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SEQUENTIAL EFFECTS AND MEMORY IN CATEGORY JUDGMENTS[1]

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The effects of previous stimuli on responses in an absolute judgment of loudnesses situation were investigated when feedback was and was not provided. Whether or not information feedback was provided, responses were assimilated to the value of the immediately previous stimulus in the series. The effects of stimuli more than one trial back in the sequence depend on the presence or absence of feedback. When the entire stimulus scale was shifted up or down to 5 db. from the level on the previous day, a substantial shift occurred in the constant error of judgment in the direction of the scale shift, providing evidence that a relatively long-term (24-hr.) memory process was being used in the judgment situation. None of the currently available models is adequate to account for both these results and those of earlier studies. The form of the sequential dependencies observed may depend at least partially on the presence or absence of an identification function from stimuli to responses.

The effects of the previous sequence of stimuli on judgment in a psychophysical task have long been of special interest, and the nature of the effects discovered seems to be different in different experimental situations. Some investigators report an inverse relation (contrast) between the response and the preceding stimuli (Fernberger, 1920; Helson, 1948; Long, 1937; Needham, 1935; Parducci, Marshall, & Degner, 1966), while others find a direct relation (assimilation) in addition to, or in place of, contrast (Barry, 1964; Garner, 1953; Holland & Lockhead, 1968; Parducci & Marshall, 1962; Sherif, Taub, & Hovland, 1958). Attempts have been made to explain some of these diverse findings with the notion of adaptation level (Helson, 1948, 1959; Parducci & Marshall, 1962). Since several recent studies have cast doubt on the validity of such an explanation, Parducci et al. (Parducci, 1965; Parducci & Haugen, 1967; Parducci, Marshall, & Degner, 1966) have introduced an alternative model depending on response system properties (range and frequency).

Holland and Lockhead (1968) found both assimilation and contrast in an absolute judgment of loudness task with information feedback. The response to the stimulus (Trial N) was found, on the average, to vary directly with the stimulus on the preceding trial ($N-1$) and inversely with stimuli two and more trials back in the sequence. Holland and Lockhead presented a model in which only "short-term" memorial processes are considered to account for both of these effects. The model assumes that for an absolute judgment task with information feedback, the problem for Ss is to retrieve the value of the stimulus on Trial $N-1$ from a memory contaminated by stimuli two and more trials back. According to this model, the response on Trial N is generated by the addition of the judged distance between the stimulus on Trial N and S's memory for the stimulus on Trial $N-1$ to the remembered numerical value of the feedback on Trial $N-1$. Errors are made because the memory of the previous stimulus moves toward a weighted mean of the stimuli previous to it.

There are reasons to expect that this two-parameter model is too simplistic. First, since only "short-term" memorial processes are required in the Holland and Lockhead

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(1968) model to explain assimilation and contrast errors in an absolute judgment task with feedback, there is no reason to expect that relatively long-term memorial processes are involved in such tasks. This is contrary to the speculation of Wever and Zener (1928), who introduced the method of absolute judgment. Wever and Zener, as well as Tresselt (1947), provided evidence for the operation of a relatively long-term memory process when feedback is not provided. Thus, either different processes operate in feedback than in no-feedback situations, or the model is, at best, incomplete.

A second concern is that the presence of feedback may not be the crucial situational factor leading to assimilation of the response to the previous stimulus. Garner (1953) found a similar assimilative effect in an absolute judgment of loudness situation with no feedback, although his *S*s previously had been highly trained with feedback. Sherif et al. (1958) and Parducci and Marshall (1962) did not actually give feedback in their studies of the anchoring of absolute judgments of lifted weights. A variable, labeled anchor was presented on every other trial, and an unlabeled weight was presented for "absolute judgment," without feedback, after each anchor. Judgments of the unlabeled weights presumably were assimilated to the value of the anchors preceding them. The results of these studies are evidence of assimilative effects in no-feedback situations, and we have to look elsewhere for a situational variable relevant to the different types of sequential effects reported.

