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ABSTRACT

A study was designed to investigate the relationship between cognitive style and hypothesis testing strategies used in solving concept attainment problems. A field-independent (FI) and field-dependent (FD) cognitive style group of third grade students were administered concept attainment problems using a blank-trial methodology. The results demonstrated that while the hypothesis sampling of FI students coincided with a perfect focusing model, FD students did not process information systematically and showed a response bias to an available stimulus dimension. A second experiment was then designed to determine if the information processing of FD students could be enhanced by providing stimulus aids in accordance with their cognitive style characteristics. The results revealed that consistent focusing could be obtained in FD students in a treatment condition in which compound stimuli were disembedded into their component parts. (Author)

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HYPOTHESIS TESTING AND COGNITIVE STYLE IN CHILDREN

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Paper presented at the annual meeting of the American Educational Research Association, San Francisco, April, 1976.

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## A B S T R A C T

A study was designed to investigate the relationship between cognitive style and hypothesis testing strategies used in solving concept attainment problems.

A field-independent (FI) and field-dependent (FD) cognitive style group of third grade students were administered concept attainment problems using a blank-trial methodology. The results demonstrated that while the hypothesis sampling of FI students coincided with a perfect focusing model, FD students did not process information systematically and showed a response bias to an available stimulus dimension.

A second experiment was then designed to determine if the information processing of FD students could be enhanced by providing stimulus aids in accordance with their cognitive style characteristics. The results revealed that consistent focusing could be obtained in FD students in a treatment condition in which compound stimuli were disembedded into their component parts.

# HYPOTHESIS TESTING AND COGNITIVE STYLE IN CHILDREN[1]

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The blank-trials procedure was developed by Levine (1966) to investigate the hypothesis testing strategies used in solving concept attainment problems. As for the actual procedure, Levine presented his subjects with a series of 16 - trial problems in which three sets of four blank-trials were bounded by outcome trials. On a blank-trial no feedback is provided following a subject's response. On an outcome trial feedback is given (e.g. "right" or "wrong"). By analyzing response sequences on blank-trials it is possible to evaluate the extent to which subjects use hypotheses (*Hs*) in solving problems. In addition, the efficiency of information processing can be evaluated by determining the size of the *H* set from which subjects are sampling after each outcome trial and measuring its correspondence with the set that is still logically correct. The ability to sample *Hs* in the most systematic manner is similar to processing labelled perfect focussing (Bruner, Goodnow & Austin, 1956); a "perfect focuser" would sample only those *Hs* consistent with feedback from all previous outcome trials.

In the initial hypothesis testing research with children (Eimas, 1969; Ingalls & Dickerson, 1969; Rieber, 1969) it was clearly demonstrated the ability to formulate and use *Hs* was well established in young children.

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1. Paper presented at the annual meeting of the American Educational Research Association, San Francisco, 1976.

In solving the problems, children were actively selecting Hs and generating response sequences on this basis. On the other hand, the ability to process information efficiently (i.e. focusing) was strongly related to developmental level. Processing functions consistent with the perfect focusing model were not obtained in young children (e.g. grade two to grade five). In fact, these children experienced difficulty in eliminating irrelevant Hs beyond one outcome trial. Not before the eighth grade was there any evidence of consistent focusing (Ingalls & Dickerson, 1969).

More recently, the reasons underlying the developmental differences in focusing have been investigated. By employing memory aids, Eimas (1970a) found that focusing could be greatly enhanced in second grade children. Eimas suggested that the developmental differences in focusing were due to deficiencies in coding and retention of information which could be overcome in young children providing aids were used to alleviate the memory burdens. In a second study, Nuessle (1972) attributed developmental differences in focusing to developmental differences in reflection - impulsivity.

While attention has been given to developmental differences along with stimulus saliency variables (Eimas, 1970b) and procedural variables (Frankel, Levine & Karpf, 1970; Levine 1967) the study of individual difference variables within an age level has been neglected in previous hypothesis testing research. It is suggested that differences in hypothesis testing within a developmental level will result as a function of differences in cognitive styles of children along the field dependent-independent (FDI dimension).

Cognitive style has been used frequently in the psychological literature to denote consistencies in an individual's perceptual and cognitive functioning. The development of the FDI dimension has been based on the research of Witkin (e.g. Witkin, 1967; Witkin & Oltman, 1967; Witkin, Dyk, Faterson, Goodenough & Karp, 1962) who discovered that individuals differed consistently in the ability to keep parts of a perceptual array separate from a surrounding field or embedding context.

In assessing individuals along the FDI dimension, the term field-independent (FI) is applied to individuals who overcome embedding contexts and experience items as discrete from the surrounding field. On the other hand, field-dependent (FD) is applied to individuals for whom the overall organization of the prevailing field remains dominant and the required separations between the parts and the whole cannot be made.

The relevance of cognitive style to concept attainment is based on the reasoning that subjects who experience difficulty in separating items from and embedding context should also experience difficulty in separating relevant from irrelevant dimensions in solving concept attainment problems. However, an important distinction between measures used to assess FDI and concept attainment tasks must be considered. Coop and Sigel (1971) observed that on cognitive style tests, each instance presented to a subject does not depend on information gained from prior instances. On the other hand, in solving concept attainment problems, a subject is required to process information sequentially across several trials.

