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# PSYCHOPHYSICAL CONTEXT EFFECTS IN CHICKENS GALLUS GALLUS DOMESTICUS *(HUBBARDS)*

Barbara Zoeke, Viktor Sarris, and Giovanni Hofer

*ABSTRACT:* A quantitative frame-of-reference *(FR)* model that has been successfully tested in humans was examined in generalization experiments with chickens. In Experiment 1, three groups of two chickens each were trained to discriminate between cubes different in volume and tested with a series of cubes with volumes either below, surrounding, or above the training stimuli. The obtained psychometric functions support the assumption that asymmetrical testing after two stimulus-two response training leads to the changes predicted by the *FR* model. In Experiment 2 shifts in the context defining the test series were administered by gradually enlarging the distance between training and test stimuli. While context effects were found in both experiments these were more pronounced in Experiment 2. The results support the general hypothesis that perception in animals undergoes context effects similar to those obtained in human subjects.

*GERMAN ABSTRACT: Psychophysikalische Kontexteffekte bei Küken (Hubbards).* — Ein quantitatives Bezugssystemmodell, das sich zur Voraussage reiz- und erfahrungsbedingter Kontexteffekte im Human-versuch bewährt hat, wurde in Generalisationsversuchen mit Küken überprüft. In Experiment 1 wurden sechs Küken trainiert, zwei singulär gebotene Würfel unterschiedlichen Volumens mit zwei alternativen Reaktionen zu beantworten. Im anschließenden Generalisationstest wurden jeweils zwei der Tiere unter je einer der drei Testbedingungen getestet (Würfelserien, die in Relation zu den Trainingsreizen entweder tiefer oder höher auf der Reizskala lagen oder die Trainingsreize symmetrisch umgaben). Die resultierenden psychometrischen Funktionen belegen, daß asymmetrische Testung nach einem "two-stimulus two response training" zu den Änderungen des Antwortverhaltens führt, die das Bezugssystemmodell voraussagt. In Experiment 2 wurden sechs Küken trainiert und mit Reizserien getestet, deren Distanz zu den Trainingsreizen schrittweise vergrößert wurde. Unter diesen Bedingungen zeigten sich stärkere Kontexteffekte als in Experiment 1. Die Daten beider Experimente stützen die generelle Annahme, daß psychophysikalische Kontexteffekte nicht nur beim Menschen, sondern auch bei Tieren auftreten.

The basic assumption underlying definitions of psychophysical context effects is that perception and judgment are relational in character so that responses to an individual stimulus depend not only on its absolute attributes but also on characteristics of the situation, the context in which the stimuli are presented. Consequently, the same stimulus may be over- or underestimated in different stimulus contexts.

This relativity of stimulus-response *(S-R)* relationships is well documented not only in studies employing a frame-of-reference *(FR)*

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approach but also within the stimulus-generalization paradigm as applied to the judgmental behavior of humans (James, 1953; Johnson, 1949a, b; Thomas & Jones, 1962). The typical results obtained here are lawful changes in *S-R* functions that are not predicted from assumptions of *S-R* theories but accounted for readily by *FR* models. Whereas these findings are experimentally well established in humans, the meagre literature on *FR* effects in animals has been, so far, either silent or controversial (Thomas, 1974; Zoeke & Sarris, 1983).

The aim of our present studies was the comparative investigation of psychophysical context effects in animals. The studies were guided by a *FR* model that has been successfully tested in humans using a two stimulus-two response discrimination followed by asymmetrical generalization testing (cf. Thomas & Jones, 1962; Sarris & Zoeke, 1985; Zoeke & Sarris, 1987). Employing this method we predict changes of the form of psychometric functions depending on the context conditions and the subjects experience with the stimuli. The 50% point on such psychometric functions, the stimulus value at which the two response frequencies are equal, may be used as an indicator of these changes (*P*oint of *S*ubjective *I*ndifference, *PSI*; cf. Sarris, 1971). The prediction reads as follows:

$$PSI_{\mathrm{n}} = (k\,PSI_{\mathrm{train}} + n\,PSI_{\mathrm{test}})\ /\ (k + n), \qquad (1)$$

where $PSI_{\mathrm{n}}$ means the *PSI* for the n-th test session, $PSI_{\mathrm{train}}$ the *PSI* of the training stimuli, and $PSI_{\mathrm{test}}$ the *PSI* of the test series used; $k$ is an empirical weighting factor, reflecting the effects of experience with the training stimuli; $n$ means the number of times the series is presented.

