eScholarship
International Journal of Comparative Psychology

Title

Comparative Psychophysics: Some Contextual Effects in Birds and Humans

Permalink

https://escholarship.org/uc/item/2sc271t1

Journal

International Journal of Comparative Psychology, 3(2)

ISSN

0889-3675

Authors

Zoeke, Barbara
Sarris, Viktor
Hofer, Giovanni

Publication Date

1989

DOI

10.46867/C4RC7S

Copyright Information

Copyright 1989 by the author(s).This work is made available under the terms of a Creative Commons Attribution License, available at https://creativecommons.org/licenses/by/4.0/

Peer reviewed

eScholarship.org Powered by the California Digital Library
University of California

The International Journal of Comparative Psychology, Vol. 3, No. 2, Winter 1989

COMPARATIVE PSYCHOPHYSICS: SOME CONTEXTUAL EFFECTS IN BIRDS AND HUMANS

Barbara Zoeke
University of Würzburg

Viktor Sarris
Giovanni Hofer
University of Frankfurt

ABSTRACT: Three different types of psychophysical context effects have been studied in comparative experiments with animals and humans. The main context variables investigated were: (1) range of the test series; (2) asymmetry of training to test stimuli (anchor effects); and (3) frequency distribution of the test stimuli. A two-stimulus, two response training procedure, followed by various generalization tests, was used. All subjects (19 chickens and 128 humans) were trained and tested with cubes of different sizes. The psychometric functions support the general assumption that perception in birds undergoes psychophysical context effects similar to that observed in humans. However, while all three variables affected the judgments of human subjects, the choices of chickens and human infants were not strongly affected by the frequency distribution of the test stimuli. These data suggest that two factors are responsible for the three contextual effects investigated: a basic perceptual factor invariant across species and age groups and a cognitive component.

Three main types of context variables have been studied systematically in psychophysics and frame-of-reference (FR) research: (1) the range of the test series (Witte, 1960; Parducci, 1965, 1974, 1983); (2) the relation of training to test stimuli; a special case of what Helson (1964) refers to as an "anchor" condition; (3) the frequency distribution of the test stimuli (Parducci, 1965, 1974, 1983). The effects of these three types of context variables on the psychometric functions will be described below.

The question as to whether and under which conditions animal perception can be experimentally demonstrated to be context-dependent, i.e., to be relative, has been discussed for almost 70 years. Ge-

Address correspondence to Dr. Barbara Zoeke, Lehrstuhl für Psychologie II, Department of Psychology, University of Würzburg, Ludwigstr. 6, 8700 Würzburg, Federal Republic of Germany, or Dr. Viktor Sarris and Dr. Giovanni Hofer, Department of Psychology. University of Frankfurt, Mertonstr. 17, 6000 Frankfurt/Main, Federal Republic of Germany.

© 1989 Human Sciences Press

stalt theorists have interpreted transposition data as evidence that animals perceive relationships among stimuli (Köhler, 1918; Koffka, 1935; Wertheimer, 1959), while S-R theorists, following Spence (1937), have interpreted transposition data as resulting from summation of excitatory and inhibitory processes. Despite substantial research within the last few decades, this controversy has not yet been resolved (Reese, 1968).

Recently, the FR approach has been applied to the transposition problem (James, 1953) and to generalization studies employing asymmetrical testing procedures (Thomas, 1974; Sarris, Zoeke & Hofer, 1988; Zoeke, Sarris & Hofer, 1988). The theoretical and methodological advantages of an approach that combines quantitative modeling of relativity on the one hand, and the methodology of learning research on the other hand, promises solutions to basic problems of a comparative psychophysics including Köhler's (1918) earlier work on transposition, as well as Hollingworth's (1910) work on central tendency.

The present experiments provide a comparative investigation of context effects in animals and humans. How do birds respond to stimuli under the three context conditions described above? Are there differences between birds and humans? Is there any evidence for a species-specific distinction in how context variables affect performance?

