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CATEGORY AND STIMULUS EFFECTS: A PROCESS MODEL FOR CONTEXTUAL MEMORY IN JUDGMENT

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The effects of skewing the stimulus context for category ratings are analyzed within an information-processing framework. A specific model for the retrieval of stimulus frequencies from memory accounts for the recently demonstrated effects of number of categories and number of stimuli. The model assumes that with more categories there is less time to search memory for stimulus frequencies, reducing the contextual skewing. This assumption is supported by the disappearance of Category and Stimulus Effects when psychophysical stimuli are presented with equal frequency but unequal spacing. The model suggests practical applications to more complex value judgments.

Category ratings describe positions in a set of related stimuli. These stimuli constitute the context for judgment in the sense that the rating of any particular stimulus is determined by its place in the set. In psychophysical experiments, the context is often simply those stimuli presented for judgment. Range-frequency theory (cf., Parducci, 1965, 1974, 1983) identifies particular features of the contextual set from which the ratings can be predicted. As such, it is a theory about how information is integrated to form a judgment.

This approach oversimplifies the process of judgment when it assumes that all of the presented stimuli contribute to the judgment. When stimuli are presented successively, earlier presentations must be retrieved from memory before they can be integrated in the process of judgment. Recent research conducted in our laboratory has encouraged us to consider how past presentations are retrieved. Although complicating the model for judgment, this emphasis on retrieval from memory accounts for surprising experimental data and also yields testable predictions for new experiments.

A GENERAL PROCESSING FRAMEWORK FOR DIMENSIONAL JUDGMENT

The various operations that produce an internal judgment and then an overt category rating can be conceived as a flow of information:

SENSORY ANALYSIS OF THE STIMULUS ⟹ RETRIEVAL OF CONTEXTUAL INFORMATION ⟹ RANGE-FREQUENCY INTEGRATION OF INFORMATION ⟹ TRANSFORMATION OF JUDGMENT TO CATEGORY RATING

Information flows from left to right. After sensory analysis of the immediate stimulus, relevant contextual information is retrieved from memory. This information is then integrated according to range-frequency rules of judgment. Finally, the internal judgment is transformed to an overt category rating. Although information presumably flows in a single direction, processing constraints at any one level may affect processing at any other level. Thus, the particular type of integration may dictate what type of information is retrieved, and response constraints may also affect what information is retrieved and even how it is integrated. This dependence among processes appears to account for surprising results of research in which we have independently varied the number of categories and the number of stimuli.

CATEGORY AND STIMULUS EFFECTS

Our basic experimental procedure presents squares of varying size, one every five seconds, in a long, randomized series. The subject's task is to rate how large or small each square appears in comparison with all the other squares that have been presented. By altering relative frequencies of a small set of sizes, the frequency distribution is skewed either positively or negatively.

In agreement with past research (e.g., Helson, 1964; Johnson, 1944; Parducci, 1963), ratings of particular squares are higher when the smaller sizes are presented more frequently. According to range-frequency theory, this effect of skewing reflects the frequency principle, which is the tendency to judge stimuli on the basis of their cumulative frequency positions

or ranks in the distribution of contextual stimuli. The theory proposes that actual ratings reflect a compromise between this principle and the range principle, which is the tendency to judge the stimulus on the basis of its place in the range of contextual stimuli. This range-frequency compromise is expressed algebraically as follows:

$$J_i = wR_i + (1 - w)F_i, \quad (1$$

where J_i is the internal judgment of Stimulus i, R_i is what it would have been following simply the range principle, F_i is what it would have been following simply the frequency principle, and w is the relative weight of the range principle in determining the judgment. The overt category rating is assumed to be a linear transformation of the internal judgment. This is represented algebraically as follows:

$$C_i = bJ_i + a, \quad (2$$

where C_i is the overt category rating of Stimulus i, b is the range of numerical values assigned by the experimenter to represent the respective categories (e.g., their ranks), and a is the value assigned to the lowest category.

