RELATIONAL PSYCHOPHYSICS: MULTIDIMENSIONAL ASPECTS OF COMPARATIVE PERCEPTION

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Abstract

Whereas the contextual basis of all psychophysical responding is well founded, the compound influence of sensory and perceptual frames of reference constitutes a challenging issue in comparative one- and multidimensional psychophysics (e.g. Sarris, 2001, 2004, 2006). We refer to previous investigations which tested the assumption that the chicken's relational choice is systematically altered by context conditions similar to findings stemming from human participants (Hauf, 2001; Hauf & Sarris, 2001a, b). In Experiment 1 the asymmetry of the training and the test stimuli varying along a single dimension was investigated by means of a two-stimulus two-choice paradigm. Many objects differ in two or more dimensions, therefore the question of Experiment 2 was whether different relational choice strategies exist when, say, two psychophysical dimensions are used simultaneously; accordingly, the one-dimensional paradigm was extended to a four-stimulus two-choice setup. In this paper the common and heterogeneous findings of this line of comparative research are presented and discussed ("configurality").

While perceptual relativism is a basic characteristic of all animal and human behavior, the main contextual variables (range, asymmetry, frequency) have been studied mostly in human psychophysics. Thereby, the quantitative frame-of-reference (FR) approach deals systematically with the interaction between "focal" stimuli and their "surrounding" (contextual) stimuli. However, until now the compound influences of the sensory and perceptual features of these focal and context factors constitute a challenging issue in comparative one- and multidimensional psychophysics (cf. e.g. Sarris, 2001, 2004, 2006).

In this paper we refer to our previous one- and two-dimensional studies with humans and animals providing evidence that the chicken's relational choice is systematically altered by variable context conditions similar to human participants (Hauf & Sarris, 2001a, b; Sarris & Hauf, 2001; cf. also Hauf, 2001; Sarris, 2006). In Experiment 1 both the training and the test stimuli varied along a single psychophysical dimension (one-dimensional case: two-stimulus two-choice paradigm); whereas in Experiment 2 the training and the test stimuli differed simultaneously in two dimensions (two-dimensional case: four-stimulus two-choice paradigm).

EXPERIMENT 1: ONE-DIMENSIONAL RELATIVITY

The human and animal participants were trained and tested under comparative conditions which were held as similar to each other as possible.

Humans & Chickens

Method

Participants. A total of 20 human participants took part in this study and they were trained and tested in individual sessions (14 female and 6 male adults, all of whom were volunteers from a high school in Frankfurt City). Additionally four young chickens about six weeks old at the beginning of this study took part in this study.

Apparatus and Stimuli. The equipment used for the humans was the same as employed earlier with much younger age groups, for instance with three year old children; it was called a “bricklaying game” apparatus (cf. Sarris & Hauf, 2001, Fig. 1; Sarris, 2006, chap. 4). Behind a liftable gate, cubes with variable sizes were presented to the participant successively. To the right and to the left of the participant were two response buttons (response keys for “small” vs. “large” choices). The animal equipment consisted of a computer-controlled apparatus which permitted the successive presentation of the respective cubes, one by one (for a more detailed description of these apparatus, see Sarris, 2006, p.57 and pp. 105-106).

The geometrically ranked cubes used as training and test stimuli were the same for both humans and chickens. One pair of training stimuli (215ccm and 608ccm) served for training; two different context-test series with seven cubes each (C.1: 45, 64, 90.5, 128, 181, 256, 362ccm; C.2: 362, 512, 724, 1024, 1448, 2048, 2896ccm) were used for testing.

Procedure. The procedure was the same for both humans and chickens. During the discrimination training with the two different–sized training cubes (2A2FC method) each correct response was reinforced. The participants had to respond to one key if the large cube (608ccm) was presented and to another key if the small cube (215ccm) was exposed. After reaching the learning criterion of 95% correct, the cubes of the two asymmetrical test-series were presented, one by one, to the two subgroups of participants tested either with C.1 (smaller test series) or with C.2 (larger test series). Throughout the test sessions each animal choice was reinforced.

Results

The human participants showed profound differences in their choice behavior for the two asymmetrical test series C.1 and C.2. The two psychometric functions were very different from each other as predicted. For example, participants judged the 362ccm cube as “large” in one context condition (C1) but as “small” in the other context condition (C2). The chickens, analogous to the humans, showed striking contextual shifts in their test-choice behavior depending on the asymmetry of the test-stimulus series (see Fig. 1).

