Effect of letter-pair frequency and orientation of speed of "same" - "different" judgments by children and adults*

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In making "same"-"different" judgments of letter pairs, fourth graders took nearly twice as long to respond as did adult Ss, yet otherwise showed a similar pattern of results, responding faster on "same" than on "different" letter pairs, faster on more frequent than on less frequent letter pairs, faster on upright than on upside-down letter pairs. Contra to Egeth & Blecker (1971) and to Ellis & Chase (1972), the letter orientation effect was not restricted to "same" pairs. Contra to Krueger (1973), the letter frequency effect was not restricted to "different" pairs.

It has long been known that children have markedly longer simple and choice reaction time (RT) than do adults (see Hohle's, 1967, review), but nobody knows exactly why. Hohle (p. 227) ruled out such factors as motor coordination and motivation. Gibson (1969, p. 454) said that "not always paying attention" was not a sufficient explanation. Surwillo (1971) found that developmental changes in EEG period could account for only a small portion of the decline in RT with age in children.

The present study explored for specific differences in processing between adults and children, using a task involving the "same"-"different" comparison of two adjacent uppercase letters. Both the frequency and the orientation of the letter pairs was varied; some pairs were presented more often than other pairs, and some pairs were presented upside down rather than upright. The findings, it was hoped, would provide clues not only as to why children respond more slowly than adults, but also as to how children differ from adults in the way they organize visual elements and perceive letters. Young children may take a long time to respond, but they also have been found to be remarkably adept at discriminating very small visual details (e.g., Gaines, 1969).

METHOD

Subjects

Twelve City College of New York undergraduates, who were paid volunteers, and 12 fourth grade pupils (median age: 9 years, 11 months) from P.S. 192, Manhattan, served as Ss. English was the native language of all Ss. All Ss had 20/40 vision or better (corrected with glasses in some cases), as tested with a Snellen chart.

*This study was supported by NIH Grant HD04869. The author is grateful to Paula Elbirt and Bella Rublevich for collecting and tabulating the data, and to A. Rodriguez, principal, V. Lieber and H. Pierce, assistant principals, and C. Lazar and R. Stampp, teachers, at P.S. 192, Manhattan, for their cooperation and assistance in obtaining the fourth grade Ss.

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Apparatus

Stimuli were presented on a Gerbrands Model T-3B-1 tachistoscope with the exposure fields set to maximum intensity, 4 mL. Information on RT (measured in milliseconds by a specially built electronic timer) and on which button S pressed was punched out on paper tape for subsequent computer analysis. To start each trial, S pressed a footpedal linked to a remote-start switch on the tachistoscope.

Stimulus Materials

Two capital letters in 36-pt Futura Demibold Prestype dry-transfer symbols were placed on each 4 x 6 in. stimulus card. Each letter was centered in an imaginary .25-in.-wide x .375-in.-high box; .50 in. separated the left and right boxes, which were exactly centered on the card.

All Ss saw the same two sets of 180 cards each. In one set, the letters A, F, and R occurred four times as frequently as T, U, and Y; in the other set, T, U, and Y occurred four times as frequently as A, F, and R. The letters, which are shown in Fig. 1, were selected so that the key differentiating features between them would be located about as frequently in their lower portions as in their upper portions. Thus, presenting the letters upside down did not alter the upper-lower balance of features, though it did alter the left-right balance, though only when the horizontally asymmetrical letters F and R were presented.