The studies showing assimilation to the previous stimulus (Barry, 1964; Garner, 1953; Holland & Lockhead, 1968; Parducci & Marshall, 1962; Sherif et al., 1958) have in common the fact that response usage was highly specified. Each stimulus had a label, and the task of *S* was to respond with the appropriate label for each stimulus presented for judgment. In more formal language, the experiments could be characterized as choice experiments with an identification function present (Bush, Galanter, & Luce, 1963). On the other hand, studies reporting contrast with the previous stimulus (Fernberger, 1920; Long, 1937; Parducci et al., 1966) have been characterized by the lack of an identification function (other than that formed by *S* himself) specifying response usage for *S*. Unfortunately, many reported studies do not provide the necessary data to determine the presence of assimilation or contrast. It might be noted that in Long's (1937) study of context effects in comparative judgments of loudnesses (no feedback), assimilative effects were found in the pilot work in which *S*s were told exactly what the range of the comparison stimuli would be. In the main experiment, this knowledge was withheld from *S*s and contrast effects were found.

In all of the previously cited studies, the number of stimuli presented for judgment was between 5 and 10. The results of two additional studies (Parducci & Sandusky, 1965; Tanner, Haller, & Atkinson, 1967) indicate that the situation may be different for the judgment of only 2 stimuli. Both studies show the presence of an inverse relation (contrast) between the previous stimulus and the present response, and response usage was highly specified in both studies. The models presented in both studies emphasize the "same–different judgment" nature of the task. It may be that an identification function is superfluous in a task of this type. Certainly, it is not always possible to identify a stimulus that is a member of a larger set of stimuli with such a same–different judgment.

All of the available data together imply that for stimulus sets of more than two members, assimilation of the response to the previous stimulus may be expected whenever *S*s' use of available responses is highly specified by an identification function from a specified set of possible stimuli to a specified set of responses, whether or not feedback is provided. The studies reported in the present paper were conducted to investigate the effects of relatively long-term memory and of the availability of feedback on judgments and sequential effects when an identification function from the stimuli onto the responses is present.

METHOD

Design.—Two studies investigating the judgment of loudness levels were done with the method of single stimuli (absolute judgments) in which an identification function on the stimuli was specified to *S*s.

In the first study, information feedback was given after each response. Three undergraduates (two males and one female) judged randomly selected stimuli for 4 days (500 trials/day) following a practice session. The stimuli were 10 loudness levels centered around approximately 60 db., re .0002 dynes/cm^2, with adjacent stimuli separated by 1 db.; the total range was 9 db. On the fifth day, *S*s judged, without being informed of the change and with the same responses, 10 stimuli centered around 65 db., with adjacent stimuli again separated by 1 db. That is, the entire stimulus scale was shifted by 5 db., and feedback on a given trial was one of the numerals 1–10, as before. On the sixth day, the midpoint was changed to 60 db.; on the seventh day, to 55 db.; then back to 60 db. on the eighth day. It was predicted that if long-term memorial processes were present, where "long-term" means approximately 24 hr., they would be apparent as a shift in the constant error in the direction of the loudness level shift.

The second study was essentially the same as the first, except that no information feedback was given and that three different paid *S*s served (again two males and one female). The second study was conducted to investigate sequence effects in a no-feedback situation uncontaminated by prior feedback training or by labeled anchors and to determine the effect of a shifting scale on sequence effects and constant errors in no-feedback situations.

Apparatus and procedure.—The stimuli were 100-msec. duration, 1,000-Hz. sinusoids generated by an oscillator (Hewlett-Packard 200-CD). A random sequence generator, described by Holland and Lockhead (1968), selected 1 of 10 different attenuators on each trial, and the resulting amplitudes were delivered diotically through high-quality earphones. The *S*s typed a response on an electric typewriter and then either typed the correct value of the stimulus, presented as an illuminated numeral after *S*'s response (feedback), or typed a period without the feedback presented (no feedback). The midpoint of the stimulus series was changed by adjusting a decibel attenuator placed in series with the earphones. The interstimulus interval in the forced-pace task was 3.5 sec. The *S*s learned the pacing without difficulty early in the first practice session. Data from the first practice session are not considered since the interest was in performance after learning.

