SUBJECT–ORIENTED APPROACH IN PSYCHOPHYSICS

Irina G. Skotnikova
Institute of Psychology Russian Academy of Sciences, Moscow, Russia, iris236@yandex.ru

Abstract

Traditional psychophysical study implies quantitative analysis of sensory measurements results in dependence of external factors. An additional approach was suggested which included this analysis into a context of qualitative research of observer's individual activity in the course of measurements. Components of the activity were revealed experimentally which were significant for sensory measurements results: a task as it was accepted by an observer, his (her) cognitive styles and confidence feeling, performance strategies used. Effects of these components were found on psychophysical indices obtained in visual discrimination of spatial (line lengths and tilts) and temporal (durations) stimuli. Brief contents of the author's book: "Problems of subject-oriented psychophysics" is presented.

Traditional psychophysical research implies quantitative analysis of sensory measurements results in dependence of external factors. At the same time effects of "subject's variables" (attitudes, motivation, attention, confidence, individual differences, performance strategies, etc.) were observed on psychophysical indices obtained during the whole history of psychophysics. At present the last 4 variables are studied mostly. It is emphasized that usual analysis of resulting response proportions, "machine-like approach" in psychophysics are insufficient and investigation of observer's inner states, processes, peculiarities, etc. is necessary (Luce, 1986; Vickers, Lee, 1998).

Empirical data cumulated were generalized and a classical paradigm was completed with an approach, which implied to study effects of subject's variables in the framework of a systematic research line. Initially K. Bardin (Bardin et al., 1993) has distinguished this line as a special one and indicated it as a "subject-oriented approach" in addition to the traditional "object-oriented" one. The present research develops the line argued: more kinds of subject's variables are studied in sensory tasks, psychological structure of observer's individual activity is revealed which is significant for psychophysical measurements.

Methods

Multi-methods methodology was used in order to study different kinds of observer's individual activity: psychophysical methods, sensory motor activity and confidence registration, cognitive styles tests. Vision was choused as a leading modality, spatial and temporal stimuli were used including prothetic ones (line lengths and durations) and metathetic ones (line tilts) (according to Stevens, 1961), presented simultaneously (line lengths and tilts) and successively (durations) in "continuous" (Method of Average Error) and "discrete" (Same-Different Method) discrimination tasks.

Method of Average Error (MAE): adjustment of line tilts and of line lengths. Standard stimuli were 17°, 17 cm, variable ones — 3–31°, 2–32 cm. Statistics was: 7 and 8 participants, 210 and 156 distributions of adjustment results included 50 and 24 trials each (for line tilts and line lengths correspondingly). Mean value of adjustment results and standard deviation of them (σ) were calculated in each distribution. Participants were instructed to reproduce 5 principal points in a subjective equality region and in its neighborhood: lower and upper points of just noticeable difference (jnd) and of just not noticeable difference (jnnd), point of subjective equality (pse). Motions of participant‘s arms were recorded which controlled the variable stimulus value in line tilts adjustment.

Same-Different (=/≠) Method. Stimuli were 2 light flashes durations: t_1 = 600 ms, t_2 = 600 мс – Δt. Pairs of same (t_1, t_1) and different (t_1, t_2 and t_2, t_1) stimuli were presented. “Same” and “different” pairs and 2 kinds of “different” ones were equiprobable. Individual Δt-values were choused in a preliminary series in order to obtain PC (proportion correct) = .7–.8, i.e. Δt corresponded to a difference threshold value. In each trial observers gave 2 successive responses: 1) same or different are durations in a pair presented, 2) are they confident or unconfident in their 1st response correctness. Costs-payoffs oriented them to accept a “symmetrical” decision making criterion in the 1st series of each session, a “strict” one in the 2nd series and a “liberal’ one in the 3rd series. The 3 theoretical criterion values ($\beta_{Theor.I,II,III}$) were calculated using stimuli a priori probabilities (.5, .5) and costs-payoffs-values, as Signal Detection Theory prescribes (Egan, 1975). Statistics was: as a whole 98 series of 100 trials each, in 71 participants. For each observer the following indices were calculated: a) nonparametric criterion indices: Yes Rate (YR) — a frequency of “Yes” (≠ in our case) responses, Conditional Error Rate (CER) — ratio of misses (=-responses in ≠-trials) to false alarms (≠-responses in =-trials) (see Macmillan, Creelman, 1990); b) Bias (B) — a difference between a mean confidence category used and PC (see Baranski, Petrusic, 1999).

