

# Psychometric Methods

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## Regularities of Actualization of Templates for Standard and Deviant Stimuli in Recognition Task

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The standard ("S", 90 dB,  $P = 0.8$ ) and deviant tones ("D", 85 dB,  $P = 0.2$ ) were presented in random order. Subjects were told to press the left button by the left hand after S and the right button by the right hand after D. The EMGs of mm. thenar in both hands were recorded. Identification of concrete event-response conjunction (ERC) and actualization of templates of S and D in memory were based on the ratio of EMG activation at pre- and poststimulus interval in the left and right hands by the 8-point scale. It was found that 1) the templates related to both stimuli are actualized in memory simultaneously; 2) these templates are in relatively contradictory relations; 3) ratio of actualizations of templates depends on a-priori probability of stimuli and prehistory of stimuli presentation; 4) ratio of actualization determines the recognition time value as well as the type of ERC in a concrete trial.

**Key words:** psychophysics, event-response conjunctions, recognition task, electromyogram, reaction time

The goal of a subject performing the recognition task is to ascribe a presented stimulus to one of several preset categories. One of the essentials for recognition is the collation of parameters of the actual signal and its mental representation (template). It is obvious that the result of the collation - i.e., match or mismatch - should depend on the level of actualization in memory of all templates, representing the signals to be recognized.

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The aims of the present study were:

- 1) to estimate the level of actualization of the signals' templates in a signal recognition task using the indices of overt behaviour;
- 2) to reveal the regularities of templates' actualization in a concrete trial as well as the dynamics of actualization in the course of performance.

### Methods

**Experimental paradigm.** The standard ("S", 90 dB,  $P = 0.8$ ) and deviant tones ("D", 85 dB,  $P = 0.2$ ) were presented in random order with intervals of 1.5 s in 7 blocks of 500 stimuli through earphones. 4 subjects were told to press the left button by the left hand after S and the right button by the right hand after D as quickly as possible. The EMG of mm. thenar in both hands was recorded by surface electrodes.

**Measurement of the templates' actualization level.** Level of the templates actualization can be estimated by correspondence between presented stimulus and button pressing, i.e., type of event-response conjunctions (ERC). The applied experimental paradigm permits to evaluate the level of actualization of templates for S and D separately - by indices of EMG-activity in the left and right hands, because such separation results from the instruction and the paradigm itself.

Concrete ERCs were diagnosed by correspondence between stimulus presented and button pressed:

- Hit (H) - S/left button, D/right button;
- False alarm (FA) - D/left button, S/right button;
- Correct rejection (CR) - S/no right button, D/no left button;
- Miss of the signal (M) - S/no left button, D/no right button.

EMG activations at pre- and poststimulus intervals in left and right hands were estimated separately:

- a) EMG activations, related to button pressing;
- b) short bursts between stimulus onset and button pressing;
- c) activations, preceded stimulus presentations.

The combination of the classification of EMG activations and ERCs permitted to elaborate an 8-point scale for evaluating the actualization level of S and D templates (Table 1). The absence of any EMG activations was regarded as the minimal level of actualization, whereas FA - as the maximal one. Such a suggestion is based on results of the investigation of the single unit activity of a rabbit performing a signal detection task (Aleksandrov, 1986). From this viewpoint, pressing the button by the left hand in spite of D presentation was regarded as a sign of exceeding actualization of the S template. It should be noted that presence of EMG activation at the pre-stimulus interval is highly correlated with poststimulus activations (Chi-square = 1205.89;  $Df= 1$ ). The supposition is possible that pre- and poststimulus EMG activity reflect the "general level of template actualization", and supplementary pre-stimu-

lus EMG activation can be regarded as the actualization of a given template. Therefore FA, preceded by pre-stimulus EMG activity, was regarded to indicate an extreme level of actualization (7 scores).

**Table 1**

*Scale for estimation of the template actualization level*

Scores	ERCs	Pre-Stim EMG	Short burst after Stim
7	False alarm	+	–
6	False alarm	–	–
5	Hit	+	–
4	Hit	–	–
3	Miss or CR <sup>a</sup>	+	+
2	Miss or CR <sup>a</sup>	+	–
1	Miss or CR <sup>a</sup>	+	+
0	Miss or CR <sup>a</sup>	+	–

*Note:* <sup>a</sup> Differences between these ERCs are explained in the method section.

Using the above mentioned rules the states of the templates of S and D in each

trial can be displayed as an entry in a matrix in which rows and columns represent scores of S and D actualizations, respectively. Frequencies of trials with certain ratio of S and D actualizations, as well as RT values (means and standard deviations) in these trials were calculated.

The sequential effects on the RT and the distribution of the possible ratios of S and D template actualizations were estimated. The matrices for trials preceded by a chain of stimuli containing 1 to 14 S's and 1 to 4 D's (e. g., 'S', 'SS', ..., 'SSSS', etc.; 'D', ..., 'DDDD') were calculated. We supposed that an analysis of the states with different "prehistory" permits to reveal some regularities of dynamics of the template actualizations in the course of the recognition task performance. The Student *t*-test, the Smirnov-Kolmogorov goodness-of-fit test, and the Chi-square test were used to assess differences of RT's, frequencies, and distributions. The 5% level of confidence was adopted as the criterion of statistical significance.