This *FR* model has been tested in humans ranging in age from 3 to 85 years. The results support the suggested model and show particularly that the slope of gradients obtained with continued testing depends on stimulus conditions (e.g., the distance between training and test stimuli on the stimulus scale used) as well as typical learning variables (e.g., amount of training, practice with the test stimuli). The slope of the gradients depends also on the age of subjects. Gradients obtained from the kindergarten children change about three times as fast as those obtained from adults. Age dependent changes may reflect to some degree the greater preexperimental experience adults have with judgments and stimuli (Zoeke & Sarris, 1987).

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. Studies of transposition provided the experimental starting point for this controversy. Gestalt theorists have interpreted transposition data as perception of stimulus relations (Kohler, 1918), *S-R* theorists, following Spence (1937), have interpreted them as resulting from summation of excitatory and inhibitory processes. Despite a flood of very suggestive investigations within the last few decades, this controversy has not yet been resolved (Reese, 1968). More recently, *FR* models were applied to generalization studies employing asymmetrical testing procedures (Thomas & Barker, 1964; Thomas, 1974; Zoeke & Schuermann, 1981). Although the results of Thomas & Barker (1964) did not allow an interpretation in terms of contextual effects, the studies of Thomas (1974) and Zoeke & Schuermann (1981) showed context effects, at least under one of their test conditions. Thomas (1974) made the assumption that the amount of training animals require for the acquisition of discrimination has an important influence on the occurrence of contextual effects (see also James, 1953). Summarizing these results, psychophysical context effects in animals are expected to occur but the changes in psychometric functions should be slower than in humans. Therefore, according to the *FR* model the empirical weighting factor $k$ reflecting the amount of practice with the training stimuli should be higher in animals than in humans.

## EXPERIMENT 1

Our first study was directed to a comparison of psychophysical context effects in animals and humans using an asymmetrical generalization testing procedure.

### *Method*

*Animals.* — Six chickens *(Hubbard)* approximately seven weeks old at the beginning of the experiment, served as subjects. The chickens were kept in individual cages but were allowed to run freely in a scratching pen for about two hours after their daily test session. Food was withheld for 18 hours prior to testing. Water was continuously available in the home cage.

*Apparatus.* — The computer controlled apparatus permitted the successive presentation of three-dimensional objects. As Figure 1 shows the apparatus consisted of a test and a waiting box divided by an automatically controlled gliding door. Stimuli were presented in front of a 60 x 60 x 60 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 stimulus. 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 correct position, then the plate with the appropriate object was lifted hydraulically into the opening in the floor of the test box (see Figure 1, bottom).