According to Parducci's (1983) analyses, overt judgmental behavior in humans is to be conceived as a compromise between two different (covert) behavioral tendencies: (a) the tendency to subdivide the given range of test stimuli into equal sections (the range principle); and (b) the tendency to assign the same number of stimuli to each category used (the frequency principle). Anchor effects can be understood in terms of the range principle: Training stimuli and asymmetrical test series provide the experimental range which the subject has to subdivide into equal sections, an effect that becomes increasingly evident during continuous testing (see Johnson's 1949 a,b work on practice effects in asymmetrical testing with humans). Considering this analysis and the results of previous studies in animals (Zoeke, 1975; Sarris et al., 1988; Zoeke et al., 1988) we hypothesize that birds will subdivide a given range into equal subranges (showing range and anchor effects) but will fail on the more difficult task of assigning the same number of stimuli to each category (frequency effects).

EXPERIMENT 1—RANGE EFFECTS

The first study was directed to an examination of range effects in stimulus generalization of birds and humans. Figure 1 (left panel)

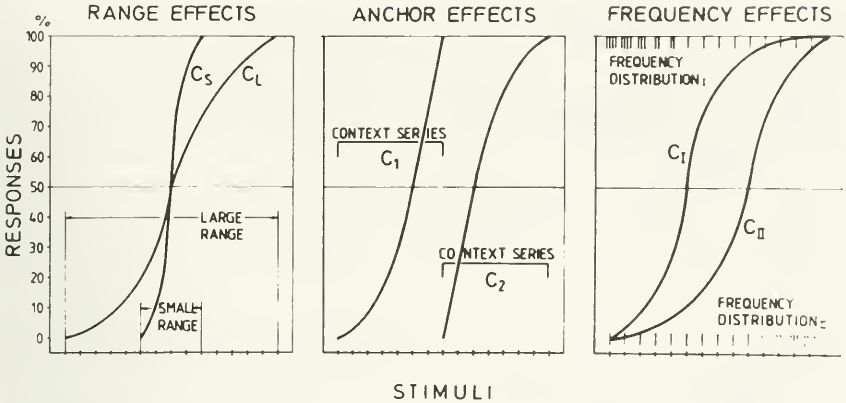

FIGURE 1. Predicted psychometric functions for three different types of psychophysical context effects. The left panel illustrates range effects: hypothetical response proportions are shown for a small (C_S) and a large (C_L) test range. The middle panel illustrates anchor effects: hypothetical response proportions for two asymmetrical test series (C_1, C_2) are shown. For C_1 the test stimuli are smaller than the training stimuli; for C_2 the test stimuli are larger. The right panel illustrates frequency effects: hypothetical psychometric functions are shown for a positively (C_I) and a negatively skewed (C_{II}) frequency distribution of test stimuli.

shows the predicted psychometric functions for a small (C_S) and a large (C_L) range condition.

METHOD

Animal Experiments

Subjects. Eight Hubbard chickens (*Gallus gallus domesticus*), six weeks old at the beginning of the experiment served as subjects. The chickens were kept as a flock in a scratching pen. Food was withheld for 18 hours prior to testing; water was continuously available.

Apparatus. Figure 2 (left panel) shows the computer-controlled apparatus permitting successive presentation of three-dimensional objects. The stimuli were presented in front of a 60x60x60 cm wall on which two pecking keys and two food magazines were fastened, one to the left and the other to the right of the area in which the stimuli could be shown. The objects were fixed underneath the test box, each on an individual plate, located on a rotatable wheel (diameter: 165 cm). A motor turned the wheel to the appropriate position, then the

