were changed promptly. Results were reviewed in the aspect of disclosing the features of the subject's elimination of the uncertainty of the moment of achieving the goal in the future and the construction of a sequence of operations of sensorimotor actions in a connection with changes in external conditions, typical for the time deficit regime. The conditionality of the time synthesis of sensorimotor action by the actual operational meaning was established revealing that the successful temporal synthesis of sensorimotor action in changing conditions is associated with the fastest acceptance of an adequate apperceptive scheme, with effective anticipation of the moment of achieving the goal and the formation of a detailed setting duration of action, with the formation of a temporal sequence of required operations. Conclusions. The levels of success of the time synthesis of sensorimotor action in changing conditions are highlighted: "quite successful; moderately successful; unsuccessful."*

**Keywords:** *Setting, anticipation, operational meaning, duration, apperceptive scheme.*

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## 1. Introduction

In studies of self-regulation of the psychological system of activity, the emphasis is on determining the composition, content, functions, connections of the components of its structure, on highlighting the specifics of the successive stages of goal achievement (Gordeeva, 2000). At the same time, the time parameter of the organization of actions is presented mainly in quantitative terms in generally accepted units of time assessment as the sum of the durations of performing sequential operations, and as the measured total duration of solving the task. In general, knowledge of certain time guidelines (including clock readings) in the implementation of the action program for the subject is necessary. But often this is not enough for effective self-regulation. This insufficiency is especially evident in the organization of actions at small time intervals (seconds), when the use of external time meters becomes ineffective and often inhibits the performance of basic operations (Plokhikh, 2006; Strelkov, 2008). The latter is becoming increasingly evident in sports (Camenidis et al., 2021; Cheban et al., 2020; Hromcik et al., 2019), when driving high-speed vehicles (Zinchenko et al., 2019, 2020a, 2020b, 2020c), in solving problems in numerous extreme situations (Nosov et al., 2020a, 2020b, 2020c; Shevchenko et al., 2020a, 2020b).

The information basis of activity contains information about the current situation that changes in a regular or random way (Konopkin, 1980). At the same time, changes in the situation at any stage of the action program, limited in duration, are important not only for current corrections but also including coordination of operations. Relevant changes in conditions must necessarily be taken into planning of timely achievement of the final goal. Current changes in the speed and intensity of the implementation of operations of the program sequence should be consistent with the integral time perspective of the performance of actions: with the time and effort already spent with the results achieved; with the remaining time to complete the required operations. Such a reconciliation of the whole and parts of the time dimension of action is actually represented as its time synthesis.

Analysis of the literature shows that in studies of time, a special role is assigned to the consideration of the time sequence and the disclosure of the meaning of duration (Plokhikh, 2019). In a natural process, the duration and temporal sequence of changes appear in unity as the proper time of the process (Vladimirskiy et al., 2014). Simultaneously, the removal of the problem of the time synthesis of duration and sequence is considered in

terms of resolving the contradictions between the whole and its parts, content and form, continuity and discreteness.

In representations of duration, a qualitative uniqueness of a certain process is noted in connection with the continuity, direction, integrity of its implementation (Bergson, 2006; Gaydenko, 2006; Vladimirskiy et al., 2014). In quantitative terms, the duration as a whole appears as a unit measure of the proper time of the process, and in measurements from the outside by generally accepted units of time - as the total duration of the process. At the same time, the temporal sequence is viewed as a chain of events that naturally unfolds in time, some of which, due to their importance, act as “special points”. Studies of time sequences do not provide a reliable basis for proving the continuity of the passage of time. To highlight such grounds, Grünbaum (2003) and Poincaré (1990) propose to refer to qualitatively specific psychological time.

In literary sources, psychological time is characterized as experienced, lasting, qualitatively determined, marked by the presence of “special points”, not measured by conventional measures and methods (Bergson, 2006; Gaydenko, 2006). Psychological time is viewed as a synthesis of the duration experienced by a person and the distinguished sequence of events in the processes of reality. A model of hierarchical subordination and parity of processes with their assignment to different levels of temporality can be taken as a theoretical basis for describing such a temporary synthesis (Alyushin & Knyazeva, 2008). In this case, it is assumed that the duration of the process, in accordance with a certain meaning, is established at a higher level of the hierarchy, and the sequence of events unfolds at the underlying levels of temporality.

The connecting, determining and guiding role of the duration of the realization of mental processes in the organization of human behavior and actions is noted by Strelkov (2008). Within the limits of the continuing process, the events of the time plans of the past, present and future unite and interpenetrate. As a mental phenomenon, the duration of actions is associated with the actual attitude (Plokhikh, 2019). It is the attitude in its integrity, continuity and stability that ensures the implementation of a continuing action in the unity of its constituent structures.

The estimated and actual durations of action ideally coincide. However, in reality, the targeted efforts of the subject are influenced not only by, accounted for, but also by random factors. The latter requires flexibility and necessary restructuring of both individual components and the entire system of regulation of actions and, accordingly, an adequate time synthesis (Strelkov, 2008). In the case of small disturbances, the correction

of time synthesis can take place at the level of a time sequence by changing the pace, intensity of implementation, combining operations and actions, as, for example, in modes of acute or moderate time deficit (Plokhikh, 2006). With more radical changes in the situation, the question is raised about changing the most relevant attitude. A constructive prerequisite for the latter is the presence in the information basis of the activity of a significant amount of conscious and unconscious information about the current situation. This information, together with accompanying information from past experience and expectations for the future, can be viewed by the subject from different "positions" and with the allocation of different content into a holistic, panoramic, dynamic operational image (Zavalova et al., 1986). Such "positions" are quite consistent with the definition of operational meaning (Tikhomirov, 1981). It is in this variant that the unconscious operational meanings in the corresponding time frame of the duration of the action act as a kind of "pre-goal" and are manifested in apperceptive schemes, anticipation, and expectations.