Each set was shown to half the Ss in upright orientation and to half in upside-down orientation; within each orientation, the set was shown first half the time. Each set consisted of six subsets of 30 cards each, which included 12 more frequent "same" cards, 12 more frequent "different" cards, 3 less frequent "same" pairs, and 3 less frequent "different" pairs. In the "ARF" set, each subset of 30 contained 4 each of AA, FF, and RR; 3 each of RA, FR, and AF; 1 each of AR, RF, and FA; 1 each of UU, TT, and YY; 1 each of UT, YU, and TY (or, on alternate subsets, TU, UY, and YT). In the "TUY" set, each subset of 30 contained 4 each of TT, UU, and YY; 3 each of UT, YU, and TY; 1 each of TU, UY, YT; 1 each of AA, FF, and RR; 1 each of RA, FR, and AF (or, on alternate subsets, AR, RF, and FA). As may be noted, within the 12 more frequent "different" cards, some particular pairs (e.g., UT) occurred more frequently than other pairs (e.g., TU). This variation, which was designed to test whether the effect of letter frequency was rather than of letter-pair configuration, had no significant effect, and all data analyses presented below will be based on all 12 more frequent "different" cards lumped together.

Practice cards, half "same" and half "different," were prepared by sampling randomly from the entire alphabet. Forty practice cards were shown before the first 180-card set, and had the same orientation (upright or upside-down) as the first set. Ten practice cards were shown immediately prior to, and in the same orientation as, the second 180-card set.

A F R
T U Y

Fig. 1. The two letter sets (A F R, T U Y) from which pairs were constructed. Except for photographic reduction, the horizontal separation between letters and the letters themselves (Prestype 36-pt. Futura Demibold) are exactly as presented to Ss.

Table 1
Mean Response Time in Milliseconds for Adult and Fourth-Grade Ss by Stimulus Frequency, "Same" vs "Different" and Upright vs Upside Down

Stimulus Frequency	"Same"		"Different"	
	Upright	Upside Down	Upright	Upside Down
Adult Ss				
More Frequent	549	560	589	595
Less Frequent	563	567	618	627
Fourth-Grade Ss				
More Frequent	904	957	926	970
Less Frequent	925	980	988	1002

Note— $N = 12$ each for adults and fourth-grade Ss. Letters in the more frequent condition occurred four times as frequently as letters in the less frequent condition.

Procedure

The Ss were instructed to fixate on a prior, small black dot located midway between the two letters in a pair. On each trial, the fixation point appeared for 0.8 sec, then the letter pair appeared for 0.6 sec, after which the fixation point reappeared for 2.0 sec. The S's response did not terminate the stimulus display, which always remained in view for 0.6 sec. The E changed the stimulus card after S responded, so that 3 to 4 sec typically elapsed between trials.

The Ss were told to respond as quickly as possible, but not at the expense of accuracy. The Ss received a 50 cent bonus if their error rate was below 5% and their speed of response was in the top quartile for all Ss. Half the Ss pressed the right button for "same" and the left button for "different," and half had the reverse hand assignment.

A buzzer sounded briefly when S pressed the incorrect button or pressed before the stimulus card appeared. All responses which exceeded 3 sec or on which S pressed the incorrect button were excluded before the response times were averaged.

RESULTS

As Table 1 shows, for adults and children combined, mean RT was 27 msec shorter for upright than for upside-down pairs, which was not significant, $F(1,22) = 2.88$, $p < .10$; 28 msec shorter for more-frequent than for less-frequent stimuli, which was significant, $F(1,22) = 9.28$, $p < .01$; and 32 msec shorter for "same" than for "different," which also was significant, $F(1,22) = 8.41$, $p < .01$. Further, adults responded significantly faster than the fourth grade Ss, $F(1,22) = 23.44$, $p < .001$. No interaction was significant.

The nonsignificance of the upright-vs-upside-down RT difference may have been due to extraneous variability introduced by having half the Ss view the upright pairs first and half the upside-down pairs first. For the first set as compared with the second set, mean RT was 50 msec shorter among fourth grade Ss and 11 msec longer among adults. When 50 msec was added to the mean RT for the first set among the fourth grade Ss, and 11 msec was subtracted among the adults, RT was significantly shorter, on one-tailed t tests, for upright than for upside-down, for fourth grade and adult Ss combined, $t(23) = 1.95$, $p < .05$, for fourth grade Ss alone, $t(11) = 1.79$, $p < .05$, but not for adult Ss alone, $t(11) = 0.93$, $p < .20$. The reliability of the upright-vs-upside-down

effect is further attested to by the fact that RT is shorter for upright than for upside down in all eight possible comparisons shown in Table 1 (sign test, $p = .004$).

