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The Effects of a Pay-Off Matrix on Selective Attention[1]

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Abstract

Recall of information of differential value was studied in children at each of two CA levels: 11.0 and 14.7 years. *Ss* were retarded and the respective MA levels were 8.0 and 10.6 years. Two stimulus dimensions were used; one was designated primary and had a greater reward value than the other, designated secondary. Four primary and four secondary stimuli were presented and then the location of one primary and one secondary stimuli was to be recalled. A total of 12 trials was presented. It was found that significantly more primary than secondary stimuli were recalled. The expected improvement as a function of CA level was not found. The *Ss* at the younger CA level showed significant improvement in the last half of the trials as compared to the first half. No improvement was shown by the older *Ss*. The implications of the results were discussed in terms of the development of attention and information processing abilities.

That young children are less selective than older children in attending to certain aspects of their environments has been observed by many. WERNER [1961] described the young child's perceptual processes as global and undifferentiated. As he matures, his perception becomes more differentiated. GIBSON and GIBSON [1955] propose that through experience the child learns to differentiate aspects of his environment which were not noticed before. BROADBENT's information-processing model [1958] has been the basis for some recent developmental studies on selective attention. He postulates that when more information is available than can be processed, those aspects deemed as relevant are selected and stored, while other aspects are not processed. A developmental paradigm was devised by MACCOBY and HAGEN [1965] which presented information to children at various age levels, some of which was

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relevant to the task at hand and some of which was irrevelant. It was found that recall of task-relevant information increased monotonically as a function of chronological age (CA) while task-irrelevant information did not increase, and in some conditions decreased. Recent studies have confirmed this finding [Hagen, 1967; Hagen and Sabo, 1967]; thus the hypothesis that as a function of CA, efficiency in information processing increases, was supported.

Thus far it has not been possible to determine whether the older children have actually improved in ability to attend to certain relevant information or whether other aspects of the task determine performance level. The present study was designed so that all aspects of the task are relevant, but certain cues have a higher payoff value. A subjective expected utility theory such as Edward's [Atkinson, 1964] predicts that an individual is motivated to attend to those aspects of available information which have the greatest subjective worth. There is evidence that adults attempt to maximize the payoff in experimental situations. Lawrence and LaBerge [1956] presented stimulus cards which differed in color, form and numerosity. In one condition instructions indicated that *S*s should imagine that the 'emphasized' dimension was worth $100 and the other dimensions $1. In another condition all dimensions were equal, each $34. Accuracy of reporting the emphasized dimension was higher than the other dimensions. There was also an order effect: the emphasized dimension was more often reported first. The authors concluded that the differential pay-off instruction had an effect on order of report, which meant that memory and not perception was involved in the differential responses. Egeth [1967] reviewed this study and concluded that the 'emphasis' condition had a greater effect than that attributable to order alone. A study by Harris and Haber [1963] which controlled the order factor still found higher accuracy for the emphasized dimension.

The present study utilized differential payoffs in a short-term memory task (STM) with mildly retarded children at two different CA levels. A recent study with this same population (different children in the same institution) found that these children did not perform as well in the selective attention task as children of normal IQ [Hagen and Huntsman, 1969]. Visual stimuli were presented which contained two conceptual dimensions. One was defined as primary, and was more highly rewarded, and the other was secondary, and had less reward value. After each trial, the child was asked

to report on either a primary or a secondary stimulus, first, and the order was determined randomly. It was predicted that the number of correct responses would be greater to primary than to secondary stimuli and that the older children would maximize their performance more than the younger. Performance was expected to improve as a function of trials. If the older children show better maximizing performance than the younger, then they are less likely to improve over trials than the younger, who do not perform at maximum. If, on the other hand, the younger perform more poorly but do not improve over trials, then one might argue that they are performing near their maximum ability, which is less than that of the older children.