At least in the one-dimensional case both humans and animals follow one and the same principle trend of asymmetrical context effects (for more parametric data see Sarris, 2006, p. 38 and p. 47). The highly important issue of the different short- and long-term memory processes involved has been discussed elsewhere (Sarris, e.g. 2006, 2007).

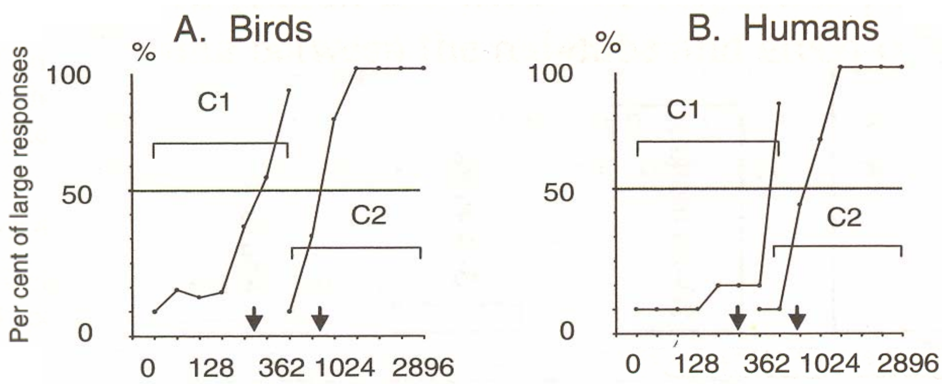

Fig. 1. Asymmetrical context-effect trends for chickens (left) as compared to humans (right). The arrows point to the training stimuli (adapted from Sarris, 2006, p. 54).

EXPERIMENT 2: TWO-DIMENSIONAL RELATIVITY

Here the main question was raised if and to which extent humans, in contrast to animals, use different choice strategies ("rules") for tasks related to the multidimensional post-generalization paradigm (4A2FC).

Chickens

Method

Subjects. Six chickens, about six weeks old at the beginning of the study, served as subjects.

Apparatus and stimuli. The same apparatus as described in Experiment 1 was used also for the multidimensional study with chickens. The training and test stimuli were red and green cubes differing in volume. All subjects were trained with two pairs of training stimuli (45/181ccm red cubes and 724/2896ccm green cubes); the test objects were 7 red and 7 green cubes with equally log spaced values, namely 45, 90.5, 181, 362, 724, 1448, and 2896ccm.

Procedure. The chickens were trained to peck key 1 if the small red cube (45ccm) was presented and to peck key 2 if the large red cube (181ccm) was exposed. The chickens had to respond to key 1, also, if the small green cube (724ccm) – larger than both red cubes – was presented and to key 2 if the large green cube (2896ccm) was shown (4A2FC method). After they had reached learning criterion (95% correct responses for three successive training sessions) tests were given with the entire range of sizes in both colors (see Sarris, 2006, p. 50 for more details about the apparatus and the procedure).

Results

The proportions of "large" responses to the different-sized cubes differed remarkably depending on the color of the test-series objects (red vs. green cubes); for example, the size of stimulus no. 4 was judged as "small" when green-colored, however as "large" when red-colored (two-dimensional choice strategy). The psychometric trends of the chickens followed exclusively this type III response rule (Fig. 2 left; cf. also Sarris & Hauf, 2001; Sarris, 2006, p. 51). This is in marked contrast to the human data sets which will be described below.

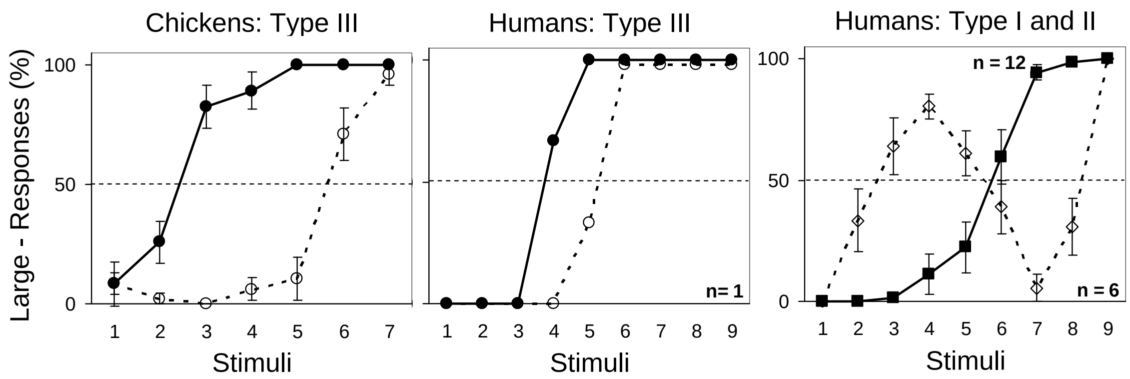

Fig. 2. Choice data trends in the two-dimensional case. Left and centered panel depicts Type III choice behavior of chickens and humans; whereas right panel shows Type I (solid line) and Type II (dashed line) choice behavior of humans.