In past research, ratings of a wide variety of stimuli were usually consistent with a somewhat equal compromise between range and frequency principles, i.e., w was close to .5 (Birnbaum, 1974; Parducci, Calfee, Marshall, & Davidson, 1960; Parducci & Perrett, 1971; Riskey, Parducci, & Beauchamp, 1979). But in our more recent research (Parducci, 1982; Parducci & Wedell, 1984; Wedell, 1984), w appears to change systematically with variation in either the number of categories available to the subject or the number of stimuli used to create the contextual distributions.

Table 1 characterizes the effects of these variations in terms of the difference in adaptation level (the mean of the stimulus values rated "average") between negative and positive conditions of skewing and also in terms of the best-fit estimates of $(1 - w)$. Both measures vary inversely with number of categories (the Category Effect) but directly with number of

Table 1

Effects of Skewing: Mean Differences in Adaptation Level and Frequency Weightings $(1 - w)$ for Different Numbers of Categories and Stimuli

Number of Stimuli	Number of Categories								
	2	3	4	Open	5	7	9	20	100
Five									
$(AL^- - AL^+)$	9.87	5.87	4.24	4.93	2.03	----	3.06	0.49	0.88
$(1 - w)$	0.69	0.45	0.32	0.30	0.25	----	0.20	0.09	0.07
Nine									
$(AL^- - AL^+)$	9.87	6.22	----	7.07	6.67	6.53	3.37	----	1.62
$(1 - w)$	0.87	0.51	----	0.48	0.46	0.51	0.33	----	0.14

stimuli (the Stimulus Effect). Statistical analysis shows that both the number of categories and the number of stimuli interact significantly with skewing.

INTERPRETING CATEGORY AND STIMULUS EFFECTS

Within our general framework for the processing of information, the Category and Stimulus Effects may occur at any one or more of the four stages. However, it seems highly unlikely that these effects are the result of the sensory analysis of the stimulus. Sensory analysis is conceived as a very low-level process, accounting for only a small portion of contextual effects (cf., Braida & Durlach, 1972).

RESPONSE TRANSFORMATION

Could the Category and Stimulus Effects represent changes only in the overt ratings and not in the internal judgments of the stimuli? Instead of the

simple linear relationship between judgment and rating (Equation 2), the form of the relationship may depend on the number of categories or stimuli. Equation 2 equates the respective end-categories, so that "large" in a three-category scale is equated with "very very large" in a nine-category scale. But perhaps the verbal labels carry some meaning in themselves, so that the category "large" represents the same judgment in both three- and nine-category scales.

This does not seem to be the case. The middle category was labeled "average" for the 3-, 5-, 7- and 9-category conditions, and yet Table 1 shows that the effects of skewing on adaptation-level (what stimulus is rated "average") vary systematically with number of categories and number of stimuli. Furthermore, keeping the number of categories constant but changing their labels (seven-category scales varying either from "small" to "large" or from "very very small" to "very very large") does not change the form of the rating functions. Finally, tabulating the nine-category scales as though there were only three categories (e.g., "very very small," "very small," and "small" tabulated as "small," etc.) produces scales that are remarkably similar to the nine-category scales. The results of these and other of our attempts to "scale out" the Category and Stimulus Effects have led us to believe that they are not merely the result of how the internal judgments are transformed to overt, category ratings.

INFORMATION INTEGRATION

Because both Category and Stimulus Effects can be described in terms of variations in a single parameter (w in Equation 1), it is tempting to attribute them to the integration process. Indeed, past formulations of range-frequency theory (e.g., Parducci & Perrett, 1971) have included the number of rating categories directly in the integration process. For example, the frequency principle has been stated as a tendency to put the same number of stimuli in each category and the range principle as the tendency to divide the stimulus range into equal subranges corresponding to the respective categories. We have achieved good fits to both five- and nine-stimulus data by holding range and frequency values constant and allowing only w to vary with number of categories and number of stimuli (Parducci & Wedell, 1984).