A separate analysis for adults indicated a significant effect for frequency, $F(1,11) = 7.08$, $p < .025$, and for "same" vs "different," $F(1,11) = 6.06$, $p < .05$. A separate analysis for fourth graders revealed only a marginally significant effect for frequency, $F(1,11) = 4.47$, $p < .10$.

The error rate was slightly higher for adults than for fourth graders (2.3% vs 1.5%), for upside-down than for upright pairs (2.0% vs 1.8%), for less frequent than for more frequent stimuli (2.1% vs 1.7%), and for "same" than for "different" pairs (2.0% vs 1.8%). No main effect or interaction on error rate was significant.

DISCUSSION

As Table 1 shows, mean RT of the fourth grade children was nearly double that of the adult Ss, a result quite similar to that obtained in recent visual search studies by Forsman (1967) and Leslie & Calfee (1971). Within the fourth graders, further, mean RT correlated negatively and significantly ($r = -.50$, $p < .05$) with reading score on the Metropolitan Achievement Test, which had been administered by the children's school 2 months before the experimental sessions. Thus, better readers tended to respond more rapidly than poorer readers. Spring (1971), using third, fourth, and fifth graders, similarly found longer latencies for poor than for normal readers on the "same"-"different" judgment of letter pairs.

Perhaps the most striking result of the present study, however, was not in how different, but in how much alike the children and adults were. As Table 1 shows, the various effects for children were quite similar in size to those of adults: on more frequent vs less frequent, 35 msec for fourth graders, 21 msec for adults; on "same" vs "different," 23 msec for fourth graders, 41 msec for adults; on upright vs upside down, 46 msec for fourth graders, 8 msec for adults. Thus, the present results provide no clue as to why adults are more efficient processors than children. The children seemed just as much attuned to the "higher level" factors, such as letter orientation and frequency, as were the adults. Only on the general factor of overall RT did the children clearly differ from the adults.

The present experiment found shorter latencies for upright than for upside-down letters, but since the Upright-Upside-down by "Same"-"Different" interaction was not significant, the present results do not confirm the findings by Egeth & Blecker (1971) and Ellis & Chase (1972) that letter orientation affects only "same" judgments. The data nevertheless do reveal a slightly larger effect on "same" judgments: the upright vs upside-down effect measured 31 msec among "same" pairs and 22 msec among "different" pairs. The results also failed to confirm Krueger's (1973) finding that stimulus frequency affects only "different" judgments, since the Frequency by "Same"-"Different" interaction was not significant. Frequency effects were also found to be restricted to the "different" case by Robinson (1969), and, to some extent, by Williams (1972; cf. his Figs. 1 and 2). The results do indicate a slightly larger effect on "different" judgments: the more frequent vs less frequent difference was 39 msec among "different" pairs and 16 msec among "same" pairs.

REFERENCES

- Egeth, H., & Blecker, D. Differential effects of familiarity on judgments of sameness and difference. *Perception & Psychophysics*, 1971, 9, 321-326.
- Ellis, S. H., & Chase, W. G. Effects of familiarity, complexity, and spacing on "same"-"different" judgments. Paper

presented at meeting of the Midwestern Psychological Association, Cleveland, May 1972.

Forsman, R. Age differences in the effects of stimulus complexity and symmetrical form on choice reaction time and visual search performance. *Journal of Experimental Child Psychology*, 1967, 5, 406-429.

Gaines, R. The discriminability of form among young children. *Journal of Experimental Child Psychology*, 1969, 8, 418-431.

Gibson, E. J. *Principles of perceptual learning and development*. New York: Appleton-Century-Crofts, 1969.