Within the set duration of the action, the subject combines the time plans of significant processes on the basis of an updated operational meaning that determines the accents of a holistic view of reality. The combined processes are characterized by their own intensity, direction, tendency, their own "special points". Time plans for these processes were initially largely inconsistent. For their expedient coordination or dilution, directed efforts of the subject are required to identify the sequences of "special points" of processes, to assess and change the available time intervals between these "points" in the integral time structure of the action. In such a representation of the time regulation of the action, its setting duration, the time sequence of operations and significant changes in conditions are combined with an orientation towards a certain expedient effect in the future. The latter, in fact, corresponds to anticipation as a necessary component of the organization of the system of activity (Zavalova et al., 1986).

Anticipation in the development of the set duration of action is determined by the operational meaning, proceeds from information about the events of the past and the present, and is a foreseeable limiting event at some moment in the future. In terms of organizing the time sequence in the action program, anticipation orients towards the logical completion of the chain of operations and changes in conditions. A successful time synthesis in the organization of an action must coordinate in a changing situation the anticipated moment of achieving the goal with the expected moment of completion of the entire sequence of necessary operations.

The presented time relationships in the organization of actions are of a general nature. For a specific action, they are specified depending on the meaning, goals, means, conditions. The longer the process of achieving the goal is, the more difficult is to determine the experiences and outlines of the set duration of the action, but the more clearly the events that make up the time sequence can be distinguished. The necessary clarity in the allocation of the components of temporary synthesis can be achieved in the study of sensorimotor actions carried by the subject under various conditions out. The prerequisites for that are the following: admissibility of effective control over the connection of external influences with the result of the response; the ability to select a relatively simple sequence of operations in the structure of an action; short duration of action, realized mainly at an unconscious level of mental activity; known regulatory function of the warning (indicative) signal; relatively simple assessment of anticipatory effects (Boyko, 2002; Gellershteyn, 1958; Shoshol, 1978). To this should be added the great practical and theoretical value of studies of sensorimotor actions noted in the literature (Barkhuizen et al., 2002; Boyko, 2002; Gellershteyn, 1958; Strelkov, 2008).

Sensomotor actions simulate the maximum speed and intensity modes of human activity. In these modes, the uncertainty of the situation and changes in the individual components of the temporary synthesis of the mental organization of the action are essentially interrelated. The duration of the action is associated with implementation of the sequence of operations with the required speed and accuracy. However, within the very duration set by the target setting (Asmolov, 1979), the integral complex of consistent, purposeful human efforts must be consistent with changes in conditions. The subject of the research is the time synthesis of the setting duration and the time sequence of operations in the mental organization of sensorimotor action in changing conditions.

### ***The aim***

Experimentally to establish the connection between success of time synthesis and the effectiveness of the implementation of sensorimotor action in changing conditions.

### ***Hypothesis***

Successful time synthesis of the setting duration and time sequence of operations in the mental organization of sensorimotor action in changing conditions is realized in accordance with the corresponding operational

meaning and is resolved by anticipatory effects and an increase in the effectiveness of the action.

***Research tasks:***

1) theoretically to highlight constituent components and indicators of the success of the temporary synthesis of sensorimotor action;

2) experimentally to establish the connection between the effectiveness of sensorimotor action and the level of certainty of the components of the mental organization of time synthesis;

3) to determine the success of the time synthesis of sensorimotor action in connection with anticipatory effects and general effectiveness of the action.

**2. Materials and methods**

While constructing an empirical picture of the study of time synthesis in the organization of sensorimotor action, methodological principles were taken into account by us, validated in adaptation (Blynova et al., 2020a, 2020d), professional activity (Blynova et al., 2020b, 2020c; Griban et al., 2019; Halian et al., 2020b, 2020c; Popovych et al., 2020) and emotional intelligence (Halian et al., 2020a, 2021; Khmiliar et al., 2020; Shkola et al., 2019).

The study subjects were male and female students. In experiments 1 and 2 (intra-subject experimental and quasi-experimental schemes), held with a difference of one and a half years, male groups included 35 (age: Me = 20, min = 17, max = 25) and 43 (age: Me = 19, min = 17, max = 24) people, and women's groups, which included 31 (age: Me = 20, min = 17, max = 23) and 43 (age: Me = 18, min = 16, max = 25) people, completely differed in the composition of the subjects.

The subjects performed a range of experimental series, solving problems of sensorimotor response in various conditions (Plokhikh, 2021). The experimental tasks were implemented in the form of computer programs. In solving problems, the subjects were required to react as quickly as possible to the appearance of a stimulus (a burgundy square) on the monitor screen by pressing the corresponding key on the keyboard. In the experiments, the actual variants of stimulation and the place of the appearance of the stimulus on the screen in the next test were established using a random number generator. The subjects performed training and experimental tests. The time interval between the samples varied randomly within 1.70 – 2.30 s.