But why should the weighting parameter change? There seems nothing in the concept of the compromise between range and frequency principles to suggest that the range should get greater weighting with either more categories or fewer stimuli. Of course, post hoc accounts can be generated: when the instructions call for more categories, the subject may interpret them to call for finer discrimination with respect to position in the range and hence greater weighting of the range principle; alternatively, the problem of putting the same number of stimuli in each category may seem too difficult when there are many categories or when the number of categories is large relative to the number of stimuli. These remain possibilities, but they have not suggested new conditions for which they entail specific predictions.

INFORMATION RETRIEVAL

A new interpretation that we find attractive places both Category and Stimulus Effects at the retrieval stage (Wedell, 1984). This represents a marked departure from earlier accounts of psychophysical judgment. The primary attraction of the psychophysical experiment as a testing ground for contextual theories has been the evidence that the context for judgment is simply the other stimuli in the experimental series: this puts the context under complete experimental control. However, the procedure of successive presentation requires that earlier presentations be retrieved from memory if they are to affect the judgment of the present stimulus. The frequency principle requires the retrieval of contextual frequencies. Previous research on memory for frequencies (Hasher & Zacks, 1979; Hintzman, 1969) has demonstrated systematic underestimation for the frequencies of those stimuli that come more often. This suggests that the effective context for judgment in our psychophysical experiments may be less skewed than the actual frequency distribution presented as the experimental series.

To account for our own data, this systematic distortion in the memory for stimulus frequencies must reduce the effective skewing with an increase in number of categories but increase it with an increase in the number of stimuli. How might this occur? One interpretation (Wedell, 1984) is that as the number of categories increases, response transformation requires more time for processing, limiting the time available for retrieving stim-

ulus frequencies. Reduced time for retrieval leads to insufficient retrieval of higher frequencies and consequently to reduced effects of skewing. This same interpretation accounts for decreased skewing effects with fewer stimuli as well: using nine rather than five stimuli means that each stimulus tends to occur less often (e.g., frequencies: 5-5-6-2-2-2-1-1-1 vs. 10-7-4-2-2 for nine- and five-stimulus, positively-skewed sets, respectively). Thus, incomplete retrieval of the more frequent stimuli is aggravated when the same degree of skewing is produced using fewer stimuli.

TESTABLE IMPLICATIONS OF THE RETRIEVAL INTERPRETATION

If this interpretation is correct, Category and Stimulus Effects ought not to be found when stimuli occur with equal frequency, for then there would be no need to differentiate stimulus frequencies. This implication has been confirmed in experiments in which skewing has been produced by varying the spacing (along the dimension of judgment) of stimuli presented with equal frequency (Parducci & Perrett, 1971; Parducci & Wedell, 1984; Wedell, 1984). The Category Effect is also absent with simultaneous presentation when skewing is produced primarily by spacing (Mellers & Birnbaum, 1982; Parducci & Wedell, 1984; Wedell, 1984).

Another implication of the retrieval interpretation follows from the explanation of the Stimulus Effect in terms of differences in individual stimulus frequencies rather than differences in the actual number of stimuli. In a recent experiment (Parducci & Wedell, 1984), we compared two sets of nine-stimulus distributions, our original set and a new set in which equivalent skewing was created by piling up frequencies on a single stimulus (e.g., 2-12-2-2-2-2-1-1-1 instead of 5-5-6-2-2-2-1-1-1 for positively-skewed sets). The effects of skewing were significantly reduced for the modified set. This is consistent with an interpretation of the Stimulus Effect in terms of underestimation of stimuli presented with greater frequency.

A MEMORY MODEL OF CATEGORY AND STIMULUS EFFECTS

This model is described in greater detail elsewhere (Wedell, 1984). We

present it here in a more general form to illustrate ways in which memory processes may affect the context for judgment.