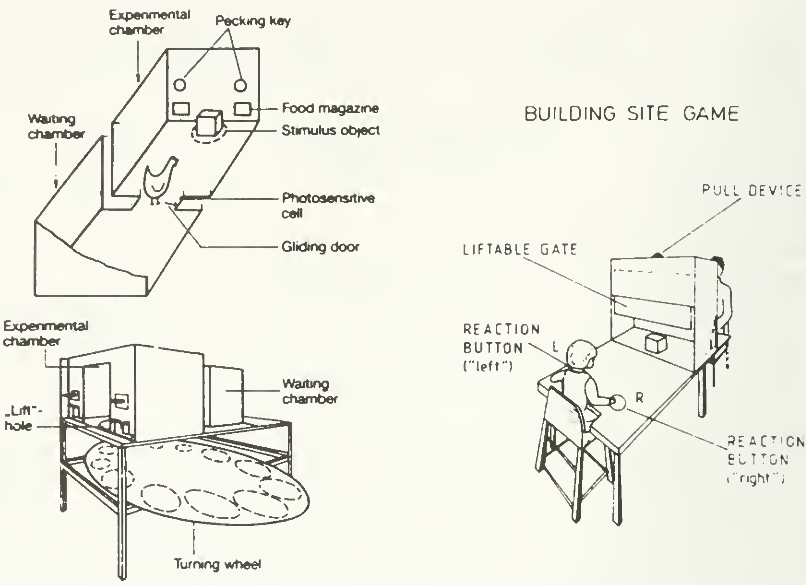

FIGURE 2. Schematic view of both apparatuses used in these experiments. The left panel is a schematic diagram of the animal apparatus. Top: test and waiting chamber with the subject, the cube, two pecking keys, and two food magazines. Bottom: automatic stimulus presentation device with an object attached to a plate located on a rotatable wheel. A motor turns the wheel to a predetermined position, then the plate with the chosen object is lifted hydraulically into the test box. The right panel is a schematic diagram of the apparatus used for the human subjects.

plate with the object to be presented was lifted to the floor of the test box (for additional details see Zoeke et al., 1988).

Stimulus material. The stimuli were orange cubes differing in volume. All subjects were trained with the same pair of training stimuli (TS), a 128 ccm and a 512 ccm cube, but tested with two different sets of stimuli. The test stimuli were equally spaced on a log scale with the geometric mean of the two training stimuli defining the midpoint of both series. The small-range test series, C_S, consisted of five stimuli with the training stimuli, 128 and 512 ccm cubes, defining the upper and lower limits of the set. The stimuli were 128, 181, 256, 362, and 512 ccm cubes. The large-range test series, C_L, consisted of nine stimuli, cubes of 64, 90.5, 128, 181, 256, 362, 512, 724, and 1024 ccm.

Procedure. After training to peck the key that was illuminated in order to obtain food, the subjects learned to peck key 1 if TS 1, the

128 ccm cube, was presented, and to peck key 2 if TS 2, the 512 ccm cube, was shown. Key positions were counterbalanced across subjects. Daily training sessions consisted of 30 trials. In this and all subsequent experiments, the training stimuli were presented in random order with the restriction that each stimulus was presented with equal frequency. Pecks at the correct key were reinforced by access to the food magazine for 3 sec. Darkness immediately followed an incorrect key choice and the same stimulus was presented immediately thereafter.

After reaching the learning criterion (95% correct choices for three successive training sessions) the eight subjects were assigned randomly to the two test conditions (C_S, C_L). Each series of five or nine stimuli was presented 10 times during 10 test sessions. All choices were reinforced.

Human Experiments

Subjects. Eight young adults (about 20 years old), non-paid volunteers from an introductory psychology class, served as subjects.

Apparatus. Figure 2 (right panel) shows the apparatus used for the three experiments reported here. The subjects were seated at a distance of 80 cm in front of a gate that could be lifted. Behind this gate the test stimuli, orange cubes differing in volume, were presented in random order. One of two blue buttons at the right or left hand of the subject had to be pushed down in order to indicate whether the cube was "small" or "large."

Stimulus material. The stimuli were the same as those used for animal experiments.