Method

Subjects. The *S*s were 40 males from the Wayne County Child Development Center, Northville, Michigan. The younger CA group contained 20 *S*s with a mean CA of 11.0 (Range = 9.8–12.2). The older CA group of 20 *S*s had a mean CA of 14.7 (Range = 13.3–15.2). The mean Stanford Binet intelligence scores were: younger, 72.6; older, 71.9. Mean MA scores were 8.0 and 10.6 years respectively.

Stimulus Materials. Fourteen color 35 mm slides were used. Each slide contained a picture of four cards in a 2×2 spatial arrangement. A different line-drawn shape was on each card (shape dimension). On top and in the center of each shape was a different color circle (dot-color dimension). The shapes were a star, a triangle, a circle, and a square. Each shape was approximately 6 cm in size. The dots were red, yellow, blue, or brown in color. They were approximately 4 cm in diameter. Each of the four shapes and four dots appeared on every slide, and their positions were randomly varied. Cards and dots identical to those pictured in the slides were used as cues on the position locating tasks.

Apparatus. The slides were projected onto a screen from a Kodak Carousel 800 slide projector. The screen consisted of the white surface of a 30 cm square box. The box was positioned on a table in front of the *S*. The projected sizes of the shapes and dots were approximately the same as those of the cue cards. On the table, between the *S* and the screen, was a square white sheet of paper marked off into four smaller squares. These squares corresponded to the projected positions of the cards on the screen. During the trials, the slides were presented on the screen for the shortest duration that the projector permitted (approximately 0.3 s). Non-transparent slides were used before and after color slide presentations to block all light from the projector.

Red and white poker chips were used as rewards for correct responses. Red chips were worth 5 points each and white chips were worth 1 point each. Points were worth ½ cent each. Chips received were placed in a glass jar on the table until the end of the last trial.

Procedure. The *S*s were tested individually by one male *E*. Color was the high reward dimension (color primary condition) for 10 *S*s in each CA group. Shape was the high reward dimension (shape primary condition) for the remaining 10 *S*s in each CA group. The following instructions were given to each *S*.

Hello. We are going to play a difficult memory game. I am going to show you some slides like this one (*E* points to the first slide projection). Each slide will have these shapes and colored dots. But their positions will be mixed up differently for each slide (*E* shows how a shape and a dot might be positioned on the next slide). I will flash the slides on the screen for a very short time and then ask you to guess where you think you saw a particular color and a particular shape. For example, I might ask you where you saw this shape (*E* shows one of the cue cards and then shows where to place the card on the white sheet on the table. The *S* is then quizzed to make sure that he understands where he would have placed other cue cards, had he been asked their location).

Now, where did you see this color dot? (One of the color dots is given to the *S* and he places it on the sheet. Any mistake is corrected). If you correctly guess where a *color* was flashed (or a *shape* depending on condition), you receive a red chip, and this is worth 5 points. And if you also correctly guess where a *shape* was flashed (or a *color*), you also receive a white chip worth 1 point. If you are only correct in guessing where a *shape* was flashed (or *color*), you don't receive any chips. (An example of this pay-off matrix was then shown.) We shall save all the chips you earn in this jar. Try to win all the points you can. At the end of the game we shall count up all your points, and divide that number by two, and that's the number of pennies you get to keep.

After the above instructions were given, the first slide was removed from the screen. Then the *Ss* were instructed to prepare for a practice slide. They were told that the next slide would be only briefly visible, and the second slide was shown. Then *Ss* were asked to locate two particular cues, one color and one shape (one primary and one secondary stimulus). The second cue was not presented until after the *Ss* had responded to the first cue. The order of the cues presented and the particular shape or color selected had been selected in advance from a random schedule. After both of the responses were completed the second slide was again projected on the screen so that the *Ss* could see if their responses were correct. The responses were corrected and they were questioned to make sure that they understood their task and the pay-off matrix. The procedure did not seem to be confusing to them.