The central assumption of the model is that due to the quickness and apparent automaticity with which category ratings are made, there is competition for a limited amount of processing time. The view that category ratings are made automatically is based on two observations: 1) subjects take little time to perform the task (perhaps less than a second); and 2) subjects do not appear to have access to the judgment process itself, often reporting that the rating just "popped" into their heads or (when pressed for an analysis) reporting rules that may be inconsistent with their own ratings (Parducci, 1983).

Do more categories really require more time? Bevan and Avant (1968) demonstrated that response latencies in a rating task increase directly with the number of categories. They attributed this increase to greater processing time required for response transformation. If total time is limited, then increasing the number of categories reduces the time available for retrieving and integrating contextual information. The disappearance of Category and Stimulus Effects when skewing is based on spacing rather than frequencies supports the hypothesis that retrieval is what is affected. The memory model's account of retrieval of stimulus frequencies introduces two theoretical concepts, depth of search and size of the search set.

DEPTH OF SEARCH

This concept refers to how much information can be retrieved, the limiting factor being the time available for retrieval. In the present case, we are concerned with retrieval of the number of repetitions of each stimulus. The model proposes that past presentations are counted separately, but in parallel, for the different stimuli. When time is shortened by having to place the stimulus in one of an increased number of categories, the depth of search (i.e., maximum count per stimulus) is reduced. Thus, the model proposes that increasing the number of categories places a ceiling on the maximum number of repetitions that can be counted for any given stimulus. Lowering this ceiling reduces remembered differences in stimulus frequen-

cies because some of the presentations of the more frequent stimuli are not counted while all of the presentations of the less frequent stimuli are counted. As a consequence, the effective context for judgment is less skewed than the frequency distribution of stimuli actually presented.

Limitations upon the depth of search also entail the Stimulus Effect. The frequency with which each stimulus is presented in each block of trials decreases when the number of stimuli increases; hence, less depth of search is required to retrieve all (or most) of the presentations of even the most frequent stimulus. This means that the remembered skewing of stimulus frequencies will not be reduced as much when less time is available with more categories.

Finally, an explanation of Category and Stimulus Effects in terms of time-restricted depth of search accounts for the elimination of these effects when skewing is achieved by varying the spacing rather than the frequencies of the stimuli. Lowering the ceiling on the number of repetitions retrieved cannot reduce remembered differences in stimulus frequencies when there are no differences to reduce. In our empirical fits, the depth of search has varied between six presentations per stimulus with two categories to fewer than two presentations for nine or more categories.

SEARCH SET

This concept refers to the set of stimulus traces available for retrieval. The size of the search set must be limited; for otherwise the effects of skewing would decrease when the number of trials increased, and they would disappear completely when the least frequent stimulus exceeded the depth of search. Instead, skewing effects remain constant over the series of presentations. Wedell (1984) tested the hypothesis of a limited search set using a transfer design in which the number of preshift trials was varied: rate and level of post-shift adjustment were largely unaffected by the number of preshift trials beyond 10. This suggests that the search set may be limited to the last 10 to 15 trials.

THEORETICAL FIT TO THE DATA

Wedell (1984) developed a computer-simulation program to test the theoretical fit of the model to the data. Depth of search was the major parameter allowed to vary between categories (6.00, 4.50, 2.75, 2.25, 2.00, 1.50, and 1.25 for 2-, 3-, 4-, 5-, 7-, 9-, and 100-point scales, respectively). Search set included only the last 12 presentation trials for all conditions. For three, four, five, seven and nine categories, $\underline{w}$ was set at .5. The theoretical predictions were similar to those that had been obtained by varying only $\underline{w}$; however, an important feature of the fit was that depth of search varied with only a single variable, number of categories. To account for the data in terms of changes in $\underline{w}$, $\underline{w}$ must vary with three variables: number of categories, number of stimuli and source of skewing (unequal frequencies or unequal spacing). Thus, the memory interpretation appears to have greater explanatory power. Another advantage of the memory interpretation is that it enriches speculation about the broader implications of contextual effects.