While previous investigations have shown that FI subjects are more successful than FD subjects on concept attainment tasks (Baggaley, 1955; Dickstein, 1968; Elkind, Koegler & Go., 1963; Ohnmacht, 1966; Panda, 1971), they have been based largely on the use of trials or errors to problem solution as criterion variables. As a result, insufficient information is available on the relationship between FDI and the component information processing operations involved in solving concept attainment problems. In constructing a model of cognitive development, Pascual-Leone (1970) has defined FI subjects as higher processors of information than FD subjects. It is suggested that Levine's hypothesis testing procedure provides a framework to investigate the relationship between cognitive style and the information processing required in concept attainment.

## EXPERIMENT 1

The aim of the first experiment was to investigate the relationship between cognitive style and hypothesis testing in children. The study examined the effects of cognitive style on the ability to formulate and use hypotheses (Hs) and on focussing ability, a measure of information processing. It was hypothesized that the information processing of FI subjects would approach the perfect focusing model, while that of FD subjects would approximate a less efficient model.

The relationship of FDI to the component processes involved in focusing were also examined. According to Levine's (1966) theoretical model, the subject must be able to code (and recode) the stimulus into a functional set of Hs and then he must retain the information across outcome trials and be capable of the process of intersection. For effective coding (or recoding) on any trial, a subject must break down the stimulus array into all its component parts. For example, a stimulus containing a large, red, S, on the left side must be responded to in terms of its "largeness", "redness", "S-shape" and its "left side". The processes of retention and intersection involve not only coding and recoding but also processing only the overlap of the cues from the present stimulus and the previous set of logically correct Hs. By employing a memory aid similar to Eimas (1970a), it was assured that any relationship to FDI would not be attributable to memory factors but rather to differences in processing available information. It was hypothesized that FD subjects would perform less effectively than FI subjects on the component processes of focusing.

## METHODOLOGY

### Subjects:

The Children's Embedded Figures Test (CEFT) was administered individually according to the standardized procedure (Karp & Konstadt, 1963) to 46 third-grade pupils (21 boys, 25 girls) from two classes in a public school in a middle class area of Metropolitan Toronto. The CEFT consists of 25 pictorial test items in which simple figures are embedded in complex designs. The child's task is to locate the simple figures (the maximum score is 25). From this initial pool of children, a field-independent (FI) and a field-dependent (FD) group were selected according to the criteria that: (a) the scores of all subjects in the FI group come from the upper end of the CEFT distribution with those in the FD group coming from the lower end; and (b) the ratio of boys and girls in the two cognitive style groups be the same.

Accordingly, each group consisted of seven girls and five boys, who ranged in age from 8 years-6 months to 9 years-5 months. All the FI children obtained CEFT scores $\geq 19$ ($\bar{x} = 20.5$) while all the FD ones had scores $\leq 12$ ($\bar{x} = 9$).

### Stimulus Materials:

A series of twelve 16-trial problems were constructed similar to those used by Eimas (1970a). In all problems, the stimuli varied along four dimensions with two values of colour, letter, size and position. The stimuli were constructed by affixing 1- or 1/2-inch coloured squares to 3- x 5-inch cards. Black Letraset letters 3/4- or 3/8 inch in height then were attached to the coloured squares. Different colours and letters were used in each problem in random combinations. The values of the dimensions of size and position remained constant in all problems.

Each card contained two stimulus patterns, 2 1/2- inches apart. One pair contained one value on each dimension (e.g. large, red, S, on the left) while the other contained the complimentary values (e.g. small, blue, O, on the right). With four dimensional bivariate stimuli as described above, there are eight possible stimulus pairs for the cards. Four of these are shown in Figure 1, while the remaining four are formed by reversing the left-right positioning within each card. Each set of four stimulus cards is internally orthogonal in that, each value of every dimension appears exactly twice with each value of every other dimension. In each problem one set of internally orthogonal stimuli was used for the outcome trials and the other set for the blank-trials.

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Insert Figure 1 about here

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In all experimental problems there were four outcome trials (trials 1, 6, 11 & 16) and 12 blank-trials arranged in three sets of four (trials 2-5, 7-10, & 12-15). Each set of blank-trials was arranged in a different random order.

Procedure:

The series of concept attainment problems was administered individually to all children in the FI and FD groups. Each subject was presented with four practice and eight test problems. For each problem, the subject received a deck of 16 cards face up. He was required to respond to the top card, turn the card face down and then continue this procedure with all 16 cards in the deck.

In order to ensure that the subject's set of potential Hs conformed to the eight simple Hs (Figure 1) representing the only possible solutions, detailed instructions (similar to Eimas, 1969; Ingalls & Dickerson, 1969) were provided. The first two training problems, which were designed to achieve the above aim, consisted entirely of outcome trials; feedback (either "right" or "wrong") was provided on each trial. The relevant dimensions were letter and colour in Problems 1 and 2 respectively.

On the remaining two training problems, the blank-trials procedure was introduced with instructions informing the children that feedback would not be provided on all trials. The relevant dimensions were position and size. As a result, the subject received practice with a problem solution based on a cue from each of the four dimensions. On the training problems, the criterion was eight consecutive correct responses in a row. At criterion the subject was asked the solution. Those who failed to attain criterion within 16 trials were provided with hints: e.g. "Why don't you try one of the colours?"