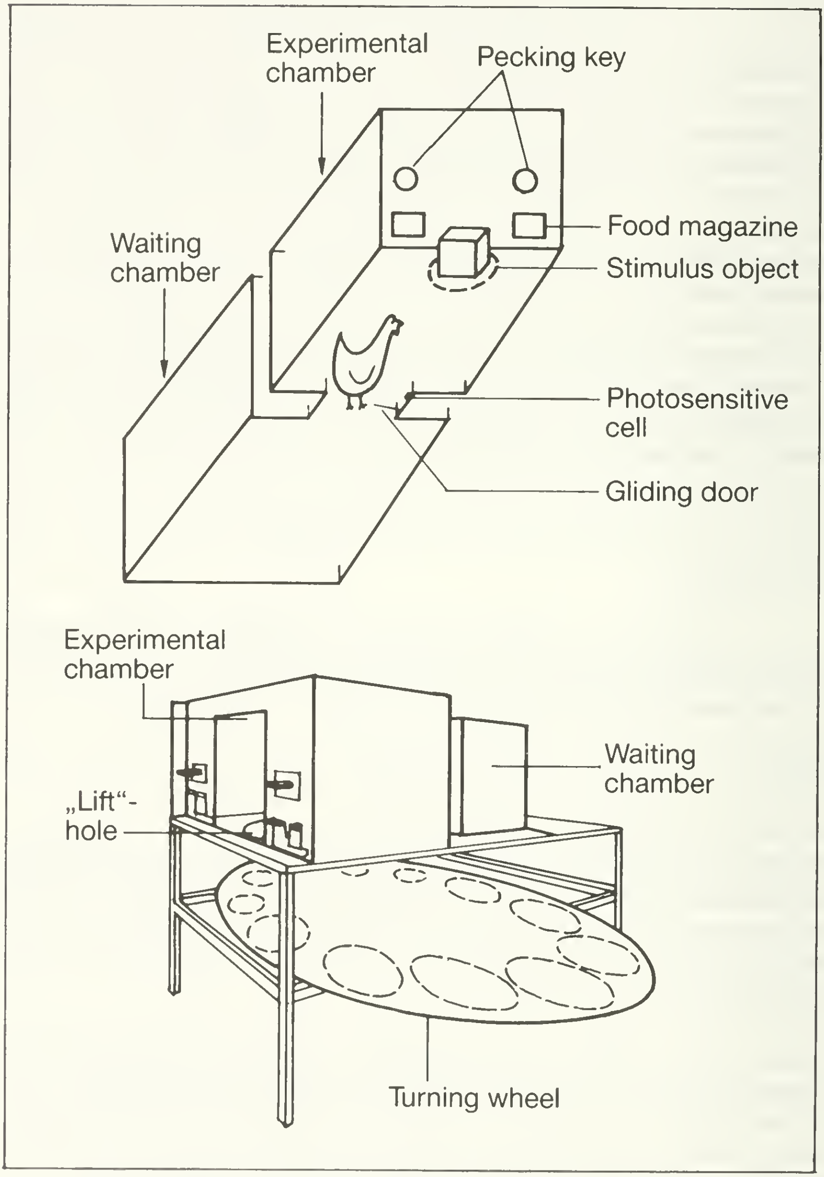


Figure 1

*Schematic view of the apparatus used for three-dimensional object presentation.* — *Top:* Test and waiting box with the singularly presented cube and two pecking keys and food magazines. *Bottom:* Details of the automatic stimulus presentation. The objects are fixed underneath the test box each on an individual plate on a turning wheel. A motor turns the wheel in the correct position, then the plate with the randomly chosen object is lifted hydraulically into the test box.

*Stimulus material.* — The stimuli were orange cubes differing in volume in equal logarithmetic steps. All subjects were trained with the same pair of training stimuli (TS), a 215 ccm and a 608 ccm cube, but tested with three different test series. Table 1 shows the physical measurements of training and test stimuli. The test stimuli were equally spaced on a log scale with the geometric mean of the two training stimuli defining the midpoint of the null test series, $C_O$. For the small contextual series, $C_1$, the geometric mean of the training stimuli was the largest of the test stimuli. For the large contextual series, $C_2$, this was the smallest of the test stimuli.

**Table 1**

**Set of training and test stimuli used (general design logic)**

| Physical Scale Volume (in ccm) | 45 | 64 | 90.5 | 128 | 181 | 256 | 362[a] | 512 | 724 | 1024 | 1448 | 2048 | 2896 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Training Stimului | | | | | | 215 | | | 608 | | | | |
| Null Test Series ($C_0$) | | | | 128 | 181 | 256 | $\boxed{362}$ | 512 | 724 | 1024 | | | |
| Small Contextual Test Series ($C_1$) | 45 | 64 | 90.5 | 128 | 181 | 256 | $\boxed{362}$ | | | | | | |
| Large Contextual Test Series ($C_2$) | | | | | | | $\boxed{362}$ | 512 | 724 | 1024 | 1448 | 2048 | 2896 |

*Note.* Subjects are trained with two successively presented training stimuli (*TS*) and tested with different test series either symmetrically ($C_0$) or asymmetrically distributed to the *TS* ($C_1$, $C_2$).

[a] The stimulus surrounded by black lines is middle-sized under $C_0$, the largest and $C_1$, the smallest under $C_2$.