In series 1, in experiments 1 and 2, subjects solved a problem, organized according to the scheme of a simple visual-motor reaction. In accordance with such a scheme, a square stimulus automatically appeared in the centre of the monitor screen. In response, the subject had to press the “↓” key on the keyboard as quickly as possible. The reaction time was determined. In series 1, the subjects performed 5-7 training and 25 experimental tests according to the following instruction: “You should react as quickly as possible to the appearance of a burgundy square in the central part of the screen by pressing the “↓” key”.

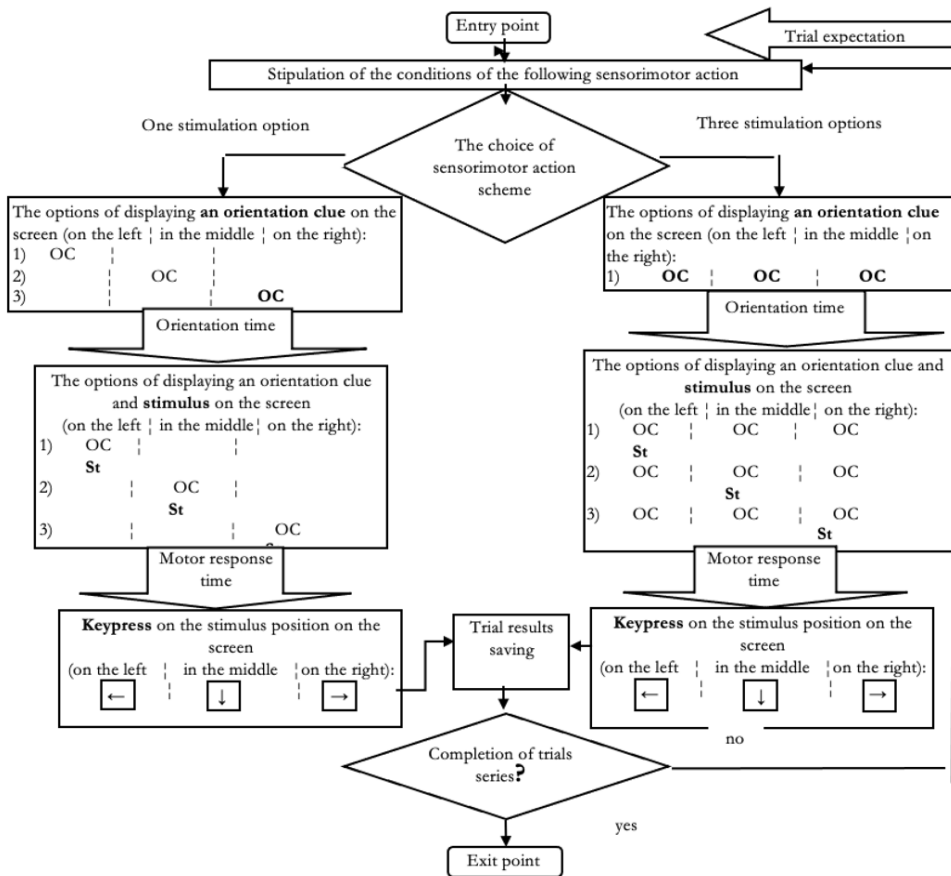
In series 2, in experiments 1 and 2, subjects solved a problem, organized according to the scheme of the visual-motor selection reaction. In this problem, a square stimulus could appear on the screen in one of three places: to the left of the center of the screen; in the center of the screen; to the right of the center of the screen. For each variant of the appearance of a stimulus, the fastest reaction of the subject was assumed by pressing the corresponding key on the keyboard: stimulus on the left – key “←”; stimulus in the center – “↓” key; the stimulus to the right is the “→” key. The response time was determined. In series 2, 5 – 7 training and 25 experimental tests were performed. In the problem on the selection reaction, the subject received the following instruction: “You must react as quickly and correctly as possible to the appearance of a burgundy square in one of three possible places on the screen by pressing one of the adjacent keyboard keys: the square on the left of the screen – “←”; square in the center of the screen – “↓”; the square on the screen to the right is “→””.

In series 3 and 4 of experiment 1 and series 3, 4, and 5 of experiment 2, the subjects solved the “double choice” (DC) problem, in which the scheme of action (apperceptive) was first adopted with one stimulation option (1\_SO) or with three stimulation options (3\_SO), and then a key for a motor response was selected (Fig.). Option 1\_SO was implemented on the monitor screen as one of three possible cases of implementation of option 3\_SO.

The DC task was developed according to a response scheme with a warning signal and taking into account the effects described by W. Hick's law (an increase in the number of options for possible stimuli causes an increase in the reaction time) (Chuprikova, 1995; Shoshol, 1978). In constructing the experimental problem, it was taken into account that, under conditions of uncertainty, the subject is guided by the broadest information context and the largest number of options for the development of the situation (Shoshol, 1978; Plokhikh, 2019), and reorientation to a new situation takes time (Gordeeva, 2000).