After completion of the practice problems, the eight test problems were presented one at a time. Each was preceded by repeating instructions concerning both the blank-trials procedure and the set of available Hs.

Immediately prior to the first test problem, the memory aid procedure was introduced with instructions (similar to Eimas 1970a) informing the children that they would be given some help in solving the problems. At this point, the children were shown the positive and negative signs and instructed that on outcome trials, a positive sign would be placed over a correct choice or a negative sign would be placed over an incorrect choice. In addition, the children were told that the outcome stimuli and signs would remain in view for the duration of the problem.

The experimenter said "right" or "wrong" on the first three outcome trials according to a prearranged order, regardless of the subject's response. Each of the eight possible right-wrong permutations which could occur on three trials was used once per subject; each permutation was assigned to one of the eight experimental problems. Although the solution to any problem was not predetermined, each problem had one logical solution by the end of the third outcome trial. This solution depended on the subject's particular responses and the right-wrong permutation. On all trials, the child was required to point to the stimulus pattern that he considered to be correct. At the end of the session, the child was told that he had performed very well and he was thanked for participating. The session required 40-45 minutes per subject.

## RESULTS

### Blank-Trials Data

There are two classes of response sequences from the sets of blank-trials: the eight sequences conforming to the simple Hs (cf., Figure 1) and the eight sequences not defining any simple H (i.e. the 3-1 sequences). By analyzing responses on the blank-trials, it is possible to evaluate the extent to which subjects used Hs. The mean percentages of blank-trial responses that conformed to H-defining sequences were 90 and 81 for the FI and FD groups respectively. Each of these percentages differed from the chance level of 50%, the expected score had subjects been generating response sequences randomly rather than responding on the basis of Hs, $t = 17.3$, (for FI subjects) and 6.7 (for FD subjects), $p < .001$. A one-way analysis of variance on the number of blank-trial sets with simple Hs indicated no significant cognitive style effect at the .05 level, $F\ (1,22) = 3.4$.

Another measure of the ability to respond on the basis of Hs is the extent to which responses on outcome trials can be predicted from a knowledge of blank-trials behaviour. For example, if a child responded on the basis of the H large on a set of blank-trials, then his choice on the succeeding outcome trial should be the stimulus containing the large cue. The mean percentages of correctly predicted outcome trials were 95 and 93 for the FI and FD groups respectively. Each of these percentages differed from the chance expectation of 50%, $t$ = 21.1 (for FI subjects) and 16.0 (for FD subjects), $p < .001$. A one-way analysis of variance on the predicted outcome trial percentage scores, normalized by the arc sine transformation, yielded no significant cognitive style effect at the .05 level, $F$ (1,22) = .06.

Focusing

Focusing essentially measures the efficiency with which a subject uses outcome information to systematically eliminate irrelvant Hs. Because of the manner in which the problems were constructed, the number of logically correct Hs is decreased by one-half after each outcome trial; four Hs are logically correct after the first outcome trial, two after the second and only one after the third. From the proportion of instances in which the subjects' Hs correspond to the set of logically correct Hs, it is possible to determine the size of the H set from which subjects are sampling after each outcome trial (Levine, 1966). The equation is as follows: The proportion of correct Hs equals the number of logically correct Hs divided by the size of the H set from which the subjects are sampling. The final term is the only unknown in the equation.

In deriving focusing functions, the obtained proportions of correct Hs are calculated only from those Hs occurring after negative outcomes (i.e. "wrong").

There are several reasons for this procedure which has also been followed in previous research. First, subjects tend to repeat the same H after a positive outcome trial (Levine, 1966), a strategy which will inflate the focussing score. Second, it is possible to make comparisons with the following information processing models which are based on hypothesis resampling after "wrong": the perfect focusing strategy (Bruner et al., 1956); the replacement model (Restle, 1962); and the local consistency model (Gregg & Simon, 1967).

The mean size of the functional H sets sampled after the first three negative outcome trials was 4.4, 2.6 and 1.6 for FI subjects and 4.8, 3.7 and 4.0 for FD subjects. These data are plotted in Figure 2 as a function of cognitive style and the blank-trial sequence. Also presented are the expected theoretical curves for the perfect focusing, replacement and local consistency models. It is clearly demonstrated that the performance of both cognitive style groups does not match the replacement model. This further substantiated Levine's (1966) finding that sampling with replacement was an inadequate description of human problem-solving. A chi-square test comparing the obtained H set sizes with the expected theoretical values indicated that the function for FI subjects coincided with the perfect focusing model, $\chi^2(2) = .54$. However, this was not the case for FD subjects; their performance deviated markedly from that expected under the perfect focusing model, $\chi^2(2) = 10.61$, $p < .01$. The function for FD subjects did not differ from that predicted by the local consistency model, $\chi^2(2) = .18$.

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Insert Figure 2 about here

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An analysis of variance, cognitive style x blank-trial sequence, was performed on the obtained proportions of logically correct Hs normalized by the arc sine transformation. These results indicated that FI subjects sampled significantly more logically correct *Hs* that FD subjects, $F$ (1,22) = 9.2, $p < .01$ and that the percentage of logically correct *Hs* was significantly greater after the earlier outcomes (i.e. on $H_i$) than after the later ones (i.e. on $H_{i+1}$), $F$ (1,22) = 13.4, $p < .005$. The interaction of cognitive style x blank-trial sequence did not reach significance at the .05 level, $F$ (2,44) = 1.04.

