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AGE AND THE PERCEPTION OF INCOMPLETE FIGURES

WARREN L. DANZIGER

Department of Psychology
Washington University
St. Louis, Missouri 63130
and

TIMOTHY A. SALTHOUSE

Department of Psychology
University of Missouri, Columbia
Columbia, Missouri 65201

Danziger, W. L., & Salthouse, T. A. Age and the perception of incomplete figures. **Experimental Aging Research, 1978, 4 (1), 67-80.** Three experiments are described. They investigated four possible explanations for the previously reported poorer performance of older adults relative to younger adults in accuracy of identifying incomplete figures: (1) a higher criterion on the part of older adults for producing a response; (2) a lesser familiarity on their part with the stimulus materials; (3) a less adequate knowledge of the information value of particular segments of the figure; (4) a less efficient utilization of partial information. The results of the experiments supported the fourth hypothesis and indicated that older adults are unable to utilize stimulus information as effectively as younger adults in making perceptual inferences.

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A typical finding in the research literature concerned with aging is that older adults perform less accurately or less rapidly on perceptual and motor tasks than younger adults. In perceptual tasks, some of the difficulty of the older person may be attributable to decreased receptor sensitivity (*e. g.*, Weale, 1965; Weiss, 1959), or to a slower perceptual-encoding time (*e. g.*, Eriksen, Hamlin, & Breitmeyer, 1970; Kline & Szafran, 1974; Salthouse, 1976; Walsh, 1975). However, neither of these factors appears able to account for the difficulty that the older person experiences with tasks such as identification of incomplete figures in which the stimuli are clearly visible and where ample time is allowed to inspect each stimulus (*e. g.*, Eisner, 1972; Glanzer & Glaser, 1959; Verville & Cameron, 1946).

The present study investigates four hypotheses that could account for this perceptual deficiency of older individuals. One hypothesis is the *higher-criterion hypothesis.* This hypothesis attributes the poorer performance of older individuals (relative to young individuals) on tasks such as the incomplete figures test to a greater reluctance to venture a response that may be incorrect. The higher-criterion hypothesis thus 'explains' the poorer performance of older subjects by assuming that they are receiving and processing essentially the same information as the younger subjects, but are requiring the information to exceed a higher criterion before they are willing to produce a response. This hypothesis is examined in Experiments I and II in conditions which minimize or eliminate individual differences in response criteria.

A second hypothesis is one of *unfamiliarity.* Here, it is proposed that older individuals are less accurate at identifying incomplete figures simply because they are less familiar than the younger individuals with the complete versions of the figures. This unfamiliarity hypothesis is investigated in Experiment II by comparing the performance of young and old groups of subjects when they were shown the complete version of each figure prior to attempting to report its identity.

A third hypothesis is that *older individuals extract less useful information* from the stimulus display than younger individuals.

Elderly subjects might be less accurate at judging the information value of the stimulus components and, consequently, attend to unimportant and irrelevant aspects of the stimulus neglecting aspects which provide the most information about the identity of the figure. This inappropriate attention hypothesis is investigated in Experiment III by comparing the rankings of the information value of segments of the figures by young and old subjects.

The fourth hypothesis attributes the poorer performance of older subjects in incomplete figure identification tasks to a *less effective perceptual inference process.* This hypothesis suggests that, compared to young adults, older adults do not utilize incomplete information as effectively. One implication of this ineffective inference hypothesis is that the older subjects should be less accurate than the younger subjects even when the information value of the partial information is carefully controlled. This prediction is tested in Experiment III.

Experiment I

Two different response-mode conditions were investigated in this experiment to test the higher-criterion hypothesis. In one condition the subjects were instructed to identify a figure whenever they were 95% certain that their response would be correct. This was an arbitrary criterion of confidence selected merely to provide subjects with some indication of a high criterion for responding. The other condition was a four-alternative forced-choice (4AFC) condition in which the subject was presented with four response alternatives on each trial and was required to select one of them. Since a response was required on each trial in the 4AFC condition, this condition presumably minimizes response criterion effects concerned with the production or non-production of a response. If the higher-criterion hypothesis is correct, the age difference in perceptual identification should be eliminated in one or both of these response conditions.

Method

Subjects. Twenty-four college students (mean age = 19.3 years, range = 17 to 25) and 24 older adults (mean age = 70.3 years, range

62 to 80) of both sexes participated in a single session of approximately one hour. Education level for the young subjects averaged 12.9 years with a range from 12 to 16. The old subjects had a mean of 12.4 years of education with a range from 7 to 18. The older subjects were recruited from community organizations and generally reported themselves to be in good health.