Procedure. The subjects were told to press one of the reaction buttons if TS 1, the 128ccm cube, was presented and to press the other reaction button if TS 2, the 512 ccm cube, was presented. All correct responses were verbally reinforced with errors corrected immediately. After reaching the learning criterion (20 consecutive correct responses) the experimenter instructed the subjects that they now had to continue without further interactions with the experimenter. The eight subjects were assigned randomly to the two test conditions (C_S, C_L). Each series was presented 10 times in a row. The test was completed within a single session.

RESULTS AND DISCUSSION

Figure 3 (top row) shows the results of the generalization tests for birds (left) as well as for humans (right). Each data point represents the combined average of 10 choices for each subject. The psychometric functions are very similar for the humans and the chickens. For both groups the functions obtained with the smaller range, C_S, are steeper than those obtained with the larger range, C_L. This is confirmed by the finding that the proportions of "large" judgments for the two test series (C_S, C_L) are significantly different for the 181 and 362 ccm cubes (for chickens: chi-square (1, 79) = 5.64, $p<.02$ for the 181 ccm cube, and chi-square (1, 79) = 4.51, $p<.05$ for the 362 ccm cube; for humans: chi-square (1, 79) = 5.72, $p<.02$ and chi-square (1, 79) = 4.32, $p<.05$). The differences in proportions of "large" judgments for the two groups are insignificant ($p<.05$) for the 128, 256 and 512 cubes as expected.

The range principle predicts that the psychometric function should be steeper under C_S than under C_L since it is hypothesized that the test stimulus range is divided into equal parts. The data for both the human and animal subjects confirm this hypothesis.

EXPERIMENT 2—ANCHOR EFFECTS

The second study was directed towards an examination of anchor effects in generalization testing with birds and humans. Figure 1 (middle panel) shows the predicted psychometric functions for two asymmetrical test series.

METHOD

Animal Experiments

Subjects. —Four Hubbard chickens (*Gallus gallus domesticus*), approximately seven weeks old at the beginning of the experiment, served as subjects. Housing conditions were the same as described in Experiment 1.

Apparatus. —The apparatus was the same as in Experiment 1.

Stimulus material. —The stimuli were orange cubes differing in volume in equal logarithmic steps. All subjects were trained with the same pair of TS, a 215 ccm and a 608 ccm cube, but tested with two different test series. The test stimuli were seven cubes, with volumes equally spaced on a log scale. The geometric mean of the training stimuli defined the largest test stimulus of the small contextual series, C_1, and the smallest test stimulus of the large contextual test series, C_2. For C_1 the test stimuli were cubes of 45, 64, 90.5, 128, 181, 256, and 362 ccm; for C_2 the test stimuli were cubes of 362, 512, 724, 1024, 1448, 2048, and 2896 ccm.

Procedure. —The procedure was similar to that described in Experiment 1. After key training subjects were trained to peck key 1 if TS 1, the 215 ccm cube was presented, and to peck key 2 if TS 2, the 608 ccm cube was presented. Daily training sessions consisted of 50 trials. After reaching the learning criterion (95% correct responses for three successive training sessions) the four subjects were assigned randomly to each text condition (C_1, C_2). Each series of seven stimuli was presented six times daily during sex test days.

Human Experiments

Subjects. —Twenty young adults (about 18 years old) served as subjects. Subjects were non-paid volunteers from a high school.

Apparatus. —The apparatus was the same as for Experiment 1.

Stimulus material. —The stimuli were again orange cubes differing in volume. All subjects were trained with the same pair of training stimuli, a 32 ccm and a 256 ccm cube but tested with two different test series (C_1, C_2). The test stimuli were equally spaced on a log scale. For the context series, C_1, five of eight cubes were smaller than TS 1; for context series, C_2, five stimuli were larger than TS 2. Both test series included two stimuli of the same volume (64 ccm, 128 ccm), the largest and the smallest under C_1 and C_2 respectively. For C_1 the test stimuli were cubes of 1, 2, 4, 16, 32, 64 and 128 ccm. For C_2 the test stimuli were cubes of 64, 128, 256, 512, 1024, 2048, 4096 and 8192 ccm.