The procedure was repeated for each of the remaining 12 slides; a primary and a secondary cue was presented after each slide presentation. The positions of the colors and the shapes had been randomly varied for each slide. The order of cue presentation and the particular color or shapes of the cues for the primary and secondary locating tasks was also randomly varied. The *Ss* were given a red chip (5 points) for each correct primary response. They were given a red and a white chip (1 point) for each correct primary and secondary response. No points were given for a correct secondary response only. No points were given for an incorrect response. The chips earned were placed in a jar on the table after each trial. *Ss* were paid after the last trial was completed. Only the last 12 trials were included in the data analysis. The testing period lasted approximately 15 min.

Results

The main results are shown in tables I, II and III. Ceiling effects were avoided, since the largest mean number of correct responses reported in table I was 5.80, which was 48% correct. All of the obtained means were above a chance level of 3 correct responses. Figure 1 indicates that both groups correctly responded to more of the primary than secondary cues. This effect was greater for the older group. A two-way analysis of variance with repeated measures

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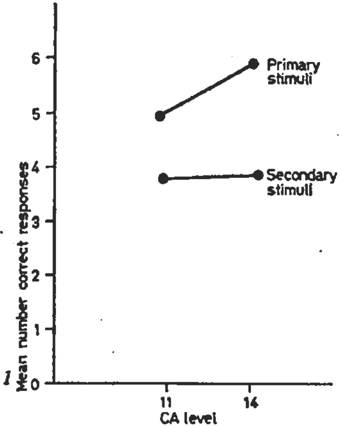

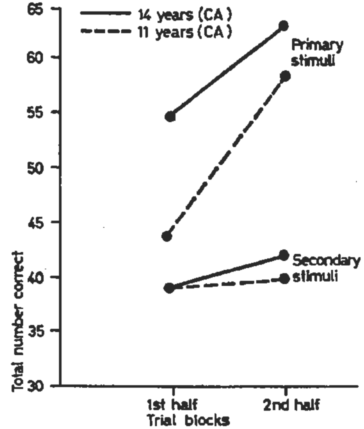

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Fig. 1. Mean number of primary and secondary correct responses at each CA level.

Fig. 2. Total number correct responses for the first versus second trial blocks.

on one factor [WINER, 1962] indicated that the difference between the number of correct primary and secondary responses (differential pay-off factors) was significant ($F[1,18] = 14.73$, $p < 0.01$) for the older group. This value approached significance for the younger group ($F[1,18] = 3.66$, $p < 0.10$). The conceptual dimension factor (whether color or shape was the primary dimension) had a significant effect for the younger CA group ($F[1,18] = 5.06$, $p < 0.05$) but had no effect for the older CA group ($F < 1$). The interaction between the pay-off and dimension factors was significant for the younger group ($F[1,18] = 5.04$, $p < 0.05$) and for the older group ($F[1,18] = 7.68$, $p < 0.05$).

A three-factor analysis of variance with repeated measures on one factor [WINER, 1962] was performed in order to compare the

Table I. Mean scores for each CA group

CA	Pay-off condition		Dimension condition		Order of cue presentation	
	Primary	Secondary	Color	Shape	First	Second
11	5.0	3.9	5.1	3.8	4.9	4.0
14	5.8	4.0	5.6	4.3	5.2	4.7

Table II. Total correct for first and second blocks of trials

CA 11 years (MA 8.0)	Total number correct	Number primary correct	Number secondary correct
Number of trials correct	177	100	77
Number of first 6 trials correct	81	43	38
Number of second 6 trials correct	96	57	39
CA 14 years (MA 10.6)			
Number of trials correct	196	116	80
Number of first 6 trials correct	92	54	38
Number of second 6 trials correct	104	62	42

Table III. Correlations between trial number and the number of correct responses

	11-year-old group	14-year-old group
Trial number and number primary correct	0.75[1]	0.30
Trial number and number secondary correct	0.11	0.22

[1] Significant at 0.01 level ($t = 3.62$).

effects of the CA groups, pay-off, and dimension factors. The CA level factor ($F = 1.16$) and dimension condition ($F = 2.35$) differences were not significant. The effect of the pay-off condition was significant ($F[1,36] = 14.96$, $p < 0.001$). The interaction between the dimension and the pay-off factors was significant ($F[1,36] = 12.06$, $p < 0.01$). All other interactions were not significant.