RESULTS

Sequential dependencies with unchanging stimulus scale.—The data from both studies

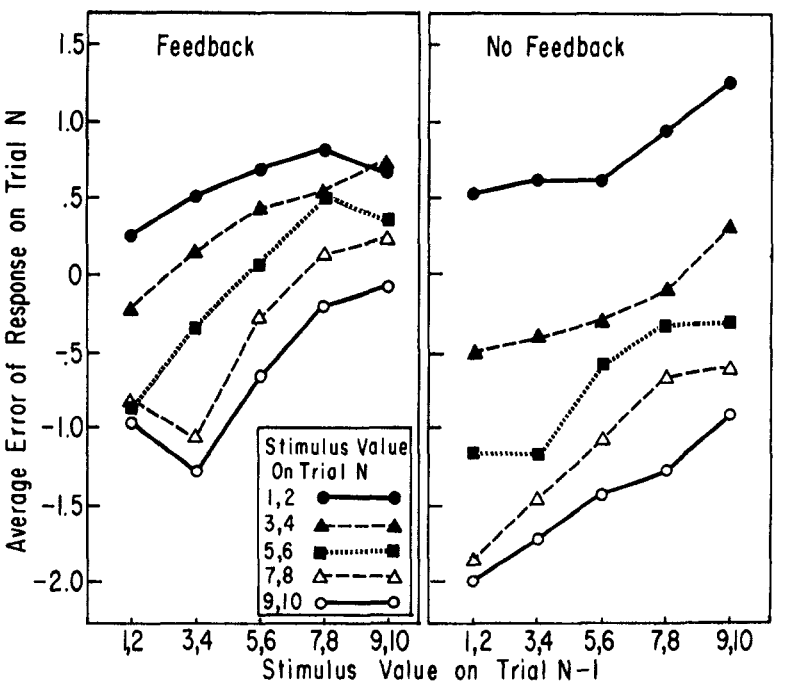

FIG. 1. Average effect of the stimulus at Trial $N-1$ on the average error of the response at Trial N for the feedback and no-feedback studies. (There are approximately 240 observations per point.)

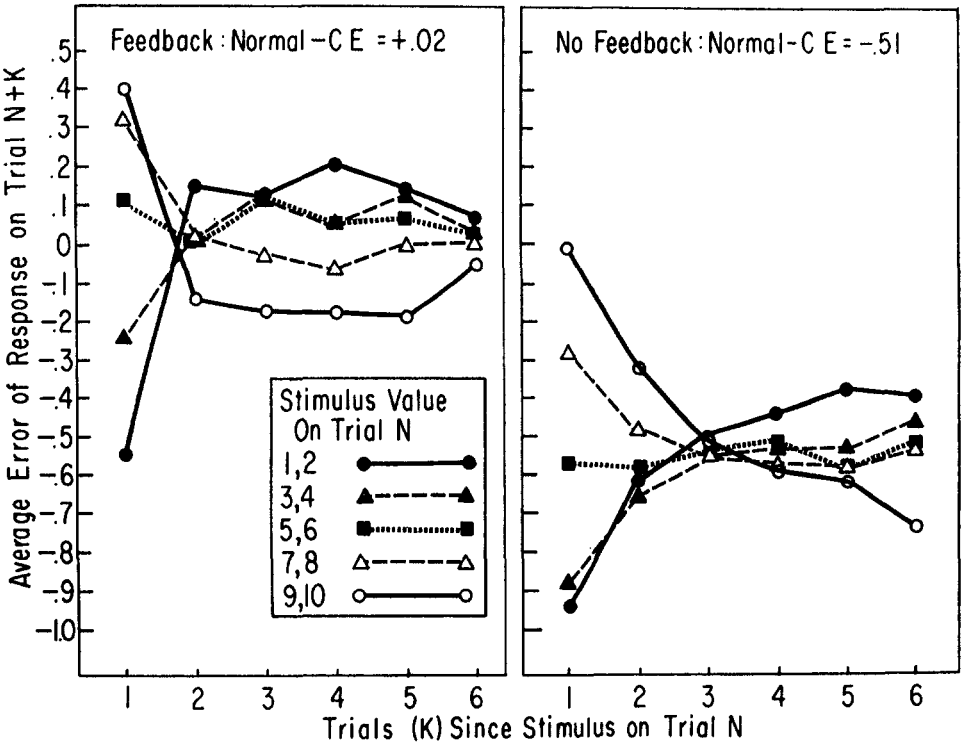

FIG. 2. Average error of the response at Trial $N+K$ attributable to the stimulus at Trial N for the feedback and no-feedback studies. (There are approximately 1,200 observations per point.)

were collapsed across Days 1–4 and *S*s, providing 6,000 responses in each study for the analysis of sequential effects. Data were pooled over days since performance, in information transmission and percentage of correct responses, was nearly asymptotic. Overall average information transmission was 1.27 bits with feedback and .95 bits without feedback; percentage correct averaged 36.1 with feedback and 27.1 without feedback. Data were pooled over *S*s since the form of the results was the same for each of them, and the pooled curves are less variable. Data were collapsed across pairs of adjacent stimuli to simplify the analysis and, again, to reduce variability.