Stimuli. The stimulus figures were 40 line drawings of common objects and animals similar to those found in children's picture-word cards. As an example, four of the figures were a key, a pipe, a squirrel, and a bird. All drawings occupied an area approximately 4 inches (10.2 cm) by 6 inches (15.2 cm) centered on a sheet of 8.5 inch (21.6 cm) by 11 inch (27.9 cm) white paper. An incomplete version was produced by overlaying a mask consisting of horizontal and vertical strips of paper on top of a figure, and then photocopying the figure through the mask. Various combinations of horizontal and vertical strips, varying in width from 0.125 inch (0.3 cm) to 1.000 inch (2.5 cm) were used to create nine different degrees of incompleteness. The percentage of the total paper area that was *not masked* by the strips ranged from 4.4% to 25.0%, with intermediate values of 6.3%, 8.8%, 10.7%, 12.59%, 15.6%, 17.8% and 20.9%. All masks were independently constructed and applied. Therefore, although each mask allowed different amounts of the total area of the figure to be transmitted, the particular regions of the figure that were transmitted were not necessarily the same in all incomplete figures.

Procedure. The 24 subjects in each age group were divided into two response conditions. In the first condition, 12 young and 12 old subjects were instructed to write a response whenever they were 95% certain that the response would be correct. The second condition was the 4AFC condition. In this condition the subjects were given four possible alternatives including the correct one for each figure, and instructed to choose one of the alternatives for each version of the figure presented. The incorrect alternatives were selected from the most frequent incorrect responses in a pilot experiment with young subjects. Four lists of the alternatives were employed such that the correct response for each figure would be in a different position on each list. Within each list the positions

of the correct responses for the figures were arranged randomly. The task was unpaced and the subjects were allowed unlimited time to view the figures and to choose their responses.

Results

The mean percent correct scores were 73.4 for the young subjects in the 4AFC condition, 54.8 for the old subjects in the 4AFC condition, 53.6 for the young subjects in the 95% certain condition, and 31.5 for the old subjects in the 95% certain condition. An analysis of variance revealed that the Age ($p < 0.0001$) and Condition ($p < 0.0001$) factors were significant. The Age X Condition interaction ($F(1,44) < 1.00$) was not significant.

An observation relevant to the differential-familiarity hypothesis is that the Spearman rank-order correlation between the ordering of the difficulty of identifying the stimuli was + 0.84 ($p < 0.01$) between young and old groups, *i. e.*, young and old subjects generally had difficulty with the same stimulus figures.

Discussion

The higher-criterion hypothesis predicted the elimination of the age difference in identification accuracy in either the 95% confidence condition or the 4AFC condition because these conditions presumably minimized any possible differences in response criterion across individuals or groups of individuals. The existence of quite sizeable age differences in both conditions therefore constitutes evidence against this hypothesis.

Experiment II

Although the higher-criterion hypothesis received no support in the results of Experiment I, it should be examined further because of the possibility that older individuals maintained a criterion that was so high that all information failing to reach or exceed that criterion might be disregarded, wih the individual merely guessing from the four alternatives. This modification of the higher-criterion hypothesis might account for the age differences in the 95% and 4AFC conditions in the preceding experiment if

one postulates that the partial information provided by the incomplete versions of the figures was not sufficient to reach or exceed the very high criterion that the older subjects were utilizing. This new version of the high-criterion hypothesis is examined in the present experiment by comparing the performance of young and old subjects in a Yes/No identification task in which each incomplete version is presented with a single alternative that is correct on one-half of the trials. The Yes/No task was selected because it was considered to be so simple that it would minimize nearly all variations in response or decision criterion.

The second hypothesis discussed earlier, the unfamiliarity hypothesis, is investigated in this experiment by comparing performance of young and old subjects when words alone are presented as alternatives, and when the alternatives are presented as both words and the complete version of the figures. If older subjects are poorer at identifying incomplete figures because they have less familiarity with the complete versions of the figures, then the age differences should be eliminated when the complete figures are presented in the alternatives because this procedure renders the pictures high in immediate familiarity to all subjects.

Method

Subjects. Twenty-four college students (mean age = 21.4 years, range 18 to 28) and 24 older adults (mean age = 69.1 years, range 60 to 80) of both sexes participated in a single session of approximately one hour. Both groups of subjects were recruited from the same populations as in Experiment I but none had served in the earlier experiment.

Stimuli. The stimulus figures were the same as those in Experiment I. All nine incomplete versions of the 39 test figures were presented to each subject in a randomly arranged order.