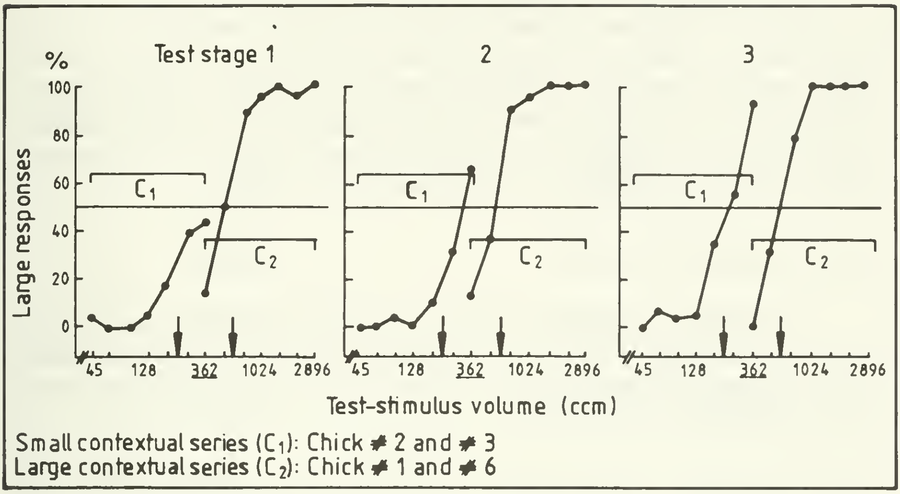
*Procedure.* — The experiment included three phases for each subject: (1) Key training, (2) discrimination training, and (3) generalization testing. After key training the subjects were trained to peck key 1 if TS 1, the 215 ccm cube was presented, to peck key 2 if TS 2, the 608 ccm cube was presented. Daily training sessions consisted of 50 trials. The stimulus sequence was randomly determined each day with the restriction that each stimulus was presented with equal frequency.

At the start of each trial the subject was held in the illuminated waiting box while a cube was positioned in the test box. Then the light was turned off in the waiting box while the light in the test box was turned on and the gliding door was opened. Following this brightness shift, the subject entered the test box. If it pecked the correct key this key choice was reinforced by access to the food magazine for three seconds. The test box was then darkened, the waiting box was illuminated again, and so forth. Darkness immediately followed an incorrect key choice and the same stimulus was presented again after six seconds.

After reaching the learning criterion (95% correct choices for three successive training sessions) the six subjects were assigned randomly to the three test conditions. Each series was presented six times daily during six test days. All choices were reinforced.

## *Results and Discussion*

The average number of trails required for reaching the learning criterion was 2230 (SD = 579). The top panel of Figure 2 shows the results of the generalization tests. The proportions of responses to the key that was correct for the large training stimulus ("large" responses) are shown for the two context conditions ($C_1$, $C_2$) separately for test stages 1, 2, and 3. Pairs of test sessions, a total number of 12 responses for each of the test stimuli were combined to form the three test stages. These data support the predictions of the microgenesis of context effects over test stages (bottom panel of Figure 2). During test stage 1 subjects tested with the small context series ($C_1$) were expected to use the response "large" infrequently while those tested with the large context series ($C_2$) were expected to use this response frequently. These results correspond to those expected by classical psychophysics. However, according to the *FR* model, as testing progresses (test stage 2, 3, . . . ) the same stimuli are increasingly judged either as "large" or "small" depending on the test series used. As a consequence, the *PSI* shifts towards the test-series center $C_1$ or $C_2$, respectively (see also Equation 1). Note, that the 362 ccm cube, physically equal for all test series, is responded to as "large" on approximately .5 of the trials at the beginning of the test phase (test stage 1), but this proportion shifts towards either "large" or "small" by the third test stage. An analysis of the proportion of "large" and "small" responses for the 362 ccm cube for each test stage under the two context conditions indicates, as expected, that the differences found between $C_1$ and $C_2$ are not statistically significant at test stage 1, but highly significant ($p < 0.001$) at test stage 2 [$\chi^2(1,N = 48) = 15.02$] and at test stage 3 [$\chi^2(1,N = 48) = 37.00$]. At the same time, two trend tests, done for the changes of *PSI*-values over the three test stages (cf. Ferguson, 1965), indicate that the *PSI*-values decrease under $C_1$ ($z = 1.73$, $p < 0.05$) and increase under $C_2$ ($z = 2.23$, $p < 0.02$). Furthermore, tests of trend differences (cf. Lindquist, 1953) comparing the predicted and observed *PSI* trends under $C_1$ and $C_2$ show that Equation 1 predicts the observed changes appropriately. In fitting the model, the empirical weighting factor $k$ was found to be 34 under $C_1$ and 29 under $C_2$, $F(2,3) = 0.55$ and $F = 0.30$., respectively. These differences are insignificant as expected.