Figure 1 shows the first-order sequential dependencies, the average effect on the response to the stimulus on Trial N of the value of the stimulus in the previous trial, for the feedback and no-feedback studies. The positively increasing trends (Fig. 1) show that the higher the value of the stimulus on Trial $N-1$, the higher the average response to the stimulus on Trial N, although the relation between stimuli on the separate trials was orthogonal. That is, there is assimilation between the response to the current stimulus and the value of the stimulus on the previous trial. The only striking difference between feedback and no feedback is that the range of errors is larger, as expected, when feedback is not presented than when knowledge of the correct response is regularly given.

Figure 2 shows the average effect of a stimulus at Trial N on the responses to stimuli occurring from one to six trials later, which is as far as the analysis was conducted, again for both feedback and no feedback. The feedback study shows a really striking replication, both in form and magnitude, of the dependencies reported by Holland and Lockhead (1968). In general, higher order dependencies are such that the response on a particular trial is contrasted

with stimuli two and more trials back in the sequence. The contrast effects, especially for Stimuli 1, 2 and 9, 10, seem to be of considerable strength even as far as five trials back, and the effects do not seem to decay exponentially, as assumed by Holland and Lockhead, who also found this persistence of contrast effects, but attributed the lack of a striking decay to random error.

Figure 2 again shows the similarity between first-order dependencies of feedback and no-feedback data with an identification function operative for *S*s. The magnitudes of the errors for the no-feedback situation are almost exactly the same as those for the feedback situation. Assimilation of considerable magnitude occurs between the stimulus on Trial N and the response on Trial $N + 1$. However, the higher order dependencies in the no-feedback situation are different than those in the feedback situation. Comparing the studies, it is observed that there is approximately the same average magnitude of assimilation between the stimulus on Trial N and the response on Trial $N + 2$ in the no-feedback condition as there is contrast in the feedback condition. Without feedback, the effects of a stimulus on a response three trials later are essentially zero, and contrast finally seems to occur four and more trials following the stimulus.

TABLE 1

SHIFT OF CONSTANT ERROR (CE) WITH SHIFT IN THE MIDPOINT OF THE STIMULUS SERIES IN STUDIES 1 (FEEDBACK) AND 2 (NO FEEDBACK)

Comparison between days	Prediction of CE shift direction if long-term memory is operative	CE on Day $N + 1$ minus CE on Day N	
		Feedback	No feedback
4 and 5	+	+.23	+.53
5 and 6	−	−.32	−.72
6 and 7	−	−.17	−.16
7 and 8	+	+.34	+.59

Note.—Midpoint shift = 5 db.

Constant errors due to scale shift.—Table 1 shows the effect on the constant error