BROADER IMPLICATIONS OF THE MEMORY MODEL

How might memory affect judgments made outside the laboratory? In everyday life, the context must often be retrieved from the distant past, scales of judgment depending upon events occurring sometimes months or even years earlier. Thus, an understanding of judgments outside the laboratory entails consideration of the factors affecting this kind of retrieval.

SEARCH SET

The concept of a search set of limited size implies that only a limited set of memory traces is searched to arrive at a judgment. In the psychophysical experiment, the search set appears to be limited to perhaps the last dozen trials. But what constitutes the search set outside the laboratory? For example, when an instructor grades a student's performance, is the context simply the performances of other students in the same class? Or are other classes, perhaps from earlier years, included in the context establishing the standards for grading?

Judgments of satisfaction are greatly influenced by contextual factors (Parducci, 1968, 1984). Like "Pollyanna," can one conjure up awful events to make the present situation more bearable by comparison? Mothers attempt this to get children to finish their meals, pointing out how good the rejected food would seem to starving (usually remote) people. Although this is probably not an effective way of altering a child's context for judgment (the children may have to actually experience the misery before incorporating it into their contexts), it suggests the potential usefulness of retrieving bad events from memory. This might involve a conscious process of search or even periodic rehearsal of previous bad experiences. If one assumes that the grander contexts of everyday life include events experienced months or even years earlier, factors affecting the retrieval process would seem of overwhelming importance in establishing the effective context for judgment.

DEPTH OF SEARCH

The concept of depth of search also focuses attention on what constitutes the effective context for judgment. However, depth of search is more concerned with how this context is determined by the process of retrieval. For example, an instructor who grades on the basis of last year's students may do so by comparing each present performance to those of students who stand out in memory. However, these "outstanding" students are not likely to comprise a representative sample. A more systematic and extensive search could produce a radically different context for judgment. In this regard, Tversky and Kahneman (1974) have pointed out judgmental biases associated with the saliency and availability of stimulus events in memory.

What specific suggestions concerning the generalizability of Category and Stimulus Effects can be drawn from the depth-of-search feature of the model? Should we expect these effects in survey research? Unfortunately, our knowledge of the context for judgment in this type of situation is mostly conjectural. However, because the model locates these effects during the retrieval stage, we should expect them to occur when people are asked to make evaluations using unspecified contextual standards that are not immediately present. For example, the performance of a President may

be rated "good" (i.e., above average) on a three-category scale ("poor," "average," "good") but below average on a nine-category scale (from "very very poor" to "very very good").

Are contextual distributions for everyday judgments better characterized in terms of differences in stimulus frequencies or differences in stimulus spacing? One might assume that due to the multidimensional complexity of the stimuli that constitute the context for everyday judgments (exactly the same stimulus never occurs twice--Heraclitus), it is differences in spacing not frequency that characterize the distribution; consequently, neither Category nor Stimulus Effects should occur. However, the limits of information on a single dimension of judgment may result in similar events being grouped together in memory, creating the effects of unequal frequencies rather than of unequal spacing.

We have begun the exploration of some of these possibilities in recent research. For example, we have found a Category Effect in ratings of the perceived happiness of simple schematic faces but not in ratings of the attractiveness of photographs of natural faces--although the effects of skewing were quite robust. That the Category Effect is not limited to psychophysical stimuli was demonstrated with ratings of happiness of life-event descriptions (i.e., descriptions of different real-life situations). In research conducted with Michael Lane, the Category effect was also found with ratings of the mental disturbance exhibited by short, clinical case histories. The fact that similar manipulations lead to similar effects for psychophysical and social judgments encourages us to believe that the same basic processes occur in both areas. It is the greater control of contextual factors that recommends the psychophysical laboratory for the study of these processes.