Procedure. The subjects were told that they would be looking at a series of figures varying in degree of completeness from very incomplete to almost complete. For each figure they would be given a written alternative for what the figure might be in its completed form. The task was to decide whether the alternative matched the figure, and to rate the confidence they had in their decision on a 3-point scale. The incorrect alternatives provided were selected from the figures judged by the experimenters to be most similar to the target figure from among the remaining 38 figures. The distribution of correct and incorrect alternatives was approximately equal across versions of a particular figure, and across levels of incompleteness for all figures. One-half of the subjects in each age group, those in the no-picture condition, received only the written alternatives. The remaining subjects in each group, those in the picture condition, were allowed to inspect the complete version of the figure specified in the alternative in addition to receiving the written alternative.

Results

The mean percent correct scores for the four groups of subjects are displayed in Table 1. The practice factor involved a contrast between performance on the first 175 presentations and the second 176 presentations of the nine versions of 39 stimuli. An analysis of variance revealed that the factors of Age ($p < 0.0001$), Alternative Condition ($p < 0.0001$), and Practice ($p < 0.0001$) were statistically significant. The Age X Alternative Condition X Practice interaction was also statistically significant ($p < 0.02$), but none of the other interactions, including the Age X Alternative Condition interaction were significant. An analysis of variance on the arc-sin transformed scores yielded the same statistically significant main effects but the three-way interaction was not significant.

The proportions of high-confidence responses were analyzed by computing the percentage of responses assigned a confidence rating of "very confident", regardless of whether that response was correct or incorrect. Only the factors of Practice ($p < 0.0001$) and Alternative Condition ($p < 0.0001$) were statistically significant in an analysis of variance performed on these proportions. The interaction of Age and Practice was also significant ($p < 0.05$), but the main effect of Age was not ($p < 0.20$). The mean proportions of high-confidence responses ranged from 0.668 for the first 175 trials to 0.735 for the second 176 trials, and from 0.580 for the non-picture condition to 0.823 for the picture condition.

TABLE 1

Mean Percent Correct in the four Conditions of Experiment II

	First 175 trials	Second 176 trials
Young		
No-Pictures	90.3	94.0
Pictures	97.2	97.3
Old		
No-Pictures	84.2	85.9
Pictures	90.9	94.8

Correlational evidence relevant to the differential familiarity hypothesis is available in a comparison of the rank order of the difficulty of identifying the stimulus figures in the young and old groups of subjects. As was observed in the earlier experiment, the rank order correlations between young subjects and old subjects were moderately positive (*i. e.*, no-picture groups, rho = +0.535, $p < 0.01$; picture groups, rho = +0.455, $p < 0.01$, indicating that young and old subjects experienced difficulty with the same stimulus figures.

Discussion

The results of this experiment, consistent with those of the previous experiment, provide no support for the higher criterion hypothesis. As in the previous experiment, significant age differences were evident in a perceptual identification task selected to have minimal variations in criterion. The absence of significant age differences in the percentage of high-confidence responses also argues against attributing differences between age groups to differences in criterion.

The unfamiliarity hypothesis was also not supported as age differences remained even when the subjects were presented with

the complete figures in the response alternatives, a procedure that presumably eliminated any differential familiarity with the figures. Furthermore, the moderately high correlations between the difficulty of identifying the figures in this experiment and in the previous experiment suggest that the old subjects were not less accurate because they were less familiar with some of the stimuli.

Experiment III

The significant age differences in the two previous experiments suggest either that less information is being processed by older adults, or that the same amount of information is being processed less effectively. Although seemingly very similar, these two possibilities can be distinguished experimentally. According to the first alternative, older adults are extracting less useful information from the stimulus display, perhaps because they are attending to unimportant and irrelevant aspects of the display thus neglecting regions that provide the most information. If this inappropriate attention hypothesis is correct, then the age difference in the accuracy of identifying incomplete figures should be eliminated if the information value of the portions of the figure presented to the subjects was carefully controlled. If the second alternative were correct (*i. e.*, if elderly persons process information less effectively), the manipulation of information value should have no effect since the difficulty of the older adult is postulated to be in the interpretation process which is involved regardless of the specific information value of the stimulus component.

A second prediction from the inappropriate attention hypothesis is that older subjects would be less accurate than younger subjects in judging the true information value of the figure segments since they are presumed to be unaware of the differential importance of various regions of the figure.

Both of these predictions are examined in this experiment by requiring subjects to: (a) rank order the informativeness of figure segments; and (b) identify the figure on the basis of the figure segment.

Method

Subjects. Twenty college students (mean age = 24.5 years, range 19 to 29) and 20 older adults (mean age = 71.4 years, range 63 to 82) of both sexes participated in a single session of approximately one hour. Both groups of subjects were recruited from the same populations as the earlier experiments, but none had served in either previous experiment.