In the next trial of the DC task, during some period of time (orientation time) before the presentation of the stimulus, the possible variants of the place of its presentation were indicated on the screen. For this purpose, burgundy-colored reference circles were displayed above the possible places of stimulus presentation (Fig. 1). If the 1\_SO scheme was assumed, then one landmark circle was displayed exactly above the place where the stimulus was presented afterwards. In the case of the 3\_SO scheme, reference circles were displayed above all three possible places of the stimulus appearance, and then the stimulus was presented in one of these places. Both according to the 1\_SO scheme and the 3\_SO scheme, in response to the presentation of the stimulus, the subject had to press the keyboard key as quickly as possible, which corresponded to the position of the stimulus on the screen (see Fig. 1). The correspondence of keyboard keys and places of stimulus presentation on the screen in the DC task is the same as in the scheme of the visual-motor selection reaction in series 2. The instruction for solving the DC problem was the following: “Some time before the appearance of the square stimulus, the places of its possible appearance are indicated on the screen (one or three) by displaying small burgundy circles above these places. You must react as quickly and correctly as possible to the appearance of a burgundy square on the screen by pressing one of the adjacent keyboard keys: the square on the left of the screen – “←”; square in the center of the screen – “↓”; the square on the screen to the right is “→””.





Notes: MRT – motor (motor) response time of the subject; OC – orientation; St – stimulus.

**Fig. 1.** Scheme of the organization of sensorimotor action in the “double choice” problem

The DC task in experiments 1 and 2 differed in the way of changing the orientation time in a series of tests. In experiment 1, series 3 and 4 each had three possible values of the orientation time, selected for the next sample using a random number generator. In series 3, the orientation time was: .05 s; .15 s; .25 s. In series 4, the orientation time was: .10 s; .20 s; .30 s. In experiment 2, in series 3, 4, and 5, the orientation time from sample to sample was automatically changed with a “step” of .05 s (no less than zero seconds). The indication for a change in the duration of orientation in the next test was the result of a program comparison of the motor response time in the performed test in the case of 1\_SO and the previously

established quantile of the distribution of the simple reaction time of the subject in series 1 as a criterion for changing the orientation time (COT criterion). If the value of the first parameter exceeded the value of the second one, then the orientation time in the next test increased by .05 s; otherwise, the orientation time decreased by .05 s. In experiment 2 in series 3, 4, and 5, the value of the COT criterion was different. These criteria for each subject were: median 50.0% (series 3), 75.0% (series 4), and 95.0% (series 5) quantiles of the time distribution for a simple reaction in series 1.

In experiment 1, in series 3 and 4, in the DC task, it was supposed to perform 7–10 training and 65 experimental tests. In experiment 2 in series 3, 4 and 5, the subjects performed 7–10 training and 41 experimental tests.

In the experimental task DC, the independent variables were: orientation time and the number of stimulation options (one or three); the dependent variable – motor response time (MRT) of the subject to the appearance of the stimulus. The number of stimulation options determined the apperceptive scheme and the operational sequence of the subject's motor response to the appearance of the stimulus. The orientation time also conditioned the transition from the sequence of operations for variant 3\_SO to the sequence of operations for variant 1\_SO, and the activation of anticipation processes. The independent variables had a complex effect: the orientation signal indicated the operational sequence (1\_SO or 3\_SO) and was the starting point for the orientation time. In the experiments in each trial, the subject had to take into account three possible variants of the orientation time: in experiment 1 – three given; in experiment 2 – according to the performed test, more and less by .05 seconds from the orientation time in the performed test. In the series of experiment 1, the range of possible changes in the orientation time in the next test as an indicator of changes in external conditions is at least twice as large as in experiment 2. Accordingly, in experiment 2, the external conditions were more stable, and the connection between the setting duration and the operational the sequence of sensorimotor action was more pronounced.

After each test, the following information was recorded in the data array: stimulus code; time between samples; reaction time (RT) in series 1 and 2; the time of the motor response in the DC task; the fact of the correct choice and pressing of the key; the fact that the key was pressed prematurely; orientation time (task DC); relevant options for stimulation (task DC). At the end of the series of tests, the data were automatically processed and entered into the test subject's results file. The success of the temporary synthesis of sensorimotor action was assessed by error-free tests according to the following parameters: RT; MRT; orientation time; the likelihood of

pronounced anticipatory effects. Data processing was carried out by using the statistical package IBM SPSS Statistics v. 20.

### 3. Results

The distributions of RT and MRT in the groups of subjects in experiment 1 were checked for compliance with the normal law (Kolmogorov-Smirnov criterion). In this regard, a positive result was obtained in most cases. However, for the time of a simple reaction in both groups and for two regimes in the 3\_SO variant in the DC task in the female group, the normal law was not established in the distributions of sample data. Statistical indicators of MRT in groups of subjects for solving the problem of DC in experiment 1 are given in Tabl. 1.

**Table 1.** The time of the motor response in the male and female groups of subjects in experiment 1 with different values of the orientation time in the “double choice” problem

Groups	Quantity of stimulus variants	Parameter, s	Orientation time					
			.050	.100	.150	.200	.250	.300
Men (n=35)	1	$\bar{M}$	.331	.291	.268	.219	.191	.135
		SD	.041	.038	.048	.045	.063	.064
		Me	.330	.290	.270	.230	.200	.140
	3	$\bar{M}$	.319	.308	.304	.295	.287	.280
		SD	.038	.030	.037	.038	.032	.039
		Me	.320	.310	.300	.290	.290	.270
Women (n=31)	1	$\bar{M}$	.340	.308	.273	.237	.197	.154
		SD	.048	.040	.044	.057	.063	.075
		Me	.340	.300	.260	.240	.210	.150
	3	Me	.320	.320	.300	.280	.290	.290
		min	.240	.210	.230	.230	.190	.230
		max	.420	.390	.380	.390	.410	.380

There were pronounced anticipatory effects in the decisions of the subjects in experiment 2. These effects were noted in cases where the subject's MRT to the stimulus in option 1\_SO was less than the minimum reference value for a simple visual-motor response (.150 s) (Boyko, 2002). The probability of anticipation was determined as the ratio of the number of pronounced anticipatory effects to the number of error-free samples in the series. Male and female groups were divided into subgroups according to the probability of anticipation in series 3, 4 and 5. Cluster analysis (hierarchical

clustering) made it possible to identify male subgroups 1 and 2 (23 and 20 subjects) and female subgroups 1 and 2 (22 and 21 subjects). The correspondence of the distributions of MRT and the time of orientation in subgroups to the normal law was established, and the parameters of these distributions were determined (Tabl. 2 and Tabl. 3).