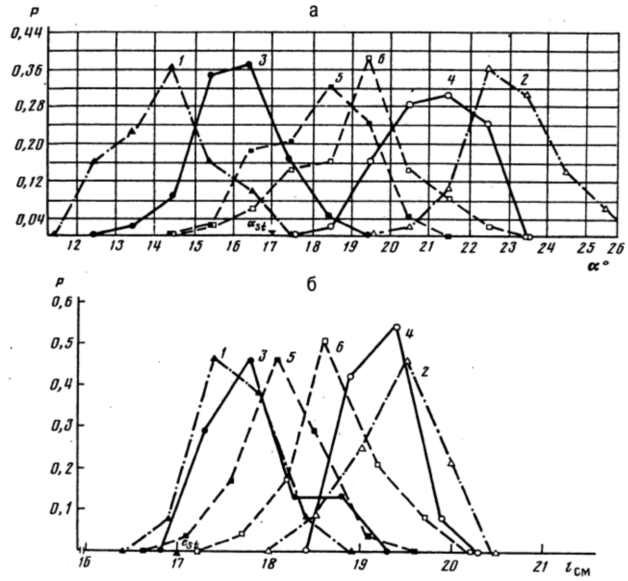
Cognitive styles tests and indices. Witkin’s Embedded Figures Test: t_w — mean time of 12 embedded figures distinguishing (see Skotnikova, 1995 for the references). Stroop Test: ri_s (rigidity index) — relation of increase of the 3rd (conflicted) table performing time regarding to the 2nd table performing time (expressed in percents). Kagan’s Matching Familiar Figures Test: total number of errors (n_k) in 6 cards (see Skotnikova, 1990, 2008 for the references).

Results and discussion

1. MAE-data had shown that every participant was able to discriminate 5 principal points in a subjective equality region and in its neighborhood (though such an ability appeared to be doubtful in literature) and to reproduce them stably: 2 jnd, 2 jnnd and pse, ($p<.05–.001$). The distances between lower and upper jnd-points were 3–8.5° for line tilts and 4–7 cm for line lengths (see examples in Figure 1), i.e. 17–88% of standard stimuli values.

2. Some of participants changed their visual–motor strategies according to points searched specificity (final approach to ind from subjective equality region, to jnnd — from subjective inequality one, to pse — using forward and back motions), while strategies of others were not adequate to the points. Figure 2 shows examples of the both groups (*a* and *b*). Also negative Starting Position Effect (SPE — dependence of adjustment results on a variable stimulus initial values) was observed twice more frequently in *b*-group (in 58% of trials) than in *a*-one (in 27% of trials). And high accuracy (low variability: σ = 40’–50’) of adjustment results was obtained in *a*-group, while low accuracy (high variability: σ = 60’–73’) — in *b*-one. In the control series persons of *b*-group were given a feedback about their mistakes, began use adequate strategies and avoid SPE which frequency decreased 1.6 times. As a consequence σ of their adjustment results decreased by 1/4.

3. Participants of *a*-group appeared as twice more field independent than those of *b*-group: t_w–scores were 8,55 sec and 17,88 sec correspondingly (Skotnikova, 1995). These differences reflect an ability of the 1st ones to reconstruct information given and their own behavior actively according to sensory tasks changes and therefore to show better results, in distinction of the 2nd ones.



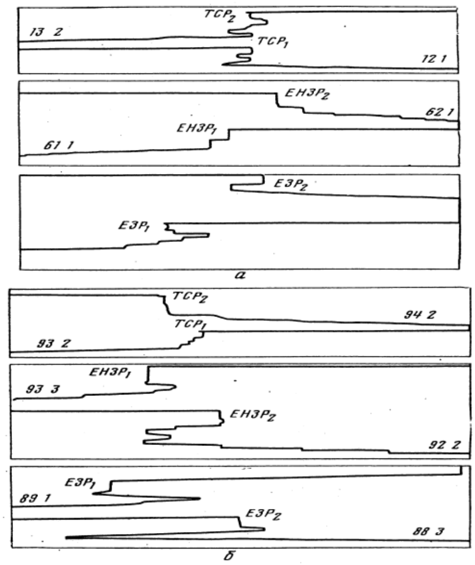


Figure 1. Adjustment results distributions of jnd- (1, 2), jnnd- (3, 4) and pse (5, 6)-points reproduction. Broken lines — the lower points, solid lines — the upper points. a — line tilts, b — line lengths. p — probability densities, α°, l_{cm} — stimuli values in degrees and centimeters. α_{st}, l_{st} — standard stimuli.

Figure 2. Fragments of line tilts adjustment recordings obtained in participants N.S. and T.G. whose visual-motor strategies were adequate (a) and non-adequate (b) for lower (1) jnd-, jnnd- and pse-points and for upper (2) ones.