Procedure. —The procedure was similar to that described in Experiment 1. After reaching the learning criterion (20 correct responses in a row), the 20 subjects were assigned randomly to the two context conditions (C_1, C_2). Both series were presented six times consecutively within a single session.

RESULTS AND DISCUSSION

Figure 3 (middle row) shows the results of the asymmetrical generalization test (C_1, C_2) for birds (left panel) and humans (right panel). Each data point represents the averaged choices of the last two of the six test sessions. The final test sessions were used for analysis since anchor effects become most evident as testing proceeds (see Zoeke *et al.*, 1988). Note, especially, that for the two test conditions, C_1 and C_2, the differences in the percent of large judgments for the two stimuli of the same volume (the 362 ccm cube for the birds, and the 128 ccm cube for the humans) are highly significant ($p<.001$). For the birds chi-square $(1, 47) = 37$; for the humans chi-square $(1, 39) = 32$.

The results of experiment 2 support the assumption that judg-

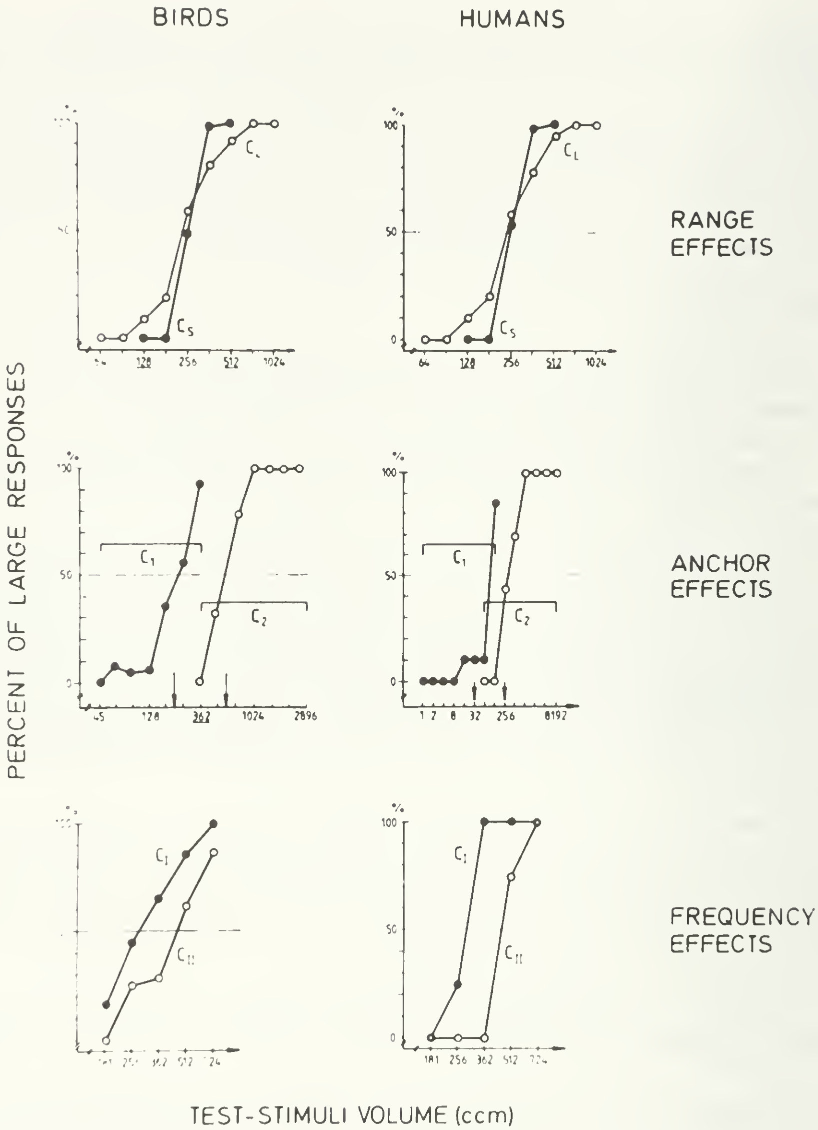

FIGURE 3. Empirical psychometric functions for birds (left) and humans (right). Top Row: Range effects—response rates for a small (C_S) and a large (C_L) test range. Middle Row: Anchor effects—response rates for two asymmetrical test series (C_1, C_2) either smaller or larger than the training stimuli. Bottom Row: Frequency effects—psychometric functions for a positively (C_I) and a negatively skewed (C_{II}) frequency distribution of test stimuli.