Stimuli. Twenty of the stimulus figures from the earlier experiments were used as stimuli. Each stimulus was presented in two forms. One form, used in ranking the information value of the segments, was a complete figure with a superimposed grid containing a different letter in each cell of the grid. The other form, used in determining identification accuracy for each segment, consisted of each cell from the grid presented on a separate sheet of paper. The number of cells in the grid, and hence the number of separate presentations of segments of the figure, ranged from 10 to 16 across stimulus figures. The figures were arranged in two sets of 10 figures each. The separate segments of the figures were randomly arranged within each stimulus set.

Procedure. Both young and old subjects were divided into two groups. Group 1 received one set of 10 figures in the *information rating task* and the other set of figures in the *identification task.* Group 2 received the remaining set of figures in each task.

The instructions in the information rating task informed subjects that they were to rank order the cells of the figure according to their judged information value. The cells containing the figure segments considered to be the most useful in identifying the figure were to be assigned low numbers, while the cells considered to be the least informative for judging the figure's identity were to be assigned high numbers.

The instructions in the identification task simply stated that the subjects were to choose the appropriate figure name for each figure segment. A list of the names of the figures used in the experiment was available to the subjects to constrain their identification responses.

Two practice figures were administered prior to each task to insure that the subjects understood the instructions and could perform the task in the appropriate manner.

Results

Two types of analyses were conducted. The first was a series of correlational analyses to determine the relationship between the information value and identification accuracies of young and old subjects. A product-moment correlation coefficient was computed for each stimulus figure by contrasting, for each figure segment, the average ranking of the information value by the young subjects with the average ranking of the information value by the old subjects. These 20 correlations were then transformed to z-scores, averaged, and the average re-transformed to the correlation scale. The mean correlation between the young and old rankings computed in this manner was $+0.917$ ($p < 0.01$). Obviously the two groups of subjects are in substantial agreement as to the judged information value of the figure segments.

For each stimulus figure a correlation was also computed between the mean percent correct identifications for each figure segment and the mean informativeness ranking for that segment. The average correlations, computed using the r-to-z transform procedure, were -0.697 ($p < 0.01$) for the young subjects, and -0.506 ($p < 0.01$) for the old subjects. The difference between these scores was statistically significant [t (18) = 2.31, $p < 0.05$] indicating that the young subjects had a closer relationship between their judgments of the informativeness of figure segments and their actual accuracy at identifying the figure from these segments than did older subjects.

The second analysis conducted on the data consisted of classifying the segments of each figure into high, moderate, or low information categories on the basis of the informativeness rankings of the young subjects, and then examining the effects of age and information value on percent correct identifications in an analysis of variance. The analysis of variance was conducted across stimuli with the data for each stimulus consisting of the mean percent

correct values for the high, moderate, and low information segments from young and old subjects. The main effects of Age ($p < 0.0001$) and Information Value ($p < 0.0001$), and the Age X Information Value interaction ($p < 0.0001$) were all statistically significant. The means of the two age groups are displayed in Table 2.

TABLE 2

Mean Percent Correct in Experiment III as a Function of Segment Information Value

	Judged Information Value		
	High	*Moderate*	*Low*
Young	68.6	38.9	21.6
Old	46.2	26.1	15.7

Discussion

Two sets of results from this experiment suggest that the inappropriate attention hypothesis cannot account for the age difference in incomplete figure identification. First, the high correlation between the informativeness rankings of the young and old subjects indicates that the two groups of subjects were in very close agreement about specifying the stimulus segments that were most relevant or important for identifying the figure. The second result that is inconsistent with the inappropriate attention hypothesis is the significant age difference in the analysis of variance when the information value of the segments was held constant. Since all subjects are compared when examining the same segments of the figure, the age differences that remain cannot be attributed to the older subjects attending to less informative regions of the stimulus than younger subjects.

The ineffective inference hypothesis is more successful in accounting for the age differences in incomplete figure identification than are the previously discussed hypotheses. One result in support of this hypothesis is the significant difference between the

information value — identification accuracy correlations of the young and old groups of subjects. The lower correlations for the older subjects indicate that they are less effective than younger subjects at utilizing segment information in identifying the stimulus figure. A second result favoring the ineffective inference hypothesis is the significant Age X Information Value interaction in the analysis of variance. The interaction is in the direction of the age difference increasing with increases in the information value of the figure segments. This finding indicates that older subjects are actually relatively less effective at utilizing the segment information when that information is most useful in aiding figure identification.

Conclusions

The major conclusions that may be drawn from the results of all these experiments considered together is that the age difference in incomplete figure identification is not: 1) simply an artifact of a response criterion difference; 2) a differential familiarity with the stimulus materials; 3) a difference in the distribution of attention across the incomplete figures. The explanation for the age difference in identification accuracy rests in the cognitive inference process.

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