Correlations between trial number and correct performance are reported in Table 3. The correlation between the trial number and the number of correct primary task responses was significant for the younger group ($r = 0.75$; $t = 3.62$, $p < 0.01$) but was not significant for the older group ($r = 0.35$). The difference between these correlations for the two groups was in the expected direction ($t = 1.78$). The correlation between the trial number and the number of correct secondary responses was not significant for the younger group ($r = 0.11$) or for the older group ($r = 0.22$). The difference between the two correlations for the younger group ($r = 0.75$ and $r = 0.11$) was significant ($t = 2.31$, $p < 0.05$).

Figure 2 shows the results for the first versus the second half of the test trials, for the number of correct primary and secondary responses at each CA level. The younger *S*s improved in maximizing strategy for the last 6 trials or second block. A three-way analysis of variance with repeated measures on two factors [WINER, 1962] examined the effects of the CA group, the pay-off task, and the first versus second trial blocks. The pay-off task condition was again significant ($F[1,38] = 11.82$, $p < 0.01$). The first versus second trial blocks factor approached significance ($F[1,38] = 3.26$, $p < 0.10$). The CA level factor and the interactions were not significant.

A two-factor analysis of variance with repeated measures on one factor was performed, on the first block of trials only, for CA level and pay-off factors. No significant differences were found, but the pay-off factor approached significance ($F[1,38] = 3.35$, $p < 0.10$).

The effect of the order of cue presentation was next examined. Another two-factor analysis of variance with repeated measures on one factor was performed. The effects of the CA level and the order-of-cue presentation factors were included. The effect of the order factor on the number of correct responses was significant ($F[1,38] = 4.15$, $p < 0.05$). The other factor and the interaction had no significant effects.

The correlation between the number of correct primary and secondary responses were not significant for either age level, as was the case for all other correlations reported in table IV.

Discussion

The results supported the hypothesis that primary stimuli were recalled correctly more often than secondary stimuli. The *S*s were able to employ selective processing in the task, consistent with the

Table IV. Correlations between MA and the number of primary and secondary correct responses

	CA (years) 11	14
Number of primary and secondary correct responses	–0.08	0.21
Number of primary correct and MA	0.27	0.006
Primary correct/total correct and MA	0.11	0.10
Total number correct and MA	0.35	0.29

findings of HARRIS and HABER [1963]. The predicted interaction between age level and the differential pay-off condition was not significant. Thus increasing CA was not associated with more efficient task performance.

At the younger CA level, the expected positive correlation between trial number and correct primary responses was found. Further, this correlation was significantly higher than the equivalent correlation for the older CA level. Thus the younger children learned to improve their performance during the task, consistent with the hypothesis that they would be able to develop more efficient selective processing strategies and thus perform more like the older children if given practice. In a task such as has been used previously, in which no explicit differential reward was offered, no such improvement occurred [HAGEN, 1967].

The order effect which had been reported by LAWRENCE and LABERGE [1956] was also found in the present study, but the counter-balanced design used here showed that the differential pay-off results were not simply due to order of report.

Although the expected interaction between primary versus secondary correct performance and CA level was not found, figure 1 shows that the results were in the expected direction. Several differences between this and previous studies could account for this finding. First, the dimensions used here, color and shape, were not equally salient for the two age levels. Color appeared to be particularly salient for the younger level. The older *Ss* may have been more able to ignore the salient color dimension when it was secondary. Developmental effects could have been attenuated. Also, the *Ss* utilized in this study were different from those of previous studies, with the exception of the HAGEN and HUNTSMAN study [1969]. In that study it was found that children from this same institution showed a deficit in selective attention performance. The earlier studies with average intelligence, normal *Ss* have found that there is a marked improvement in ability to ignore irrelevant information at about a CA of 11–13 years [MACCOBY and HAGEN, 1965; HAGEN, 1967]. Even though the CA range is equivalent in this study, the MA levels here were considerably lower.