## Coding, Recoding and Retention

The individual processes of coding, recoding and retention involved in focusing were examined in a manner similar to Eimas (1969). Coding was measured by the proportion of *Hs* that were consistent with an immediately preceding positive outcome trial. Recoding was measured by the proportion of *Hs* consistent with an immediately preceding negative outcome trial. Retention effects were measured by evaluating the extent to which *Hs* were consistent with reference outcome trials zero, one and two steps removed. *Hs* from the first set of blank-trials ($H_1$) consistent with the first outcome trial ($0_1$) defined a consistency measure zero steps removed (C-0); $H_2$ consistent with $0_2$ or $H_3$ consistent with $0_3$ also defined C-0. Correspondence between $H_2$ and $0_1$ or between $H_3$ and $0_2$ defined a consistency score one step removed (C-1). Finally, correspondence between $H_3$ and $0_1$ defined a consistency score two steps removed (C-2).

Table 1 shows the mean percentage of *Hs* consistent with positive (0+) and negative (0-) outcomes for the three consistency measures. Analyses

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Insert Table 1 about here

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of variance, cognitive style x outcome (positive, negative), with outcome as a repeated measure, were performed separately for the three consistency measures on the individual percentage scores normalized by the arc sine transformation.

The analysis at the consistency measure zero steps removed (C-0) which directly assessed the processes of coding and recoding, revealed a significant cognitive sytle effect indicating that FI subjects performed reliably better than FD subjects, $F\ (1,22) = 6.6$, $p < .025$ and a significant outcome effect signifying that consistency was better after positive outcomes (coding) than after negative outcomes (recoding), $F\ (1,22) = 11.4$, $p < .005$. Similar analyses at C-1, and at C-2 also revealed significant cognitive style and outcome effects.

To measure the retention effects, analyses of variance, cognitive style x remoteness of outcome trials were performed separately for positive (0+) and negative (0-) outcome trials on the scores normalized by the arc sine transformation. For both positive and negative outcomes, significant results were obtained for cognitive style, $F\ (1,22) = 6.0$ (for 0+) and 8.1 (for 0-), $p < .01$ and for remoteness of outcome information, $F\ (2,44) = 16.8$ (for 0+) and 23.2 (for 0-), $p < .001$. The first main effect indicated that FI subjects sampled significantly more consistent Hs than FD subjects; the second main effect indicated that consistency was reliably better in reference to immediately preceding outcome trials than in reference to remote outcome trials. Although the differences between FI and FD subjects tended to be greater as the reference outcome trial became more remote, especially for negative outcomes (cf., Table 1), the interaction of cognitive style x remoteness did not reach significance at the .05 level, $F\ (2,44) = 0.8$ for 0+) and 2.8 (for 0-). It is noted that for the negative outcome condition, this interaction just failed to reach significance; an $F$ value of 3.2 is required for significance at the .05 level.

Classification of Hs into the four binary dimensions

In classifying the Hs manifested by children according to the four binary dimensions, it was found that colour was responded to most often (36% of the time) by FD subjects while letter was the counterpart for FI subjects (also 36% of the time). However, an inspection of the individual scores in the FD group revealed that while one child responded to the colour dimension for 95% of his Hs, a second responded to letter for 87% of his Hs, and a third to the position dimension 83% of the time.

Because of the above findings, the percentages of blank-trial Hs on the four dimensions were rank-ordered from D1 to D4 where D1 equals the dimension responded to most often and D4 the dimension responded to least often. The mean percentages of Hs on the four rank-ordered dimensions are presented in Table 2. The distribution of Hs was spread more evenly over the four dimensions for FI subjects than for FD subjects, $\chi^2(3) = 13.6$, $p < .005$. Significant differences were found between cognitive style groups at D1,

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Insert Table 2 about here

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$t\ (22) = 2.1$, $p < .025$; at D3, $t\ (22) = -2.3$, $p < .025$; and at D4, $t\ (22) = -1.8$, $p < .025$. These results demonstrated that FD children, in comparison to FI children, responded more often to a single dimension at the expense of the remaining ones.

## DISCUSSION

The present study replicated the previous findings (Ingalls & Dickerson, 1969; Eimas, 1969, 1970a; Nuessle, 1972) that children can formulate simple Hs when solving concept-attainment problems. The percentage of blank-trial responses that conformed to H defining sequences clearly indicated that subjects were not simply generating responses randomly but that both FI and FD children were selecting a cue and then executing a response on the basis of this cue.

On the other hand, the ability to focus varied as a function of cognitive style. While the H sampling of FI subjects coincided with the perfect focusing model, the performance of FD children approximated the local consistency function (Gregg & Simon, 1967). These findings demonstrated that although FD subjects could formulate simple Hs, they were unable to process information efficiently beyond one outcome trial.

In the present study, the memory aid procedure was not sufficient to effect perfect focusing in FD children. Thus, unlike Eimas' (1970a) study, factors other than memory are related to deficiencies in focusing in young children. In addition, while previous studies have investigated developmental differences in focusing (Eimas, 1970a; Nuessle, 1972) differences with a developmental level have been identified in the present study.