Humans

Method

Participants. During a discrimination training N=24 young adults learned to discriminate two-dimensional objects, i.e. fairytale figures (size and color); thereafter, during the test phase several two-dimensional stimulus-generalization tests with different-sized blue and green figures were provided, *ceteris paribus.*

Apparatus and stimuli. A special slide projector was used for the successive projection of the two-dimensional visual stimuli; the participant was seated in front of the screen with a distance of approx. 40 cm (distance between the screen and the eyes). Next to the projector, there was a board with two round buttons, at the left and right side, as the response keys. The stimuli consisted either of blue or green drawings of a fairytale figure varying in size. All participants were trained with the same two pairs of training stimuli, a 1.5cm and a 2.4cm blue figure and a 6cm and a 9.4cm green figure. The test stimuli were nine fairytale figures of 1.5, 1.9, 2.4, 3.0, 3.8, 4.8, 6.0, 7.5, and 9.4cm size in both colors, blue and green.

Procedure. After discrimination training with four different-sized drawings (four-stimulus two-choice setup), with a learning criterion of 20 correct responses in sequence, test series were given with the entire range of sizes in both colors.

Results

For the two-dimensional figures (size in blue or green color) the choice behavior of the human participants (large responses in %) clearly changed depending on the stimulus color. Again the middle stimulus of the test series was judged as “small” in one color but as “large” in the other color (two-dimensional choice strategy type III; Fig. 2 center). Additional data trends reflected choice behavior related to only one dimension (type I) or related to the absolute size values of the training stimuli (type II) which is in contrast to the chicken data sets with type III, exclusively (Fig. 2 right). Note that the asymmetry context factor was not varied in this multidimensional investigation (for additional data cf. Hauf, 2001; Hauf & Sarris, 2001b; Sarris, 2006).

DISCUSSION AND CONCLUSIONS

Lawful context-contingent trends have been established in our work with both one- and multidimensional behavior of humans and chickens. However, whereas the data sets stemming from one-dimensional psychophysics look very much the same for the human and animal subjects, notwithstanding the species-specific learning and memory history involved, the experimental trends as found for the two-dimensional case (4A2FC method) are radically different for the humans (types I, II, and III) and the chickens (type III behavior as the exclusive response rule). This general finding calls for more explanatory research including the study of other species as well (e.g. cats, dogs, and monkeys).

Three more recommendations for ongoing work in the area of comparative psychophysics are the following:

- Parametric work continued: More extensive testing of our predictive model would be welcome, in line with the implications of its specific Equation 3.1 (Sarris, 2006, pp. 33-35 chaps. 3 & 9). Such desirable research should include the investigation of the neurobiological memory processes involved in the respective training and testing tasks; such an important desideratum implies the study of the various learning variables of the "transposition" issue inherent in this research domain (Sarris, 2006, 2007).
- Multidimensional analysis extended: The present two-dimensional stimulus case belongs to the "separable" dimension issue; but it is in need of an experimental comparison with the "integral" information integration case implying the study of other object variables as well. Such needed work should be carried out both in human and animal psychophysics from a comparative point of view thus looking afresh towards the pervasive issue of "configurality" (Sarris, 2006, 2007; cf. also Townsend & Pomerantz, 2004; Townsend & Wenger, 2004).
- Flexible use of response strategies: The presented comparative studies demonstrated a much more flexible use of different response rules in humans. This might be related to memory capacities or the use of language as a means to enhance memory retrieval (Siegler & Chen, 2002). Further studies need to address these issues in more detail.

In closing, we recommend that future investigations should not only continue to analyze dimension-specific psychophysical behavior but also aim at the fascinating but complex question of how age-related differences in perceptual-cognitive abilities, such as memory and problem-solving strategies or rules, develop over time (cross-sectional and longitudinal research combined).

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