**Table 2.** Orientation time in subgroups of subjects in series 3, 4 and 5 of experiment 2 in the “double choice” problem

Subgroups	Parameter, s	Series 3 (50.0% quintile)	Series 4 (75.0% quintile)	Series 5 (95.0% quintile)
<i>Men 1</i> ( <i>n</i> =23)	$\bar{M}$	.206	.163	.085
	<i>SD</i>	.079	.042	.048
<i>Men 2</i> ( <i>n</i> =20)	$\bar{M}$	.238	.162	.109
	<i>SD</i>	.060	.045	.049
<i>Women 1</i> ( <i>n</i> =22)	$\bar{M}$	.251	.184	.106
	<i>SD</i>	.069	.082	.048
<i>Women 2</i> ( <i>n</i> =21)	$\bar{M}$	.258	.168	.104
	<i>SD</i>	.058	.055	.048

**Table 3.** Comparison results (Student’s t-) of motor response time in subgroups of subjects in series 3, 4 and 5 of experiment 2 in the “double choice” problem

Sub groups	Parameter, s	Series 3 (50.0% quintile)		Series 4 (75.0% quintile)		Series 5 (95.0% quintile)	
		MRT1	MRT3	MRT1	MRT3	MRT1	MRT3
<i>Men 1</i> ( <i>n</i> =23)	$\bar{M}$	.225	.294	.245	.297	.276	.307
	<i>SD</i>	.023	.024	.019	.024	.036	.023
<i>Men 2</i> ( <i>n</i> =20)	$\bar{M}$	.193	.295	.231	.302	.257	.303
	<i>SD</i>	.017	.031	.025	.031	.031	.027
	<i>t</i>	5.235	.131	2.094	.533	1.834	.543
	<i>p</i>	.000	.896	.042	.597	.074	.590
<i>Women 1</i> ( <i>n</i> =22)	$\bar{M}$	.249	.326	.268	.336	.302	.339
	<i>SD</i>	.031	.037	.025	.036	.031	.037
<i>Women 2</i> ( <i>n</i> =21)	$\bar{M}$	.201	.308	.244	.317	.283	.320
	<i>SD</i>	.022	.036	.035	.030	.033	.030
	<i>t</i>	5.891	1.636	2.659	1.807	1.974	1.849
	<i>p</i>	.000	.109	.011	.078	.055	.072

Notes: *p* – probability of type 1 error; MRT1 – motor time response with one possible stimulus; MRT3 - motor time response with three possible stimuli.

Significant differences were established between the subgroups in terms of the MRT parameter in option 1\_SO in the solutions of the DC problem (see Tabl. 3). The orientation time in subgroups 1 and 2 under the same conditions does not differ statistically (see Tabl. 2). It should also be noted the presence in the subgroups of pronounced similar tendencies of an increase in the orientation time and a decrease in MRT in variant 1\_SO in series 3, 4 and 5 with a change in the quantile of the distribution of the time of a simple reaction as a criterion of COT (see Tabl. 2 and Tabl. 3). Similar results were obtained in experiment 1 (see Table.1). Statistical analysis of the significance of MRT changes with a change in orientation time in option 1\_SO in the DC task for all groups and subgroups of subjects gave a positive result (Tabl. 4). Taking this into account, mathematical models were obtained for the linear connections between changes in the mean values of MRT per stimulus in variant 1\_SO with a change in orientation time for groups and subgroups of subjects (Tabl. 5).

**Table 4.** The results of comparing the motor time response of the subjects when the time of orientation was changed in the series of solving the “double choice” problem in experiments 1 (df = 5) and 2 (df = 2) according to Friedman’s  $\chi^2_r$  criterion

Stimulus	Parameter	Experiment 1		Experiment 2			
		Men (n=35)	Women (n=31)	Subgroups men		Subgroups women	
				1 (n=23)	2 (n=20)	1 (n=22)	2 (n=21)
1	$\chi^2_r$	160.033	141.659	32.725	34.203	30.545	32.667
	<i>p</i>	.000	.000	.000	.000	.000	.000
3	$\chi^2_r$	34.770	30.662	7.000	1.872	3.909	2.220
	<i>p</i>	.000	.000	.030	.392	.142	.330

Notes: p – probability of type 1 error.

**Table 5.** Parameters of mathematical models of the linear connection of the motor time response of the subjects to the signal in the variant with one possible stimulus and the orientation time in the “double choice” problem in the series of experiments 1 (df = 4) and 2 (df = 1)

Experiment	Subjects	Model Parameters		Characteristics	
		Constant	Coefficient	$R^2$	<i>p</i>
1	Men (n=35)	.372	-.759	.988	.000
	Women (n=31)	.382	-.748	.997	.000
2	Men subgroup 1 (n=23)	.312	-.419	.998	.026
	subgroup 2	.311	-.496	1.000	.003

		(n=20)			
Women	subgroup 1	.340	-.368	.991	.060
	(n=22)				
	subgroup 2	(n=21)			
	(n=21)	.336	-.529	.995	.044

Notes: p – probability of type 1 error; R<sup>2</sup> – the proportion of the variance of the motor time response due to the orientation time.