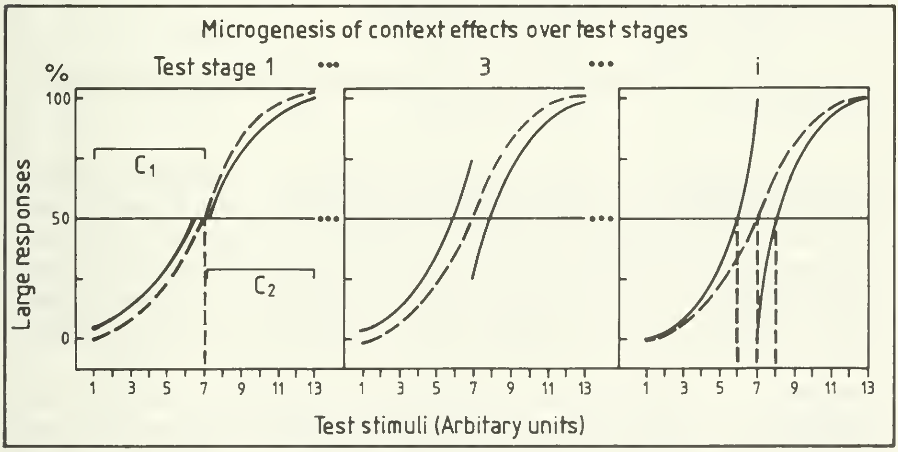


Figure 2 (upper)

*Changes of S-R functions over test stages.* — As predicted (see *Fig. 1*) *Ss* tested with a small context series ($C_1$) use in the beginning very few "large" responses, the other group ($C_2$) many (test stage *1*). These reaction rates increase and decrease over test stages (test stage *2*, *3*). At test stage *3* one and the same stimulus (volume of *362* ccm) is judged either as "small" or as "large" under $C_1$ versus $C_2$ context.

Figure 2 (lower)

*Hypothetical microgenesis of context effects over test stages.* — *Dotted lines:* Absolute psychophysical function valid for the whole stimulus scale. *Solid lines:* Psychophysical functions undergoing response changes by the different context conditions. Whereas in the first test stage (n=1) subjects tested with a small context series ($C_1$) use very few "large" responses, the other group ($C_2$) many, these reaction rates change over the test experience (test stage n=3 to n=i) physically equal stimuli are increasingly judged either as "large" or as "small" according to the context series used.

These data show, as predicted by the *FR* model, that context effects in animals do appear. However, the empirical weighting factor *k* expressing the slope of changing gradients (1/k) was about 10 times higher with the present subjects than previously found in human adults, and about 30 times higher than found in kindergarten children (Zoeke & Sarris, 1987). In addition, ascending test series ($C_2$) seem to produce larger contextual effects than descending series ($C_1$).

## EXPERIMENT 2

In this study the distance between the training and the test stimuli was gradually enlarged in order to examine the effects of series shifts. According to Koffka (1935) and Johnson (1949a,b) series shifts enhance context effects in humans.

*Animals.* — The subjects were six chickens *(Hubbard)*, approximately seven weeks old at the beginning of the experiment. Housing conditions were the same as described in Experiment 1.

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

*Stimulus material.* — Table 2 shows the three sets of training and test stimuli used (volume in ccm; log steps). Six subjects, two in each group, were trained either with middle-sized (181 and 724 ccm) or with small (45 and 181 ccm) or large (724 and 2896 ccm) cubes and tested with both ascending and descending test series. In this way, a between-group design (training) was combined with a within-group design (testing).

*Procedure.* — The training procedure was the same as described in Experiment 1. The test phase included generalization tests with the sets of stimuli shown in Table 2. Each test series was presented six times daily during five test days. The order in which the tests were given and the number of tests administered to each subject can be seen in Figure 3.

### *Results and Discussion*

Figure 3 shows the obtained results using the *PSI* as an indicator of changes of the psychometric functions.

Each of the six panels of Figure 3 shows the *PSI*-values for one subject as a function of context series. Step-by-step series shifts in the ascending direction (chicken No. 15, 16, and 18) result in increasing *PSI*-values whereas series shifts in the descending direction result in decreasing values (chicken No. 17, 19, and 20). A change in the direction of shift leads to a corresponding directional shift (indicated by the roman