The findings also related differences along the FDI dimension to deficiencies in the component psychological processes involved in focusing. Both coding and recoding were more difficult for FD subjects than FI subjects. The effects of cognitive style in these processes support the contention that FD children do not respond to the stimulus on the basis of all its component parts.

FD children also performed less effectively than FI children in the "retention" process. Retention effects were measured by evaluating the extent to which Hs were consistent with a reference outcome trial zero, one or two steps removed. For FD children, there was a marked decrease in the consistency of Hs as the outcome trials to be considered became more remote. Because a memory aid was used in the present study, retention is a misleading term. All information was readily available since the outcome trial stimuli remained in view for the duration of the problem. However, although the relevant information was available an individual still had to code, (recode) only the intersect of the previous and the present set of logically correct Hs (i.e. intersection). This involved processing information across at least two outcome trials.

Two suggestions are offered as explanations of the cognitive style effect in "retention". The first follows directly from the cognitive style effect in coding and recoding. Since FD children had difficulty in separating one stimulus array into all its component parts, this should be augmented when more than one stimulus array is involved as in the process of retention. In this case, the assumption is made that if FD children were able to code and recode effectively, then they would also be able to process the intersect of the cues from the present stimulus and the set of logically correct Hs.

The second explanation goes beyond the first in suggesting that even if all the stimulus arrays were correctly coded (or recoded), FD children would still be unable to form a logically correct intersection. In this view, the assumption is made that FD children do not possess the same hierarchical thought structures as FI children. The second experiment was conducted in an attempt to resolve this issue.

Previous investigations (Baggaley, 1955; Dickstein, 1968; Ohnmacht, 1966;

Panda, 1971) had not determined the effects of cognitive style on the component information processing operations involved in concept attainment. On tests used to assess FDI, it is required that a simple geometric figure be disembedded from a complex design. For each item a dichotomy exists; an individual either overcomes the embedding context and locates the simple figure or he does not. In concept attainment problems, the stimuli generally vary along a number of dimensions. In the present experiment values on a number of dimensions were embedded into compound stimuli. It was discovered that while FD children were capable of selecting an H out of these stimuli, they were unable to process all the available information.

As a function of FDI, children differed in their ability to utilize all aspects of the stimulus situation with equal effectiveness. While FD children tended to overrespond to one dimension, no one specific dimension was prefered by this group of children. For example, one FD subject showed a response bias to the colour dimension, another to position and a third to letter. Nevertheless on any trial, FD children were only processing part of the available information.

Suchman and Trabasso (1966) related children's dimension "preference" in a free sort situation to performance on concept attainment tasks. They found that concept tasks along the prefered dimension were solved more easily than those along the remaining dimension. In extending Suchman and Trabasso's work, Miller and Harris (1969) suggested that two additional factors were involved in a child's conceptual treatment of stimulus dimensionality: "availability" and "usability". A particular dimension is available for an individual if he can respond to two objects' mutual similarity and to their qualitative difference from a third object along that dimension. Availability is a dichotomous construct; a dimension is either available or it is not. In the present experiment, since all subjects solved a pretraining problem involving the four dimensions, it can safely be concluded that all these dimensions were available.

Usability is concerned with the extent to which stimulus differences along an available dimension are used by a child as cues in a concept attainment situation. The present study revealed that not all dimensions were readily used by FD children and the information processed was not consistent across outcome trials. For perfect focusing, a subject must consistently sample _Hs_ on all available dimensions. The second study attempted to make all dimensions us~~e~~able for FD children.

## EXPERIMENT 2

Eimas (1970a) found that focusing was greatly enhanced in young children if memory aid conditions were used. Unlike Eimas' study, the results of Experiment 1 demonstrated that factors other than memory were responsible for deficiencies in focusing. Use of the available information varied as a function of an individual's cognitive style and there was no evidence of consistent focusing in FD children. The aim of Experiment 2 was to determine whether this deficit in focusing could be overcome.

By determining the component processes of complex behavior, successful procedures have been devised to improve performance in young children (Eimas, 1970a; Gelman, 1969). In Experiment 1, data were obtained on the relationship of cognitive style to the component processes involved in focusing. These findings provided a framework from which a procedure, attempting to facilitate focusing for FD children was designed.

To enhance focusing, it was predicted that the stimulus materials had to be presented in a manner consonant with the cognitive style characteristics of FD children. Three groups were involved in this study. The first group, MR, received a memory-recoding aid, identical to the one used by Eimas (1970a). The MR aid was effected by using only positive signs and placing them over the correct stimulus regardless of whether the outcome trial was positive or negative. In addition to alleviating the memory constraints, this procedure eliminated the necessity for subjects to recode information from the incorrect to the correct stimulus.

In Experiment 1, it was discovered that FD children had difficulty with recoding and in addition, Piskkin, Wolfgang and Rasmussen (1967) reported that children's performance on a sorting task did not improve when information from prior incorrect trials was made available, although prior correct instances did reduce errors. In view of these facts, it was expected that these recoding aids would somewhat improve the H sampling of FD children. However, it was expected that the MR condition would not be sufficient to establish focusing since data from Experiment 1 also revealed that FD children did not code as well as FI children.