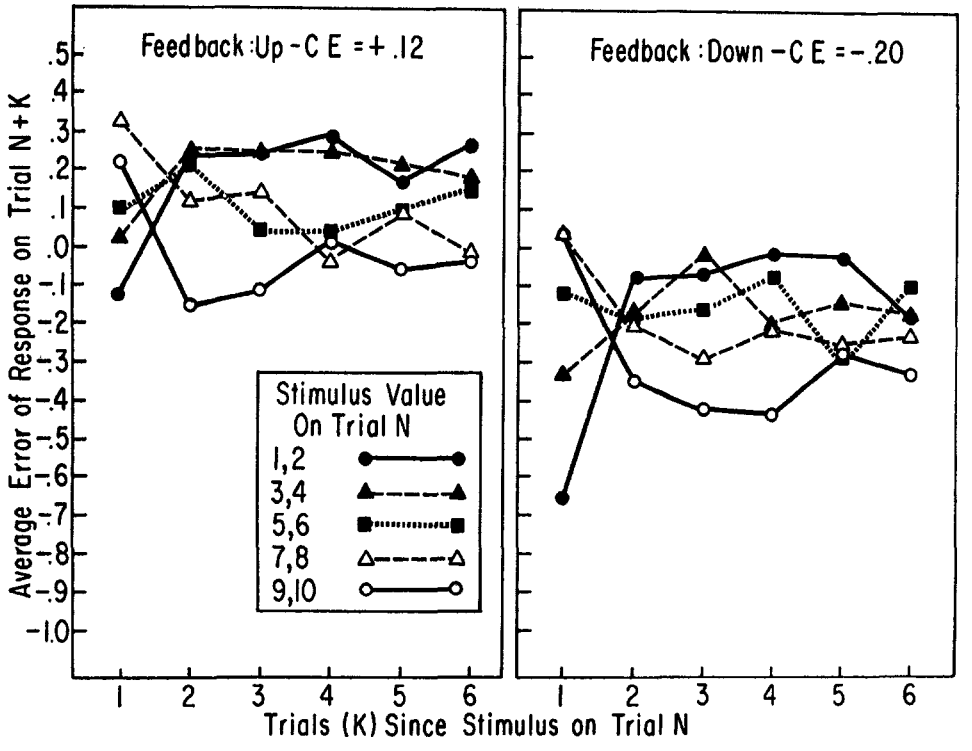

FIG. 3. Average error of the response at Trial $N + K$ attributable to the stimulus on Trial N for the feedback study when the midpoint of the stimulus series was 5 db. higher or lower than the previous day. (There are approximately 600 observations per point.)

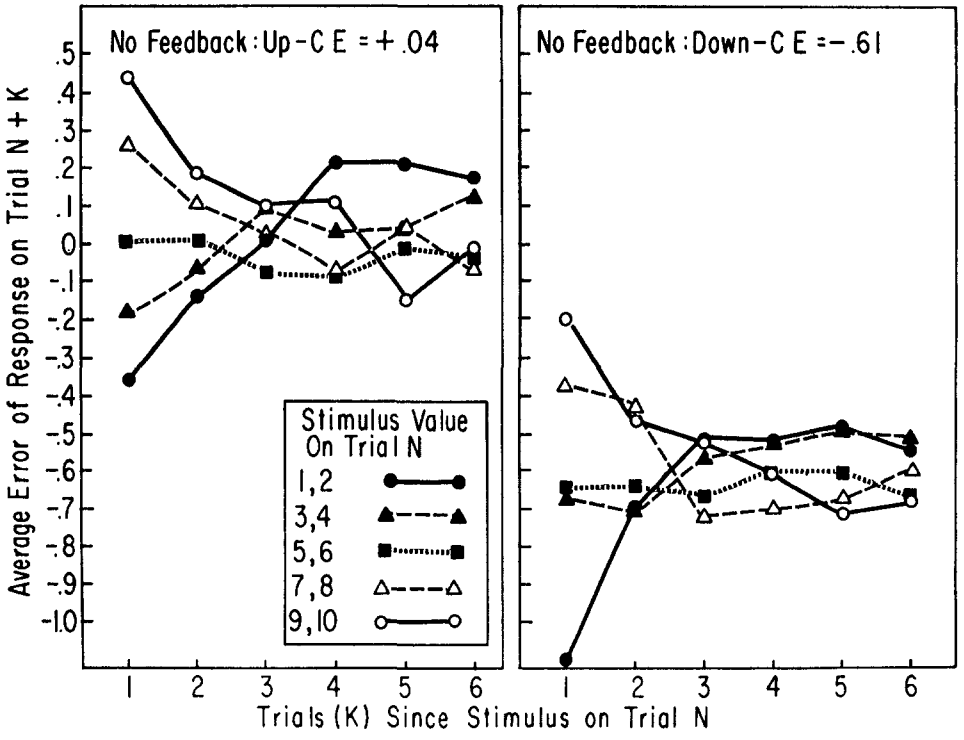

FIG. 4. Average error of the response at Trial $N+K$ attributable to the stimulus on Trial N for the no-feedback study when the midpoint of the stimulus series was 5 db. higher or lower than the previous day. (There are approximately 600 observations per point.)