## Table 2

*Sets of training and test stimuli used for gradual series shifts*

| | PHYSICAL SCALE (VOLUME IN CCM) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 22 | 32 | 45 | 64 | 90.5 | 128 | 181 | 256 | 362 | 512 | 724 | 1024 | 1448 | 2048 | 2896 | 4096 | 5791 | 8000 |
| TRAINING STIMULI | | | | | | | 181 | | | | 724 | | | | | | | |
| TEST SERIES | | | | | | | 181 | 256 | 362 | 512 | 724 | 1024 | 1448 | | | | | |
| | | | | | | | | 256 | 362 | 512 | 724 | 1024 | 1448 | 2048 | | | | |
| | | | | | | | | | 362 | 512 | 724 | 1024 | 1448 | 2048 | 2896 | | | |
| | | | | | | | | | | 512 | 724 | 1024 | 1448 | 2048 | 2896 | 4096 | | |
| | | | | | | | | | | | 724 | 1024 | 1448 | 2048 | 2896 | 4096 | 5791 | |
| | | | | | | | | | | | | 1024 | 1448 | 2048 | 2896 | 4096 | 5791 | 8000 |
| | | | | | 90.5 | 128 | 181 | 256 | 362 | 512 | 724 | | | | | | | |
| | | | | 64 | 90.5 | 128 | 181 | 256 | 362 | 512 | | | | | | | | |
| | | | 45 | 64 | 90.5 | 128 | 181 | 256 | 362 | | | | | | | | | |
| | | 32 | 45 | 64 | 90.5 | 128 | 181 | 256 | | | | | | | | | | |
| | 22 | 32 | 45 | 64 | 90.5 | 128 | 181 | | | | | | | | | | | |
| TRAINING STIMULI | | | 45 | | | | 181 | | | | | | | | | | | |
| TEST SERIES | | | 45 | 64 | 90.5 | 128 | 181 | 256 | 326 | | | | | | | | | |
| | | | | 64 | 90.5 | 128 | 181 | 256 | 362 | 512 | | | | | | | | |
| | | | | | 90.5 | 128 | 181 | 256 | 362 | 512 | 724 | | | | | | | |
| | | | | | | 128 | 181 | 256 | 362 | 512 | 724 | 1024 | | | | | | |
| | | | | | | | 181 | 256 | 362 | 512 | 724 | 1024 | 1448 | | | | | |
| | | | | | | | | 256 | 362 | 512 | 724 | 1024 | 1448 | 2048 | | | | |
| | | | | | | | | | 362 | 512 | 724 | 1024 | 1448 | 2048 | 2896 | | | |
| | | | | | | | | | | 512 | 724 | 1024 | 1448 | 2048 | 2896 | 4096 | | |
| | | | | | | | | | | | 724 | 1024 | 1448 | 2048 | 2896 | 4096 | 5791 | |
| | | | | | | | | | | | | 1024 | 1448 | 2048 | 2896 | 4096 | 5791 | 8000 |
| TRAINING STIMULI | | | | | | | | | | | 724 | | | | 2896 | | | |
| TEST SERIES | | | | | | | | | 362 | 512 | 724 | 1024 | 1448 | 2048 | 2896 | | | |
| | | | | | | | | 256 | 362 | 512 | 724 | 1024 | 1448 | 2048 | | | | |
| | | | | | | | 181 | 256 | 362 | 512 | 724 | 1024 | 1448 | | | | | |
| | | | | | | 128 | 181 | 256 | 362 | 512 | 724 | 1024 | | | | | | |
| | | | | | 90.5 | 128 | 181 | 256 | 362 | 512 | 724 | | | | | | | |
| | | | | 64 | 90.5 | 128 | 181 | 256 | 362 | 512 | | | | | | | | |
| | | | 45 | 64 | 90.5 | 128 | 181 | 256 | 362 | | | | | | | | | |
| | | 32 | 45 | 64 | 90.5 | 128 | 181 | 256 | | | | | | | | | | |
| | 22 | 32 | 45 | 64 | 90.5 | 128 | 181 | | | | | | | | | | | |