Stimulus aids designed for the other two treatment groups were based on the findings from Experiment 1 which showed that FD children had difficulty in responding on the basis of the intersect of the previous and the present set of logically correct Hs.

The second treatment group, MR + D, received "disembedding aids" in addition to the conditions provided in the MR group. Subjects in this group received stimulus cue cards in which the stimulus compounds were separated into their component parts. For each problem, eight disembedding cue cards were provided, two for each dimension of color, size, letter and position. Each cue card corresponded to one of the simple Hs in the subject's set. The eight cards containing the disembedding cues were left before the subject along with the recoded outcome trial stimuli for the duration of the problem.

It was expected that subjects in the MR + D group would be able to utilize the disembedding cues and effectively process all available information. It was hypothesized that the focusing of subjects in this group would be consistently better than those in group MR.

The third group, MR + I received "intersection" aids in addition to the conditions provided in the MR + D group. While these aids were designed to enhance focusing, it must be emphasized that subjects were not pretrained nor explained the formal rules of intersection. The MR + I condition was effected as follows: After each outcome trial, the disembedding cue card(s) corresponding to Hs that were still logically correct were retained while the unselected cards were withdrawn for the remainder of the problem. It was felt that comparisons between groups MR + I and MR + D would determine the degree to which it was necessary to structure the stimulus materials to effect efficient information processing for FD children.

# METHODOLOGY

## Subjects

The CEFT was administered individually to 66 third-grade children (29 boys and 37 girls) who ranged in age from 8 years - 6 months to 9 years - 7 months. The experimental sample of 24 FD children was chosen according to the criteria that: (a) the cut-off score on the CEFT scale for FD subjects be the same as in Experiment 1 (i.e. 12)[2] and (b) the ratio of boys and girls in each of the treatment groups be the same. The children were then randomly assigned to groups MR, MR + D and MR + I with three boys and five girls in each group.

## Stimulus Materials

The stimuli for all the problems were identical to those of Experiment 1. They varied in four dimensions with two values of colour, letter, size and position. In addition, "disembedding cue cards" were presented to groups MR + D and MR + I. These materials were prepared on 1-1/2 x 2-inch white cards. Each card contained one of the eight stimulus cues per problem, represented as follows: (a) size - one inch and1/2-inch white squares outlined in black to signify large and small respectively; (b) color - strips (1/2- x 1-inch) of the appropriate two colors were attached to separate cue cards; (c) letter - the appropriate letters were affixed to the cue cards with 5/8-inch black Letrasets; (d) position - "left" and "right" were written on two separate cue cards.

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2. Due to a depletion of the subject pool, it was necessary to select one subject per group with a CEFT score of 13.

Procedure

The series of problems (4 practice, 8 test problems) was administered individually to all children in the experimental sample. The pretraining and testing procedures were identical to those of Experiment 1 except for the appropriate instructions explaining conditions _MR_, _MR + D_ and _MR + I_ respectively:

(a) MR Treatment: It was explained to the child that on all outcome trials a positive sign would be placed above the correct stimulus pattern. For example, if a choice was incorrect, a positive sign would be placed on the alternate pattern. He was also informed that the outcome stimuli and positive signs would remain in view for the duration of the problem. A demonstration was carried out with one practice stimulus card.

(b) MR + D Treatment: As in group MR, the use of the positive signs was explained and the child was again informed that the outcome trial stimuli and signs would remain in view for the duration of the problem. In addition, the disembedding cue cards were introduced. It was explained that each card contained a cue corresponding to one of the eight available _Hs_ and that the eight cue cards would remain in view for each problem. A demonstration with one practice stimulus card was given.

(c) MR + I Treatment: The instructions with regard to the positive signs and the cue cards were identical to those for group _MR + D_. In addition, the child was informed that once a positive sign was placed on a stimulus pattern, he would be given the opportunity to pick out the cue cards which, in his opinion, might "still be correct", with the unselected cue cards then removed for the remained of the problem. It was explained that this procedure would be repeated after each outcome trial. A demonstration with one practice stimulus card was given for three possible outcome trials.

It should be noted that in all three groups, the children were never told how to solve the problem nor did they receive additonal practice problems once the above procedures had been introduced. The test problems were then presented one at a time. As in Experiment 1, instructions explaining the set of simple Hs and the blank-trials procedure were repeated before each test problem. In groups MR + D and MR + I, the disembedding cue cards were introduced with the instructions delineating the H set. At the end of the session, the child was told that he had performed well and was thanked for participating. The session required approximately 40-50 minutes per child.

## RESULTS

### Blank-Trials Data

The mean percentages of blank-trial responses that conformed to H - defining response sequences were 85.5 (MR)[redacted], 87.5 (MR + D), and 84.0 (MR + I). Each of these percentages differed from the chance expectation of 50% ($t > 6$, $p < .001$). A one-way analysis of variance was performed on the individual number of blank-trial sets with H - defining sequences. No significant treatment effect was found at the .05 level, $F\ (2, 21) < 1$.

The mean percentages of predicted outcome trials were 91 (MR), 92 (MR + D), and 87 (MR + I). Each of these percentages differed from the chance expectation of 50% ($t > 5.5$, $p < .001$). A one-way analysis of variance performed on the percentage scores normalized by the arc sine transformation yielded no significant treatment effect at the .05 level, $F\ (2, 21) < 1$.