ments of birds are relational in character. With continued testing, the birds and the human subjects showed similar behavior when presented with the asymmetrical testing procedure.

EXPERIMENT 3—FREQUENCY EFFECTS

The third study was directed to an examination of frequency effects in stimulus generalization with birds and humans. Figure 1 (right panel) shows the corresponding prediction for two test series (C_I, C_{II}) differing in the frequency distribution of stimuli.

METHOD

Animal Experiments

Subjects. Seven White Leghorn chickens (*Gallus gallus domesticus*), six weeks old at the beginning of the training, served as subjects. Housing conditions were the same as described in Experiment 1.

Apparatus. The same apparatus was used as in Experiment 1.

Stimulus material. All subjects were trained with the same pair of TS, a 181 ccm and a 724 ccm orange cube, and tested with five cubes of 181, 256, 362, 512 and 724 ccm. The frequency distributions of test stimuli were 7, 3, 3, 1, 1 (C_I, positively skewed) and 1, 1, 3, 3, 7 respectively (C_{II}, negatively skewed). A test series consisted of 15 trials with the frequency with which each of the five stimuli were presented defined above. The presentation order was random with these restrictions.

Procedure. The training procedure was the same as described in Experiment 1 with the exception that the training sessions consisted of 50 trials. During training the presentation probabilities for the two stimuli were equal. After reaching criterion (95% correct responses) the proportion of trials on which food was delivered following a correct response was reduced from every trial to an average of one in 15. This was done to prepare for testing.

For testing, the birds were then assigned randomly to one of the two frequency conditions (C_I, C_{II}). A test session consisted of two presentations of the 15 trial test series. Food was delivered only once during this series with the trial on which this occurred randomly determined. Between each test series the two training stimuli were presented ten times each in a random sequence with reinforcement following each correct response. After two test days in which one of the frequency conditions was in effect (four series presentations each) there was a shift to the second frequency condition (C_I to C_{II}, or C_{II} to C_I, respectively).

Human Experiments

Subjects. In addition to a group of 20 young adults comparable to those who served as subjects in the previous experiments, there were four younger age groups: 20 infants (20 to 26 months old), 20 kindergarten children (about 4 years old), 20 school beginners (about 8 years old) and 20 school children (about 12 years old). Gender was balanced in all age groups. Subjects were from four nursery schools, three kindergartens and two public schools.

Apparatus. The apparatus was the same as in Experiments 1 and 2.

Stimulus material. The stimuli and frequency distribution of these stimuli were the same as those described for the animal experiment.

Procedure. The training procedure was the same as described in Experiments 1 and 2. After reaching the learning criterion (20 correct responses in a row) the subjects of all age groups were assigned randomly to one of the two frequency conditions (C_I, C_{II}). The test was the same as that described for the birds except that individuals were tested under one condition and testing was done in a single session.

RESULTS AND DISCUSSION

Figure 3 (bottom row) shows the results of the generalization tests under the two frequency conditions (C_I, C_{II}) for birds (left) and humans (right). In this figure only the data obtained from the young adults are presented. Each data point represents the choices averaged over all subjects for the two series. For the young adults, the frequency effects are as expected (Parducci, 1965). The subjects adjusted the proportion of their responses according to the presentation probabilities. The response “large” is used more frequently for small cubes when the small cubes occur with greater frequency (e.g., compare the percent of “large” judgments for the 362 cm cube). Single case analysis showed significant effects of the frequency manipulation for all subjects.