(mean response minus mean stimulus) of the shift in the stimulus scale for both the feedback and no-feedback studies. Again, the data are averaged over *S*s for each study since the form of the results was the same for each of them. In all cases, the constant error shifted in the direction predicted by an argument for a long-term memory. The average constant error (CE) on the 60-db. midpoint scale prior to shifting was +.02 for the feedback study and −.51 for the no-feedback study. On the days when the shift of the loudness levels was +5 db. from the preceding day, the average CE was +.12 for feedback and +.04 for no feedback; when the shift was −5 db. from the preceding day, the average CE was −.20 for feedback and −.61 for no feedback. The effect of the scale responded to on the previous day was surprisingly tenacious and generally still apparent in the last 200 trials of each shifted day.

These data replicate earlier no-feedback findings (Tresselt, 1947; Wever & Zener, 1928) and extend them to the feedback situations, with the addition that the midpoint shift came on a day subsequent to the day with which it was compared. In the earlier experiments, the midpoint was shifted within a single session. Thus, the evidence for operation of long-term (24-hr.) memory for the stimuli or stimulus scale of the preshift stimulus series appears unequivocal.

Sequential dependencies on shifted days.— The data from the shifted days were analyzed for sequential effects for each study. Figure 3 (feedback) and Fig. 4 (no feedback) summarize the results for days when the scale was shifted up or down 5 db. from the previous day. There were 3,000 responses for each of these analyses. It can easily be seen for both studies that the form of the results is not different in any important respect from the normal days. The differences in location on the ordinate reflect the effects of the scale shift, and the figures appear to be approximately symmetrical about the CE of the appropriate condition.

It is difficult to make an unequivocal statement about the magnitude of the sequential dependencies on the shifted days. In the no-feedback study, there appear to be no differences at all from the normal days. However, a comparison of Fig. 2 and 3 indicates a trend in the feedback study for the first-order dependencies to be smaller in magnitude on the shifted days than on the normal days. There appear to be no effects of the shift on the magnitude of the higher order dependencies in either study.

Discussion

The effects of feedback.—The data reported in the present paper show that there is assimilation between the response to a stimulus and the value of the stimulus immediately prior to it in the sequence, whether or not feedback is provided, when an identification function is present. This result allows generalization of the Holland and Lockhead (1968) argument for a comparative judgment or short-term memorial process operative in absolute judgments, from feedback to no-feedback situations, if we assume that *S* is using his previous response, rather than the feedback, as the value of the comparative standard.

It is hard to imagine that the higher order effects reported could be due to short-term memorial processes that decay in time or trials (interference). It seems more reasonable to assume that the sequential effects one trial back and those later on arise from different processes: the first due to short-term memory or other such effects in the use of a comparative standard for judgment and the second from processes as yet inexplicable. An explanation for the later effects may lie in the consideration of purely response system variables, such as those suggested by Parducci (1965). For instance, *S*'s expectation of a low stimulus following a sequence of high stimuli in the series, and vice versa, might bias his report of the randomly selected stimulus which actually occurs. Such a "local frequency effect" cannot explain the first-order sequential dependencies and would have to discriminate between the differences in the higher order effects due to the presence or absence of feedback. It could do this if it were assumed that the use of the previous response as the value of the comparative standard, in the no-feedback situation, leads to a compounding of the assimilative error over trials which then more than offsets the contrast effect expected for these trials. Use of the feedback as the value of the previous stimulus in the feedback situation would avoid this compounding of error for stimuli more than one trial back, since the feedback was always the correct value of the previous stimulus and thus had not been assimilated to the value of a stimulus still further back in the sequence.

Conclusion.—The present study shows that the variable determining assimilation or contrast between the current response and the previous stimulus is not feedback. Assimilation appears to be the rule when there are more than two stimuli and when *S*s are required to label or name the stimulus, i.e., when there is an identification function present from the stimuli to the responses. Contrast seems to be the rule when *S* is required to report only the relation between the present stimulus and a previous standard, without the added task of assigning a specific name or label to the stimulus. When there are only two stimuli, the identification is possible with the use of only relational (same–different) information, and successive contrast appears to be the result.

Although long-term memory has been shown to be important in determining *S*s' responses in an absolute judgment situation, it does not appear to affect the form of the sequential dependencies. These results show that at least some important aspects of the judgmental process are a function of the experimental method used. Each method appears to introduce specific situational effects on the data, which may be superimposed on more fundamental judgmental processes.

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