### Focusing

The focusing functions, mean size of the H sets from which children were sampling after the first three negative outcome trials respectively were: 4.2, 3.3, 2.2 for group MR; 4.3, 2.5, 1.3 for group MR + D; and 4.2, 2.7, 1.1 for group MR + I. These results which are plotted in Figure 3 clearly indicated that the functions for all three groups are closer to the perfect focusing model than the one obtained for FD children in Experiment 1. Furthermore, while the scores of groups MR + D and MR + I closely approximate the logically correct scores, this is not so for group MR.

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Insert Figure 3 About Here

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In order to compare the focusing functions an analysis of variance (treatment groups x blank-trial sequence) was performed on the obtained proportions of logically correct Hs normalized by the arc sine transformation. These results revealed a significant blank-trial sequence effect, $F(2, 42) = 6.97$, $p < .001$, demonstrating that the percentage of logically correct Hs was greater after the earlier outcome trials (i.e., on $H_i$) than after the later ones (i.e. on $H_{i+1}$) and a significant interaction of treatment groups by blank-trial sequence, $F(4, 42) = 3.73$, $p < .025$. This interaction signified that from $H_1$ to $H_3$, the differences between treatment groups increased (cf., Figure 3). Although the treatment effect did not reach significance at the .05 level, $F(2, 21) = 2.29$, an inspection of the individual scores revealed that the number of children who sampled 100% logically correct Hs after the third outcome (i.e. on $H_3$) were 2, 5 and 6 for groups MR, MR + D and MR + I respectively ($n = 8$ in each group). This is in contrast to Experiment 1 in which not one FD child sampled 100% logicallly correct Hs at $H_3$. Therefore individual comparisons were conducted between treatment groups. It was revealed that in comparison to group MR, significantly more logically correct Hs were sampled at $H_3$ by group MR + D, $t(21) = 1.9$, $p < .05$, and by group MR + I, $t(21) = 2.9$, $p < .005$. The comparisons at $H_1$ and at $H_2$

did not reach significance.

The percentage of Hs consistent with positive (0+) and negative (0-) outcomes for a reference outcome trial zero (C-0), one (C-1) and two (C-2) steps removed are presented in Table 3. Because of the significant treatment group by H set interaction described above, comparisons between the three treatment groups were carried out separately for each of the consistency measures.

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Insert Table 3 About Here

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For consistency measure C-2 a significant treatment effect was found for both 0 + , $F(2, 21) = 7.2$, $p < .005$ and 0 - , $F(2,21) = 4.3$, $p < .05$. The results at C-0 and C-1 were not significant at the .05 level. Individual comparisons between treatment groups were carried out at C-2. Significant differences were found (a) between groups MR + D and MR, $t(21) = 2.5$ (for 0+), 1.9 (for 0-), $p < .05$ and (b) between groups MR + I and MR, $t(21) = 3.7$ (for 0+), 2.9 (for 0-), $p < .005$, with the MR group scoring lower than both MR + D and MR + I. Although the percentage of consistent Hs was higher in group MR + I than in MR + D, the comparison between these two groups failed to reach significance at the .05 level, $t(21) = 1.3$ (for 0+), 0.9 (for 0-).

## DISCUSSION

The results demonstrated that focusing can be enhanced with the appropriate aids. Presenting stimulus materials in accordance with the cognitive style charateristics of FD children is a viable way of enhancing their information processing.

Although groups MR + D and MR + I sampled more logically correct Hs than group MR, no significant differences in focusing attributable to treatments were found after the first or second outcome trials. This indicates that memory and recoding aids allow subjects to process information systematically from two stimulus arrays which vary on a number of dimensions. However, a significant treatment effect was found after the third outcome trial; individuals in group MR sampled significantly less logically correct Hs than those in either group MR + D or MR + I. As a result, memory-recoding was not sufficient to establish consisitent focusing for FD children when information must be processed from more than two outcome trials. In these cases, it is necessary to present stimulus aids. The procedure of disembedding stimulus compounds into their component parts proved to be extremely successful. With this treatment, FD children focused consistently after all outcome trials.

Although individuals in group MR + I sampled more logically correct Hs than those in group MR + D, there was no significant difference in focusing between these two treatments. For FD children to process information effectively, it was not necessary to structure the stimuli to the degree originally anticipated.

In Experiment 1, two possible explanations of the cognitive style effect in focusing were suggested. The first explanation inferred that FD children may not possess the same hierarchical thought structures as FI children. This infers that even if FD children processed all available information, they would still be unable to systematically sample Hs consistent with all preceding outcome trials (i.e. "intersection").

In the present study, consistent information processing was obtained in FD children by relating their cognitive functioning to the relevant method of stimulus presentation. Subjects in all treatment groups were never told how to solve the problems or explained the formal rules of "intersection:. It can now be concluded that FD children possess the same logical thought structures as FI children of the same age. The strategy of disembedding stimulus materials for FD children has promising implications for tailoring instructional materials to fit the cognitive characteristics of pupils.