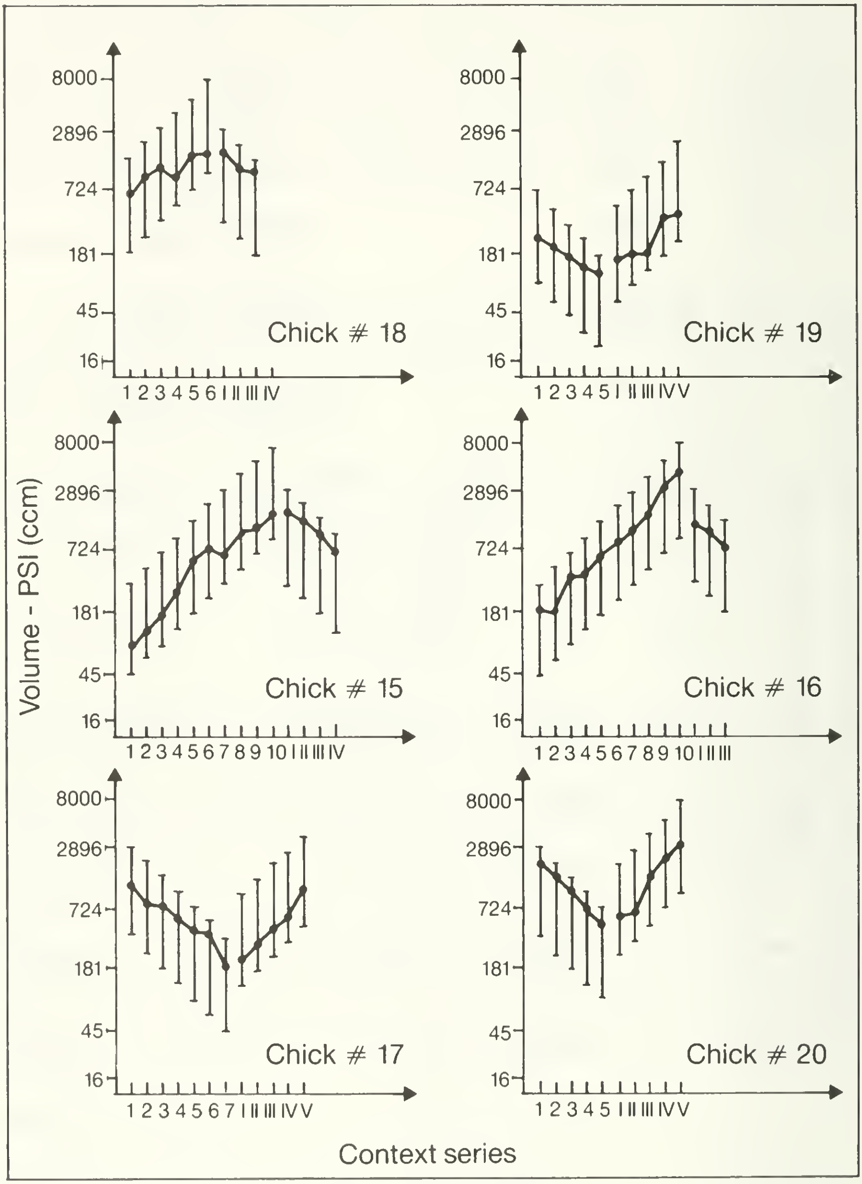


Figure 3

*Changes of the Point of Subjective Indifference (PSI) over gradual context-series shifts.* — *PSI* values (ordinate) increase for ascending test series and decrease for descending test series (abscissa). The arabical numbers on the abscissa indicate the direction of the first series shift for each *S*, the roman numbers the respective changes of shift direction.

numbers at the top absissa). Note that chicken No. 18 and 19 were trained with the same middle-sized TS but tested with the ascending and descending series presented in different orders. The obtained changes in the psychometric functions are very similar to those of human subjects. In addition, for both animals and humans, ascending testing again seems to produce larger contextual effects than descending testing (cf. Hauf, 1987; Johnson, 1949a,b; Zoeke & Sarris, 1987).

## GENERAL DISCUSSION

The present data corroborate the prediction that contextual effects, which have previously been demonstrated only in humans, are also found in animals. At the same time, it must be taken into account that the changes in the psychometric functions found for the present subjects take place much slower than in humans. One reason for this might be the amount of training animals require to learn the discrimination task as James (1953) and Thomas (1974) have assumed. This is reflected by the empirical weighting factor $k$ of the *FR* model that is used here. Failures to observe similar effects by prior investigators may to be understood in terms of testing techniques (continuous testing procedure) as well as in quantitative modeling of the expected effects. Therefore, an advantage of the *FR* model is that it considers the effects of both training and testing procedures (cf. Equation 1; $PSI_{\text{train}}$, $PSI_{\text{test}}$). Consideration of these matters is just a step towards a detailed quantitative model appropriate for comparison among species, and an understanding of the biopsychological processes involved in the behavior studied here.

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