The linear connection of a decrease in MRT to a stimulus in variant 1\_WS in the DV task with an increase in the orientation time is conditionally limited. The values of the choice reaction time and the simple reaction time act as a kind of limits between which the reorientation of the sensorimotor action from the 3\_SO variant to the 1\_SO variant should mainly occur. The fact of the presence of such a range of values and, in fact, the implementation in experiments of W. Hick's law is confirmed statistically (Tabl. 6).

MRT per stimulus in variant 3\_SO in the DC task in all cases is slightly less than the RT of choice (see Tables 1, 3, 6). In some cases, MRT to a stimulus in variant 3\_SO slightly decreases with an increase in the duration of orientation (see Tabl. 1, 3, 4). The situation is different with respect to the motor response to the stimulus in variant 1\_SO.

**Table 6.** Comparison results (Student's t-test, Wilcoxon's Z-test of sign ranks) of the time of a simple sensorimotor reaction and choice reaction in groups and subgroups of subjects in experiments 1 and 2

Reaction parameter, s	Experiment 1		Experiment 2				
	Men (n=35)	Women (n=31)	Subgroup's men		Subgroup's women		
			1 (n=23)	2 (n=20)	1 (n=22)	2 (n=21)	
<i>Simple</i>	$\bar{M}$	–	–	.224	.210	.236	.217
	<i>SD</i>	–	–	.017	.017	.019	.023
	<i>Me</i>	.220	.220	.230	.214	.235	.219
	<i>min</i>	.150	.190	.190	.175	.206	.174
	<i>max</i>	.260	.280	.260	.250	.271	.262
<i>Choice</i>	$\bar{M}$	.323	.348	.323	.323	.367	.348
	<i>SD</i>	.038	.037	.035	.034	.051	.045
	<i>Me</i>	.320	.340	.325	.326	.366	.360
	<i>min</i>	.260	.290	.264	.230	.283	.258
	<i>max</i>	.410	.420	.393	.374	.514	.452
<i>Scale</i>	<i>t</i>	–	–	15.071	16.597	13.691	16.078
	<i>Z</i>	-5.169	-4.870	–	–	–	–
	<i>p</i>	.000	.000	.000	.000	.000	.000

Notes: p - probability of type 1 error.

The orientation time, required to achieve the level of efficiency of a simple visual-motor reaction in motor responses in variant 1\_SO was determined. In experiment 1, statistical analysis (Wilcoxon's sign rank test) showed that, in the male and female groups, the motor response to a stimulus in variant 1\_SO in relation to a simple reaction: slower with an orientation time of .05 sec ( $Z = -5.169$ ,  $Z = -.865$  at  $p = .000$ ), at .10 s ( $Z = -5.170$ ,  $Z = -4.851$  at  $p = .000$ ), at .15 s ( $Z = -4.857$ ,  $Z = -4.502$  at  $p = .000$ ); does not differ for an orientation time of .20 s ( $Z = -1.296$ ,  $p = .195$ ;  $Z = -.987$ ,  $p = .324$ ); faster at an orientation time of .25 s ( $Z = -1.936$ ,  $p = .053$ ;  $Z = -2.473$ ,  $p = .013$ ), at .30 s ( $Z = -4.765$ ,  $Z = -3.993$  at  $p = .000$ ). According to the results of experiment 2, it was established (t - Student's criterion) that MRT in variant 1\_SO in series 3 (50% quantile of the distribution of the time of a simple reaction as a criterion for COT): for male and female subgroups 2 there is less time for a simple reaction ( $t = 4.145$ ,  $df = 19$ ,  $p = .001$ ;  $t = 3.819$ ,  $df = 20$ ,  $p = .001$ ); for male subgroup 1 does not differ from the simple reaction time ( $t = .107$ ,  $df = 22$ ,  $p = .916$ ); for female subgroup 1, more simple reaction time ( $t = 2.711$ ,  $df = 21$ ,  $p = .013$ ).

In connection with the presented results, two aspects of the analysis of the organization of sensorimotor action in option 1\_SO in the DC task are distinguished. This is, firstly, the determination of the shortest orientation time required for a full-fledged temporary synthesis of sensorimotor action. And, secondly, the activation in the psychological system of the activity of the mechanisms of anticipation, providing a decrease in MRT.

According to the table. 5, the mathematical relationship of MRT and orientation time was used to calculate the orientation time required to achieve MRT to a stimulus in variant 1\_SO of the time of a simple sensorimotor reaction. The following calculated values were obtained: in experiment 1 for the male and female groups, respectively - .200 s and .217 s; in experiment 2 for subgroups 1 and 2 men, respectively - .210 s and .204 s, and for subgroups 1 and 2 women, respectively - .283 s and .225 s. Statistical comparison (one-sample t-test) of the calculated and actual values of the orientation time in series 3 of experiment 2 (see Table 2) showed: for male subgroup 1, there was no statistical difference ( $t = .228$ ,  $df = 22$ ,  $p = .822$ ); for male and female subgroups 2 - the relevant orientation time is excessive ( $t = 2.543$ ,  $df = 19$ ,  $p = .020$ ;  $t = 2.599$ ,  $df = 20$ ,  $p = .017$ ); for female subgroup 1, there was no statistical difference ( $t = .896$ ,  $df = 21$ ,  $p = .380$ ) with an obvious lack of time for orientation (see Table 2) and high MRT values.