As a whole, MAE-data show that a sensory task accepted by a participant appears as an essential determinant of his/her decision making criterion and therefore — of adjustment results average value. Performance strategies influence on the results variability (σ) and looks as psychological mechanism providing compensation of sensory information deficit and mediating of field dependent/independent cognitive style effects on final results.

4. Figure 3 shows data of durations discrimination. In a group of 13 observers more flexible ones (whose mean ri_s-score was 18%) increased their decision making criteria in the 2nd "strict" series up to greater values regarding to those obtained in the 1st "symmetrical" series and decreased the criteria in the 3rd "liberal" series up to lower values regarding to those obtained in the 1st series according to costs-payoffs; also they showed high dynamics of the criterion: maximal changes of CER indices (ΔCER_{max}) were 0,45–∞ (left panel). In distinction, more rigid persons (whose mean ri_s-score was 39%) showed totally non adequate criterion dynamics or decreased their criteria in the 3rd series up to lower values regarding to those obtained in the just preceding 2nd series but not regarding to those obtained in the 1st series, in spite of costs-payoffs (right panel, a and b correspondingly); also they showed low dynamics of the criterion: ΔCER_{max} were 0,14–5,98. Positive Spearman correlation was found between ΔCER_{max} obtained in different series and rigidity indices: r=.70, p<.001. Thus, more flexible persons showed adequate, clear expressed and therefore effective criterion dynamics because of their supple and precise operations used to move the criterion in distinction of rigid ones.

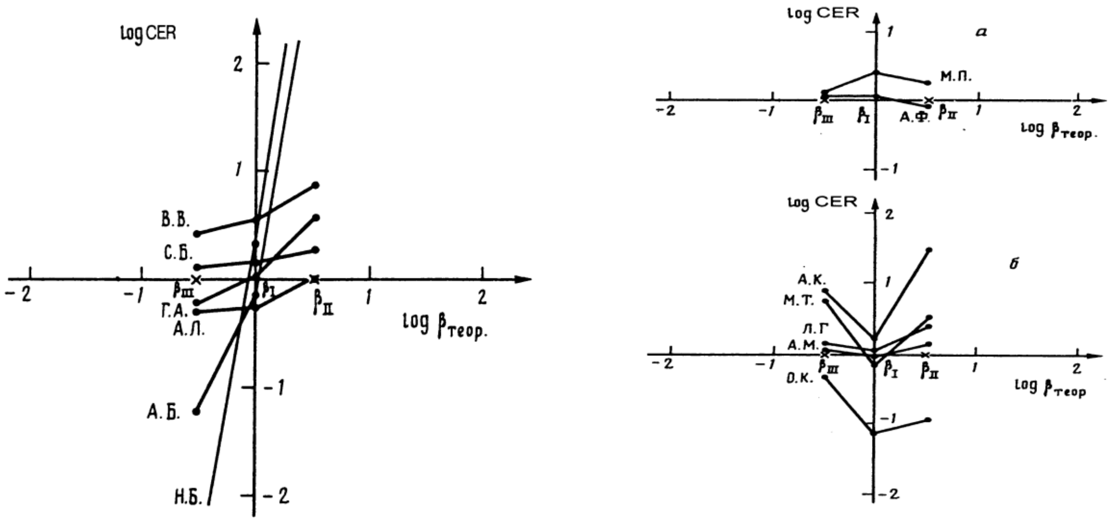


Figure 3. Dependence of obtained criterion values (CER) on its theoretical ones (β_{Theor}) calculated in the 1st (β_I), 2nd (β_{II}) and 3rd (β_{III}) series. Data of observers showed adequate (left panel) and non-adequate (right panel) criterion dynamics regarding costs-payoffs.

About twice-greater difference threshold values (Δt=178–225 msec) were found in 4 most impulsive persons (showed high n_k-scores: 5–9), than in 3 most reflective ones (Δt=100 msec, $n_k = 0$–1). Positive γ-correlation was discovered between Δt and n_k: r=.33, p<.04 while no significant correlation — between Δt and CER. The last result points out that greater Δt-values in impulsive observers appear to be caused by their lower discriminability as compared with reflective ones (Skotnikova, 1990). It may be caused by less careful information analysis which is typical for the 1st ones as compared with the 2nd ones (Borkowsky, 1983).