The data obtained from the birds are quite different. The frequency manipulation had little effect. For data averaged across subjects, all differences were insignificant ($p>0.05$). However, examination of individual test data showed significant differences as a function of frequency distribution for two of the seven birds: For one bird chi-square (1, 119) = 13.33, $p<.003$; for the second bird, chi-square (1, 119) = 7.67, $p<.005$. Figure 4 shows the results of these two birds.

The data for the human subjects of the five age groups tested under the two frequency conditions are shown in Figure 5. From this figure it can be seen that the frequency manipulation affects performance to a greater extent as age progresses. The infants showed almost no effect of the frequency manipulation. The intermediate age groups showed intermediate effects. The frequency manipulation affected the choices of the high school children almost as strongly as it did the choices of the adults. Examination of the data of the individual subjects shows an effect of the frequency distribution of the performance of 2 of the 20 infants, 11 of the 20 kindergarten children, 14 or 20 school beginners, 15 of the 20 high school children, and all 20 adults.

These results suggest the *frequency* effects are species-specific as well as age-specific.

GENERAL DISCUSSION

All together the results of these three experiments corroborate the basic assumption of FR models in psychophysics that judgments are relational in character. This holds true for birds, as well as, for humans.

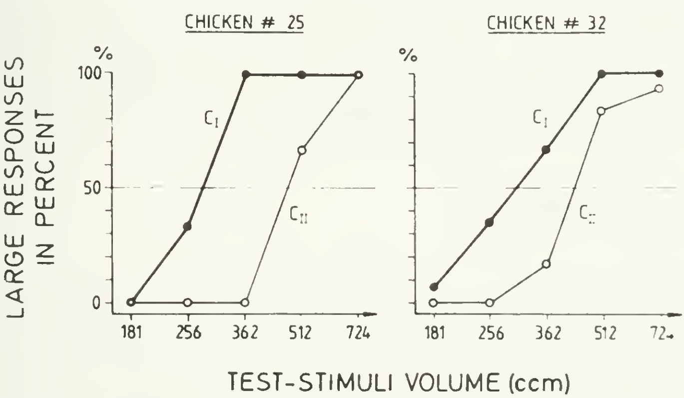

FIGURE 4. Empirical psychometric functions showing frequency effects in two birds for a positively (C_I) and a negatively skewed (C_{II}) frequency distribution of test stimuli.

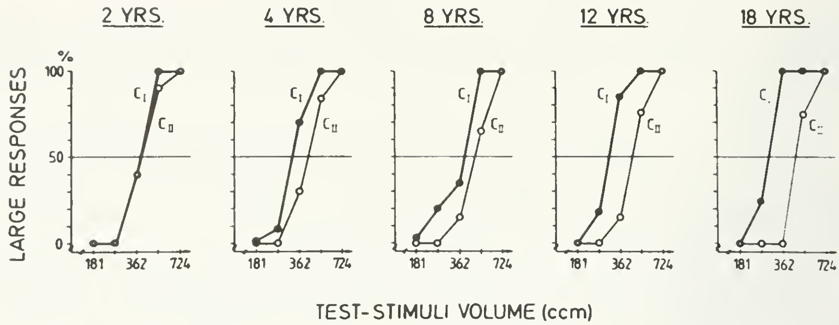

FIGURE 5. Empirical psychometric functions showing the effects of the frequency manipulation for different age groups for a positively (C_I) and a negatively skewed (C_{II}) frequency distribution of test stimuli.

While the responses of both species were strongly affected by range and anchor variables, the frequency distribution did not strongly affect the choices of birds and young children. Wedell and Parducci (1985) point out that under frequency conditions subjects have to pay attention to the size of the test stimuli as well as to their frequency distribution. Assigning the same number of stimuli to each category requires that relevant context information be retrieved from memory (i.e., the subject must remember both the range and the frequency distribution of the stimuli). Even adult humans underestimate the frequencies of those stimuli that occur more often (Wedell & Parducci, 1985).