The highest uncertainty in the temporal regulation of sensorimotor action was in cases of a simple reaction and a choice reaction (series 1 and 2). As a consequence, the probabilities of anticipation, calculated as the ratio of the number of pronounced anticipatory effects to the number of error-free samples in a series, did not exceed  $p = .017$  for these series. Other results were obtained for the solution of the DC problem. When comparing the probabilities of anticipation in series 3, 4, 5 in the subgroups of the subjects, differences were found in all cases (Tabl. 7).

Subgroups of subjects in experiment 2 were compared (U-Mann-Whitney test) in terms of the probability of premature motor responses in the DC task with a 50% quantile of the distribution of the simple reaction time as a COT criterion. The probability of premature motor responses was calculated as the ratio of the number of tests with a premature motor response to the total number of tests in the series. It was found that in the male subgroup 1 the probability of premature motor responses is lower in comparison with both the male subgroup 2 ( $U = 143.500, p = .019$ ) and with the female subgroups 1 and 2 ( $U = 189.500, p = .100; U = 145.000, p = .012$ ). In other cases of comparison, no statistical differences were noted.

**Table 7.** Comparison results ( $\chi^2_r$  – Friedman’s test) of the probabilities of anticipation when changing the orientation time in the series of solving the “double choice” problem in the subgroups of subjects in experiment 2 ( $df = 2$ )

Subjects	Medians of allocation probabilities of anticipations in series of experiment 2			$\chi^2_r$	$P$
	Series 3 (50.0% quintile)	Series 4 (75.0% quintile)	Series 5 (95.0% quintile)		
<i>Subgroup men 1</i> ( $n=23$ )	.095	.050	.000	24.405	.000
<i>Subgroup men 2</i> ( $n=20$ )	.227	.096	.045	20.865	.000
<i>Subgroup women 1</i> ( $n=22$ )	.062	.023	.000	17.294	.000
<i>Subgroup women 2</i> ( $n=21$ )	.222	.050	.000	29.951	.000

Notes:  $p$  – probability of type 1 error.

#### 4. Discussion

According to the definition of sensorimotor response, two “special points” are clearly distinguished in its structure: the appearance of a



stimulus; reaction (Shoshol, 1978). In the organization of the duration of action with such a structure, the components of the past and present are expressed, but with a high uncertainty of the moment of achieving the goal in the future. At the same time, the moment of reaction is not just the moment of the natural completion of the necessary sequence of operations against the background of increased excitability of certain parts of the brain. The studies of S. Gellershteyn (1958) showed that the subject, by purposefully combining the processes of conscious and unconscious levels of activity, is able to distinguish the features of the performance of a sensorimotor action, to establish, according to the requirements of the task, the criterion of the effectiveness of the result and significantly increase the speed of response (Gellershteyn, 1958). Through such regulation with activation of anticipation processes in the structure of action, the expected duration of goal achievement is also outlined, and uncertainty in the organization of action is reduced (Lomov & Surkov, 1980). On the contrary, an increase in the number of variants of possible stimuli, significantly increasing the uncertainty and fundamentally changing the structure of the sensorimotor action, helps to slow down the reaction (see Table. 6).

Preventive (indicative) information significantly activates the processes of anticipation in the structure of sensorimotor action. In this variant, the subject already at the moment of presentation of the stimulus, tuning in to a certain apperceptive scheme, actively develops the time perspective of the prepared action and sets its duration. At the same time, there are three key points in the mental organization of action: the appearance of a warning signal; the appearance of a stimulus; reciprocal movement. If the orientation time between the warning signal and the stimulus is unambiguous, a classic reflex for a time can be formed in a series of tests, which, within the limit, allows the simultaneous appearance of a stimulus and a response to it. A significant decrease in the time of sensorimotor action is achieved by anticipating the moment of a motor response, taking into account changes in conditions. Moreover, in our experiment, as in the study by S. Gellershteyn (1958), the anticipated moment of a motor response to a stimulus within the target setting was determined by the subjects taking into account a given criterion of response efficiency (COT criterion) at different levels of formation of the structure of sensorimotor action (see Tabl. 2 and Tabl. 3).

The transition from a “two-component” setting duration to a “three-component” duration required in solving the DC problem is a temporary synthesis, focused on changing the operational meaning of an action, on reorganizing the corresponding psychological mechanisms. These

transformations in the structure of action, in fact, take place in a time-deficit mode and are reflected in the final result (Plokhikh, 2006). In the most detailed version, the transition from “two-component” setting duration to “three-component” is represented by the results of experiment 1 (see Tabl. 1 and Tabl. 4). In series 3 and 4 of experiment 1, in a wide range of changes in conditions (orientation time), the peculiarities of the transition in the organization of sensorimotor action from the sequence of operations realized in the choice reaction to the sequence of operations of a simple reaction supplemented by anticipation operations are traced.