## Results and Discussion

The analysis of the matrices of frequencies has shown the great diversity of the ratios of S and D template actualizations: from maximal level of actualization of one template and minimal of other, to equal levels of actualizations of both templates (high or low). Such variety was found in all the subjects participating in the experiment. The most probable ratios of template actualizations are placed along the diagonal of the matrix. This fact demonstrates presumably inverse relations between

levels of actualization of two templates, that is, contradictory relationships (or competition) between the templates. Nevertheless, multimodal shape of the distribution, in our opinion, reflects incomplete contradiction between competing templates.

The shortest RT's were found in trials characterized by non-equal actualizations of two templates, e. g., in cases with maximal actualization of the S-template and minimal actualization of the D-template, so that minimal RT values are situated in upper left and lower right corners of the matrix, whereas maximal RT values are found near to the center of matrix (Table 2). It should be noted that minimal and maximal RT values differ significantly ( $p < .05$ ;  $t$ -test). This result indicates that RT to a great degree depends on the levels of actualization of both templates. It is of special interest that longer RT's correspond mainly to the cases with prevalent actualization of the D-template.

**Table 2**

*Numbers (N), Means (M) and Standard Deviations (SD) of RT (ms) for different ratios of the actualization level of the templates for S and D stimuli*

7	110	38	29	24					<i>N</i>
	184	179	201	212					<i>M</i>
	54	50	65	79					<i>SD</i>
6	38	9	15	3					<i>N</i>
	189	177	193	153					<i>M</i>
	46	30	28	28					<i>SD</i>
5	642	383	117	537	33	34			<i>N</i>
	233	247	270	283	272	280			<i>M</i>
	78	89	108	105	102	96			<i>SD</i>
4	242	110	59	146	7	6			<i>N</i>
	235	238	246	268	199	240			<i>M</i>
	87	88	94	94	33	59			<i>SD</i>
3					195	167	3	4	<i>N</i>
					365	377	333	360	<i>M</i>
					88	84	137	190	<i>SD</i>
2					25	30	5		<i>N</i>
					376	362	259		<i>M</i>
					107	105	67		<i>SD</i>
1					46	27	1		<i>N</i>
					379	328	246		<i>M</i>
					105	86	0		<i>SD</i>
0					56	35	7	1	<i>N</i>
					348	329	243	311	<i>M</i>
					71	115	80	0	<i>SD</i>
	0	1	2	3	4	5	6	7	

*Note:* Rows - scores for S, columns - scores for D.

The mean level of the S actualization is higher, as a rule, when comparing with D. Apparently this phenomenon is determined by dramatic differences in the probabilities of the S and D presentations (0.8 vs. 0.2). It may be supposed that the

mean level of the templates' actualization corresponds to the a priori probabilities of the S and D stimuli.

Sequential effects of repeated stimuli resulted in changes of the actualization of both templates. It must be noted that changes of the actualization level of templates are negatively correlated. When S or D are presented repeatedly several times (about 10 for S and 4 for D) reversion of the templates' actualization ratio can be observed (Fig. 1, right part). It is possible that such a reversion is a manifestation of anticipation of the stimulus train completion. We supposed that the dynamics of the actualization of the S and D templates in the course of the series of repeated stimuli reflects the dynamics of subjective probabilities of S and D presentation. The matrix of frequencies of different actualization levels of S and D templates in the situation with concrete prehistory of stimuli presentation is generalization of many individual cases. Nevertheless this distribution can be regarded as a probabilistic description of the real complex state of the subject, performing the recognition task. Following Prigogine and Stengers (1984) such kind of representation is a more precise description of the real state of choice whereas any single point in the space of features is rather an idealization.

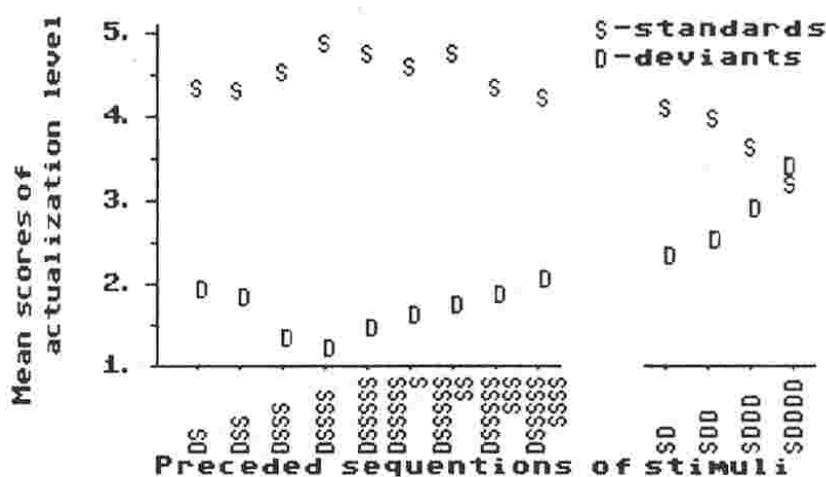


Figure 1. Sequential effect on the actualization level of the S and D templates

## Conclusions

- 1) In a recognition task the templates related to stimuli presented are actualized in memory simultaneously.
- 2) Templates of stimuli to be recognized are in relatively contradictory relations.

- 3) The ratio of actualizations of templates of stimuli to be recognized in a single trial depends on a priori probabilities of stimuli presentation as well as on the preceding stimuli sequence.
- 4) The ratio of actualizations of templates of stimuli to be recognized determines both the recognition time as well as the type of the event-response conjunction in a concrete trial.

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