Hohle, R. H. Component process latencies in reaction times of children and adults. In L. P. Lipsitt and C. C. Spiker (Eds.), *Advances in child development and behavior*. Vol. 3. New York: Academic Press, 1967. Pp. 225-261.

Krueger, L. E. Effect of stimulus frequency on speed of "same"-difference judgments. In S. Kornblum (Ed.), *Attention and performance, IV*. New York: Academic Press, 1973. Pp. 497-506.

Leslie, R., & Calfee, R. C. Visual search through word lists as a function of grade level, reading ability, and target repetition. *Perception & Psychophysics*, 1971, 10, 169-171.

Robinson, J. S. Familiar patterns are no easier to see than novel ones. *American Journal of Psychology*, 1969, 82, 513-522.

Spring, C. Perceptual speed in poor readers. *Journal of Educational Psychology*, 1971, 62, 492-500.

Surwillo, W. W. Human reaction time and period of the EEG in relation to development. *Psychophysiology*, 1971, 8, 468-482.

Williams, J. D. The effects of practice with controlled stimulus pairs on same-different judgments. *Journal of Experimental Psychology*, 1972, 96, 73-77.

(Received for publication September 14, 1973.)

A test for both positive and negative response summation in the pigeon

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Four pigeons were trained to keypeck on a multiple variable interval-extinction schedule, in which different composite stimuli were associated with the variable interval and extinction schedules. The six composite stimuli used were compounds of houselight (on or off) and form (horizontal line, vertical line, or cross) on the response key. Composite stimuli were constructed in such a way that some components of houselight or form were more frequently associated with reinforcement or extinction. It was found that the composite stimulus formed of components most frequently associated with extinction controlled a lower response rate than other composite stimuli associated with extinction. However, the composite stimulus formed of components most frequently associated with reinforcement did not control a higher response rate than other reinforced stimuli.

Response summation refers to the increase (positive or additive summation) or decrease (negative or suppressive summation) in response probability observed when two independently conditioned stimuli are simultaneously presented. For example, in the case of positive summation, light and tone can be established as separate discriminative stimuli in the presence of which some response is reinforced. In the absence of either light or tone, no reinforcement is available. When light alone, tone alone, and the compound stimulus light plus tone are presented, more responses occur during the compound light plus tone than during either light or tone alone (e.g., Wolf, 1963; Weiss, 1964; Meltzer & Freeman, 1970; Miller & Ackley, 1970). This occurrence is labeled positive response summation. The interpretation applied to this phenomenon by Weiss (1972) is that the compound "light plus tone" is devoid of any S^Δ element and thus devoid of any low-rate

controlling stimulus. It controls a higher rate than light alone and tone alone because light alone has the absence of light in common with S^Δ . Negative summation can also be demonstrated when positive reinforcement is used. For example, Weiss (1972) had described the performance of one rat which was conditioned to respond at high rates when neither light nor tone were present. Low rates were differentially reinforced when either light or tone or light plus tone was present. Response rate was lower during the compound stimulus than during either light or tone. Howerton (1972) reported a similar experiment in which rats were reinforced on a fixed-ratio schedule during tone and on a variable-interval (VI) schedule when light plus tone, neither light nor tone, or light alone was present. As predicted, Ss responded at the lowest rate during the light-alone condition. In these experiments, the simultaneous presentation of two stimuli, each of which controlled low response rates, caused the Ss to respond at a lower rate than when each stimulus was presented alone.

Although free-operant response summation has been frequently demonstrated (see Weiss, 1972), these demonstrations have occurred under quite specific conditions. First, only rats have been used as experimental Ss. Second, although both positive and negative summation have been obtained in appetitive situations, the same Ss have not been tested for both positive and negative summation within the same experimental session. In this experiment, we attempted to show both types of summation using pigeons as Ss.

METHOD

Subjects

Ss were four food-deprived pigeons which were maintained at