In effective terms (motor time response), the process of reorganization of the setting duration and the temporal sequence of operations of the sensorimotor action in connection with the time of orientation is presented as linear, overcoming the time limitations of a simple reaction through anticipation (see Tabl. 4 and Tabl. 5). In this process, the semantic accents are transferred from the accuracy of choice in the option 3\_SO to the maximum possible speed of response in the option 1\_SO. At the same time, the level of readiness of the “three-component” apperceptive scheme increases, and as a result, with a significant orientation time (.30 s), the action of anticipation mechanisms is unambiguously manifested, and the time of the subject’s motor response becomes significantly less, in comparison with a simple reaction (see Table. 1) . However, the latter is valid only for response movements to the stimulus in variant 1\_SO. In variant 3\_SO, the reference signal has a different effect on the action. Differences between the RT of choice (series 2) and MRT for stimuli in variant 3\_SO in the DC task indicate a rather rapid reorganization of psychophysiological mechanisms already at small values of the orientation time ( $\approx .05$  s). Analysis of the literature shows that such a rapid reorganization can occur due to anticipation of the subsensory level (Lomov & Surkov, 1980), which provides an anticipatory increase in nervous excitability in accordance with the current state and individual characteristics of a person (Shoshol, 1978; Silverman, 2010; Vladimirskiy et al., 2014).

Experiment 2 confirms the linear connection between the orientation time and MRT in all subgroups, as well as the pronounced orientation of the subjects to the specified criterion of effectiveness (see Tabl. 2, 3, 4). The only difference is the angle of inclination of the transition line from “two-component” to “three-component” setting duration. The latter can be closely related to a greater stability of conditions and, accordingly, stability of sensorimotor action in the DC problem in experiment 2.

In relatively stable conditions, the specificity of the ratio of anticipation of the moment of achieving the goal and the construction of a sequence of operations deployed in time becomes more pronounced. This specificity manifests itself when comparing the results of subgroups in series 3 with a 50.0% quantile of the distribution of the simple reaction time as a criterion for COT. Calculations indicate that in male subgroups 1 and 2, on average, almost the same orientation time is required for the transition to a pronounced “three-component” setting duration of action. However, in reality, in the male subgroup 2, as in the female subgroup 2, more time is spent on orientation. Additional time is spent on anticipation operations, to increase the anticipation effect and the overall effectiveness of the sensorimotor action, in comparison with a simple sensorimotor response (see Tabl. 7). In turn, according to the results of female subgroup 1, it can be seen that the subjects of this subgroup do not have enough time not only for anticipation operations, but also for a full transition to the sequence of operations of a simple sensorimotor reaction.

The stable inclusion of anticipation operations of the sensorimotor level into the structure of the sensorimotor action begins at an orientation time over .10 s (see Table 2 and Table 7). However, it should be assumed that just when the setting duration of the action is completely determined and consistent with the sequence of operations, then a sharp increase in the probability of anticipatory effects in subgroups 2 is possible with a significant increase in the effectiveness of the sensorimotor action. At the same time, the marked activation of anticipatory processes can also lead to premature motor responses with subsequent negative effects. The latter could affect the averaged results in experiment 1 (see Tabl. 1).

In terms of assessing the success of temporary synthesis and regulation of sensorimotor actions, the differences between the subgroups of the subjects in experiment 2 deserve special attention. It should be noted here that in life circumstances a person quite often faces the need for an emergency response due to sudden changes in the situation. But even an unlikely rapid change in the situation is often preceded by the appearance of precursor signals. And in this case, the ability of a person to consciously or unconsciously highlight warning signals, quickly determine the meaning of a situation, form an appropriate apperceptive scheme and target, build an appropriate program of action, anticipate future events, and the effectiveness of emergency actions actually depends. In connection with the foregoing, the following division of subjects according to the success of the temporary synthesis of sensorimotor actions (without reference to gender) is indicative: quite successful (representatives of male and female subgroups 2);

moderately successful (male subgroup 1); unsuccessful (female subgroup 1). Moderately successful ones are presumably reliable when performing actions in a subjectively convenient time frame and with a moderate shortage of time. Unsuccessful ones, characterized by delayed orientation, difficulties in anticipation, premature motor responses, may belong to the risk group when performing activities in special and extreme conditions. Quite successful representatives of subgroups 2 can be considered in the aspect of their significant opportunities for action in the modes of lack of time, but with a low tendency to errors (Plokhikh, 2006). Taking into account the latter, the diagnostic prospects for the application of the DC problem are indicated.

## 5. Conclusions

1. Temporal synthesis of sensorimotor action is realized in accordance with the operational meaning and is aimed at coordinating the setting duration of action and the time sequence of the required operations under changing conditions.

2. Successful temporal synthesis of sensorimotor action in changing conditions is associated with the removal of the uncertainty of the moment of achieving the goal in the anticipatory process and the formation of a detailed setting duration of action that combines information about the past experience, about the current moment, about the expected significant changes in the future prospects.

3. With a significant and rapid change in external conditions, a successful temporal synthesis of sensorimotor action, providing anticipatory effects and a reduction in the response time, becomes possible with a sufficient level of formation of the temporal sequence of the required operations.

4. The following levels of success of temporary synthesis and regulation of sensorimotor action in changing conditions are distinguished: quite successful (sufficient level of formation of the temporal sequence of operations, high efficiency of anticipation, low probability of erroneous actions); moderately successful (sufficient level of formation of the temporal sequence of operations, moderate effectiveness of anticipation, low probability of erroneous actions); unsuccessful (low level of formation of the time sequence of operations, low efficiency of anticipation).

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