5. Confidence in sensory judgments correctness was studied in “Same-Different” task. The following data describe the whole sample of 29 observers. Figure 4 shows that portion of unconfident responses among erroneous ones (.144) was 1.7 times as much than that among correct ones (.085, right panel). Erroneous responses were unconfident in 41 experiment of 49 (p<.001, Sign test). On the contrary, portion of unconfident correct responses (.061) was 1.6 times as much than that of erroneous ones (.039) when calculated regarding the whole data sample (left panel) as usually accepted (Bjorkman et al., 1993). The result being similar to that in Figure 4 was obtained by analogous calculations using data of another stimuli discrimination in “Greater-Lesser” task (in which confidence is usually investigated), accompanied with 2 categories confidence evaluation (data of Obrink, 1948; Bjorkman, Qvarsell, 1963, see Skotnikova, 1994 for the references).

Erroneous responses were slower than correct ones in 48 experiments of 49 and by 30% in average: 1011 msec and 775 msec correspondingly. This fact agrees with Swensson’s rule for difficult sensory tasks and accuracy-instruction while errors are faster than correct responses in easy tasks and/or speed–instruction (see Luce, 1986). Typical unconfidence and big latencies of errors point out to greater observers’ hesitations before erroneous responses than before correct ones and to rather decisional nature of confidence than post decisional one (see Caroll, Petrusic, 2006 about locus of confidence judgments).

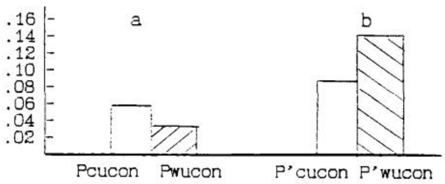


Figure 4. a — portions (%) of correct (PC_{uncon}) and erroneous (wrong — PW_{uncon}) unconfident responses

among all responses; b — portions of unconfident responses among correct (PC'_{uncon}) and erroneous (PW_{uncon}) responses separately.

In Russian observers overconfidence was discovered (B=+.218) which was greater (p<.0001) than that found in German persons (B=+.124, Skotnikova, et al., 2001) and in Canadian ones (B=+.010–.064, Baranski, Petrusic, 1999) in distinction of underconfidence in Swedish observers (B=-.013–-.079, Bjorkman et al., 1993). All B-scores are given for PC=.7–.8. These data confirm the hypothesis about cross-cultural differences of confidence in sensory judgments (Baranski, Petrusic, 1999).

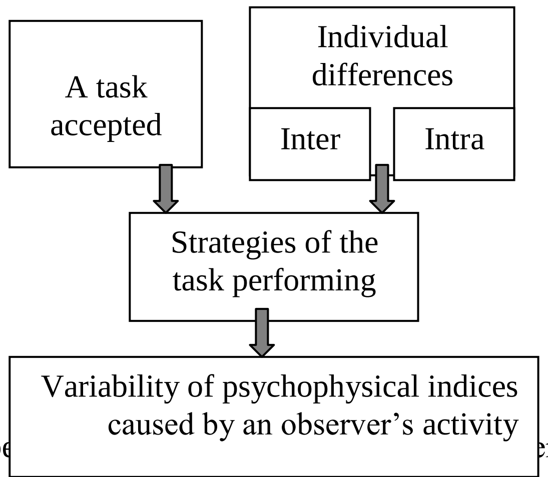
6. In durations discrimination greater frequencies of Same (=)-responses were found in 23 observers of 29 (p<.001) as compared to those of Different (≠)-ones: .56 and .44 in average correspondingly, in spite of equal probabilities of =- and ≠-pairs of stimuli presented. This fact corresponds to most data for another visual stimuli (see Luce, 1986), appears as accepting of rather strict decision making criterion for ≠-responses (YR=.44) and therefore of rather liberal criterion for =-ones, and is not connected with observers' cognitive styles. Strategically nature of =/≠-responses frequencies was confirmed with data of these frequencies changes along with a criterion changes according to costs-payoffs (see 4, Figure 3). These findings correspond to data of strategies-caused preference of =- or ≠-responses in dots patterns discrimination (Lachmann, 2001).

General discussion

As a whole, results obtained show that psychophysical indices which has to estimate discriminability, decision making criterion and its dynamics in dependence on external factors, also reflects observers 'own individual activity characteristics which appear as subsystems of this activity system. Figure 5 shows a theoretical representation of possible interrelations between them in the frame of inner hierarchical structure of the activity. They are: a task as it is accepted by an observer, his/her inter individual characteristics (ex., cognitive styles) and intra individual states (ex., confidence feelings), performance strategies caused by the task and individual characteristics. Thus, subject-oriented approach in psychophysics implies investigation of a real observer behavior (as well as of an ideal one) to

Individual structure of sensory activity and psychophysical indices obtained

Figure 5. Components of sensory activity which influence on psychophysical indices



be[...]rformance rather than more passive "object" of external factors influences. Quantitative psychophysical analysis is included into a context of qualitative research of observer's individual activity in the course of measurements.

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