Further studies have to be done to test the assumption that the cognitive demands of the frequency manipulation are greater than those involving either the range or asymmetry of the test stimuli. For instance, the differences among animals, young children and adults may be less pronounced when fewer stimuli are presented.

ACKNOWLEDGEMENTS

Partly supported by German Research Foundation (No. Sa 143/16-4). We are grateful to our student assistants, Thomas Eckerle, Petra Hauf, Martina Rohde, Heinz Schürmann, Annette Schliphack, and Cornelia Wilhelm for conducting the animal experiments, and Nesrin Cangöz, Heidi Gold, Brigitte Miksa, and Michaela Stremlau for their help with the human experiments. The authors also wish to thank Dr. Sheila Chase, The City University of New York, for correcting the manuscript.

REFERENCES

Helson, H. (1964). *Adaptation Level Theory. An experimental and systematic approach to behavior.* New York: Harper & Row.

Hollingworth, H.L. (1910). The central tendency of judgment. *Journal of Philosophical, Psychological and Scientific Methods*, *7*, 461-469.

James, H. (1953). An application of Helson's theory of adaptation level to the problem of transposition. *Psychological Review*, *60*, 345-352.

Johnson, D.M. (1949 a). Generalization of a reference scale for judging pitch. *Journal of Experimental Psychology*, *39*, 316-321.

Johnson, D.M. (1949 b). Learning function for a change in the scale of judgment. *Journal of Experimental Psychology*, *39*, 851-860.

Köhler, W. (1918). Aus der Anthropoidenstation auf Teneriffa. II. Optische Untersuchungen am Schimpansen und am Haushuhn. *Abhandlungen der königlich preußischen Akademie der Wissenschaften.* Berlin

Koffka, K. (1935). *Principles of Gestalt psychology.* New York: Harcourt.

Parducci, A. (1965). Category judgment: A range-frequency model. *Psychological Review*, *72*, 407-418.

Parducci, A. (1974). Contextual effects: A range-frequency analysis. In E.C. Carterette & M.P. Friedman (Eds.), *Handbook of Perception. Vol. 2.* New York: Academic Press.

Parducci, A. (1983). Category ratings and the relational character of judgment. In H.G. Geissler, H.F.J.M. Buffart, E.L.J. Leeuwenberg & V. Sarris (Eds.), *Modern Issues in Perception* (pp. 262-282). Berlin: VEB Deutscher VerlagderWissenschaften/Amsterdam: North-Holland.

Reese, H.W. (1968). *The perception of stimulus relations.* New York: Academic Press.

Sarris, V., Zoeke, B. & Hofer, G. (1988). Comparative psychophysics: Some contextual effects in chickens. *XXIVth International Congress of Psychology*, Sydney, Australia.

Spence, K.W. (1937). The differential response in animals to stimuli varying within a single dimension. *Psychological Review*, *44*, 430-444.

Thomas, D.R. (1974). The role of adaptation level in stimulus generalization. In G.H. Bower (Ed.), *The Psychology of Learning and Motivation: Advances in Research and Theory* (pp. 91-145). New York: Academic Press.

Wedell, D.H. & Parducci, A. (1985). Category and stimulus effects: A process model for contextual memory in judgment. In G. D'Ydewalle (Ed.), *Cognition, Information processing, and Motivation* (pp. 55-70). Amsterdam: North-Holland.

Wertheimer, M. (1959). On discrimination experiments I. Two logical structures. *Psychological Review*, *66*, 252-266.

Witte, W. (1960). Struktur, Dynamik und Genese son Bezugs-systemen. *Psychologische Beiträge*, *4*, 218-252.

Zoeke, B. (1975). *Kategorialleistungen von Haustauben. Ein vergleichend-experimenteller Beitrag zur Genese und Dynamik von Bezugssystemen.* Meisenheim: Hain.

Zoeke, B., Sarris, V. & Hofer, G. (1988). Psychophysical context effects in chickens (*Gallus gallus domesticus*). *International Journal of Comparative Psychology*, *1*, 167-178.