The occurrence of the Category Effect with ratings of the happiness of life events suggests that happiness could be increased by controlling the fineness of the rating scale. Defining experienced happiness as the mean of all value judgments (c.f., Parducci, 1984), range-frequency theory implies that higher levels are produced by negatively-skewed distributions:

$$\overline{J} = \underline{w}(\overline{S} - .5(\underline{S_{max}} + \underline{S_{min}}))/(\underline{S_{max}} - \underline{S_{min}}), \qquad (3$$

which states that the mean of all judgments is proportional to the difference between the mean and the midpoint of the contextual distribution, divided by its range. This is a measure of skewing but with the traditional direction (algebraic sign) reversed.

Apart from arguing for decisions that skew contextual distributions as negatively as possible, Equation 3 says that the average judgment ($\bar{J}$) is directly proportional to the relative weighting of the range principle, w. Alternatively, the memory model makes it inversely proportional to the depth of search. The Category Effect (interpreted either as increase in w or decrease in depth of search) suggests that the average judgment for a negatively-skewed set of contextual events can be raised by using a finely-graded scale of nine or more categories. If things are going badly, i.e., the distribution of contextual events is skewed positively, the damage can be minimized by using just two or three categories. Any mnemonic device that either aids or hinders retrieval of past frequencies could also have important consequences for the overall mean of the judgments.

This picture is complicated, however, by consideration of what happens to the subjective range of contextual stimuli as a consequence of increasing the number of categories. Even in our simple psychophysical experiments, increasing the number of categories sometimes seems to extend the subjective range beyond the set of stimuli presented. Thus, using a nine-category scale for a negatively-skewed distribution of events would be counter-productive if it extended the upper endpoint of the range. But if using the nine-category scale extended the lower endpoint of the range, it would thereby increase the negative skewing of the distribution and raise the overall mean of the judgments. The question of how changes in the number of categories affects the subjective range requires research specifically designed to disentangle inferred range from inferred frequencies.

MEMORY FOR RESPONSES

When judging a previously encountered stimulus, one may sometimes recall its previous rating and simply use that rating. Even when the search set for stimuli is limited to the most recent events, events from the more distant past may thus influence the current rating. This type of constancy of

scale has not been formally incorporated into range-frequency theory.

Wedell's (1984) transfer experiment directly addressed this problem of changing scales. Neither the rate nor level of postshift adjustment (to a distribution skewed in the opposite direction) was greatly affected by the number of preshift trials, supporting a search set limited to the last 10 to 15 trials. However, postshift adjustment was incomplete. This suggested a tendency to weight prior ratings into the present rating. An analysis of individual differences showed that different subjects within the same experimental condition varied dramatically in degree of postshift adjustment. These differences were accounted for by differences in the degree to which judgments appropriate to the preshift distribution were averaged with judgments appropriate to the postshift distribution to produce the overt, postshift ratings.

Resistance to change in scale seems a general feature of judgment. When the sequence of presentations in a psychophysical experiment includes a sudden extension of the range, the experimenter must maintain a sternly formal atmosphere to preclude exclamations from the subjects and even disparaging laughter--as though they felt tricked. Why should subjects be so concerned to maintain a constant scale? Perhaps the communicative functions of category ratings require some constancy of scale.

Grades assigned by teachers when evaluating students illustrate this point. In collaboration with Diana Roman, we have demonstrated that experimental subjects follow range-frequency principles in assigning grades to hypothetical distributions of examination scores, with their scales of judgment highly predictable from the immediate context of scores on the same exam. Professors too are no doubt much more under the influence of the distribution of performances in a particular class than they commonly believe. However, it is clear that their grades do not just communicate positions in the same class: grades tend to be higher in schools whose students are more highly selected but not as high as the grades those same students would have received in less selective schools (Parducci, 1976). Besides communicating the student's position in the class, the grade also communicates the student's position in some larger context of students.

lore generally, a rating identifies a position in the private context of :he judge; but insofar as different people share the same context, it also .dentifies a position in the shared context. Viewed in this way, sudden shifts in the judge's context must be moderated by the relative constancy of the shared context. This discourages sudden changes in the overt rating. Internal scales, as represented by covert judgments, may also be resistant to change, reflecting social constraints on how language is acquired and used.

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