Since the design of this study allowed for explicit differential reinforcement in task performance, which could cancel differences between CA levels, the early trials (the first six) were analyzed separately. No significant CA differences were found: perhaps by

the sixth trial learning had already occurred. Further research is needed to compare this paradigm with the earlier paradigm in which *Ss* are matched on relevant variables.

The finding that the younger CA level *Ss* were able to profit from task experience suggests that environmental factors may be responsible for CA differences found previously. BIJOU and BAER [1965] applied operant behavior principles to the study of perception and contend that differential responses can be established either by natural or deliberate selective reinforcement. Older *Ss* may have already developed more efficient ways of selectively responding to stimuli through naturally occurring selective reinforcement. Further, the role that learning plays in attention has been discussed by TRABASSO and BOWER [1968].

The present study demonstrated that children who are initially deficient in performance in a task which requires selective responding to task-set cues can improve their performance when differential rewards are attached to the cues. The findings suggest that the deficit in selective attention performance found in earlier studies among children of certain ages could be overcome through appropriate training procedures. Whether the improvement found here generalizes to other task situations awaits future investigation. It is also encouraging to note that improvement in task performance was found for these retarded children, who have been shown previously to be deficient in performance when compared to normal children. Since the older CA level children did not improve, it could be argued that ability to learn decreases with increasing CA for this population, but it must be remembered that the performance of the younger group was very similar to the older group for the second trial block. Perhaps a maximum performance level was reached by both groups for this particular task situation. Further research will explore this hypothesis.

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Human Develop. *13:* 53–60 (1970)

The West Virginia University Conference on Life-Span Developmental Psychology[1]

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The current status of the general field of life-span developmental psychology and the availability of cogent substantive information relevant to this approach were the focal topics of a conference held at West Virginia University, Morgantown, West Virginia, April 30–May 2, 1969. Conference co-chairmen were Drs. LARRY R. GOULET and PAUL B. BALTES of the West Virginia University psychology department.

The initial presentation, *Historical Antecedents of Life-span Developmental Psychology*, by Dr. DON C. CHARLES (Iowa State University), dealt with historical considerations in the United States. The majority of the precursor influences were specifically directed toward rather restricted age intervals in the human life-span. Thus, such endeavors as the early baby biographies, the genetic psychology movement, clinical work with children, psychometric mental measurement, educational psychology, the initial Behavioristic research of WATSON, and the child study institutes which were initiated in the 1920's and 1930's all focused upon infancy, childhood, and adolescence. A parallel interest in problems of maturity and aging, primarily evidenced in research since 1945, also has existed. However, seldom have investigators demonstrated a clear interest in developmental issues *across* the human life-span. An exception to this concerns those individuals who have conducted extensive longitudinal studies and continued to observe their respective subject samples as they reached the adolescent and adult years. These include the Stanford Studies of Gifted Children, the Oakland and Berkeley Growth Studies and the Guidance Study of the University of California, and the Fels Research Institute Growth Study. It was concluded that while life-span psychology as a distinct interest area is in an early and formative state, the continued interest in longitudinal observation and analysis offers a potential focus for generalization from one developmental interval or stage to subsequent ages.

Dr. KARL J. GROFFMANN's (University of Mannheim) presentation, *Life-Span Developmental Psychology in Germany: Past and Present*, emphasized the general role of Nineteenth Century evolutionary biology, the emergence of academic psychology as an accepted, methodologically rigorous scientific discipline, and the impact of humanita-

[1] The proceedings of the conference will be published by Academic Press in a volume coedited by Drs. GOULET and BALTES.