The present study did not determine if both disembedding and recoding are necessary for focusing to occur in FD children. For example, it would be interesting to determine if disembedding would be sufficient with a (non-recoding) memory aid, especially since the results of Experiment 1 as well as previous research (eg. Pishkin et al., 1967) suggest that the resulting task would be more difficult than the one used in the present experiment.

REFERENCES

Baggaley, A.R. Concept formation and its relation to cognitive variables. Journal of General Psychology, 1955, 52, 297-306.

Bruner, J.S., Goodnow, J.J. and Austin, A. A Study of Thinking. New York: Wiley, 1956.

Coop, R.H. and Sigel, I.E. Cognitive style: Implications for learning and instruction. Psychology in the Schools, 1971, 8, 152-160.

Eimas, P.D. A developmental study of hypothesis behavior and focusing. Journal of Experimental Child Psychology, 1969, 8, 160-172.

Eimas, P.D. Effects of memory aids on hypothesis behavior and focusing in young children and adults. Journal of Experimental Child Psychology, 1970, 10, 319-336. (a)

Eimas, P.D. Information processing in problem solving as a function of developmental level and stimulus saliency. Developmental Psychology, 1970, 2, 224-229. (b)

Elkind, D., Koegler, R.R. and Go. E. Field independence and concept formation. Perceptual and Motor Skills, 1963, 17, 383-386.

Frankel, F., Levine, M. and Karpf, D. Human discrimination learning: A test of the blank-trials assumption. Journal of Experimental Psychology, 1970, 85, 342-348.

Gelman, R. Conservation acquisition: a problem of learning to attend to relevant attributes. Journal of Experimental Child Psychology, 1969, 7, 167-187.

Gregg, L.W. and Simon, H.A. Process models and stockastic theories of simple concept formation. Journal of Mathematical Psychology, 1967, 4, 246-276.

Ingalls, R.P. and Dickerson, D.J. Development of hypothesis behavior in human concept identification. Developmental Psychology, 1969, 1, 707-716.

Karp, S.A. and Konstadt, N. Manual for the children's embedded figures test. Brooklyn: Cognitive Tests, 1963.

Levine, M. Hypothesis behavior by humans during discrimination learning. Journal of Experimental Psychology, 1966, 71, 331-338.

Levine, M. The size of the hypothesis set during discrimination learning. Psychological Review, 1967, 74, 428-430.

Miller, M.M., and Harris, L. Dimension preference and performance on a series of concept identification tasks in kindergarten, first-grade and third-grade children. Journal of Experimental Psychology, 1969, 7, 167-385.

Nuessle, W. Reflectivity as an influence on focusing behavior of children. Journal of Experimental Child Psychology, 1972, 14, 265-276.

Ohnmacht, F.W. Effects of field independence and dogmatism on reversal and non-reversal shifts in concept formation. Perceptual and Motor Skills, 1966, 22, 491-497.

Panda, K.C. Effects of social reinforcement, locus of control and cognitive-style on concept learning among educable retarded children. Experimental Publication System, 1971, 12, Ms. No. 475-34.

Pascual-Leone, J. A mathematical model for the transition rule in Piaget's developmental stages. Acta Psychologica, 1970, 32, 301-345.

Pishkin, V., Wolfgang, A., and Rasmussen, E. Age, sex, amount and type of memory information in concept learning. Journal of Experimental Psychology, 1967, 73, 121-124.

Restle, F. The selection of strategies in cue learning. Psychological Review, 1962, 69, 11-19.

Rieber, M. Hypothesis testing in children as a function of age. Developmental Psychology, 1969, 1, 389-395.

Suchman, R.G., and Trabasso, T. Stimulus preference and cue function in young children's concept attainment. Journal of Experimental Child Psychology, 1966, 3, 188-198.

Witkin, H.A. A cognitive style approach to cross-cultural research. International Journal of Psychology, 1967, 2, 233-250.

Witkin, H.A., Dyk, R.B., Faterson, H.F., Goodenough, D.R. and Karp, S.A. Psychological Differentiation. New York: Wiley, 1962.

Witkin, H.A. and Oltman, P.K. Cognitive style. International Journal of Neurology, 1967, 6, 119-135.

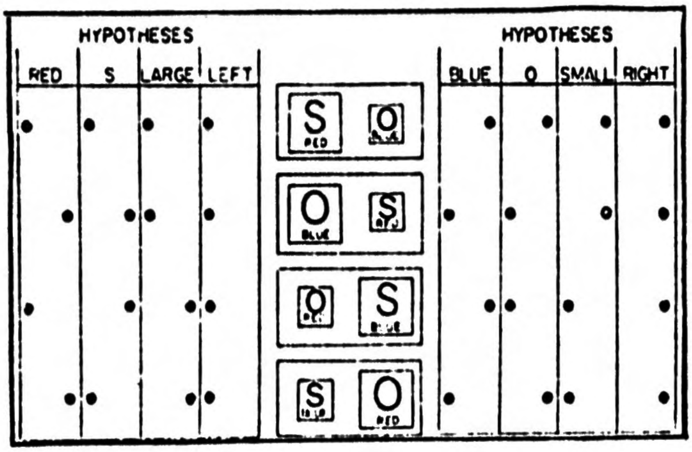


Figure 1. A description of the four dimensional bivariate stimuli and the eight sequences conforming to the set of simple hypotheses.

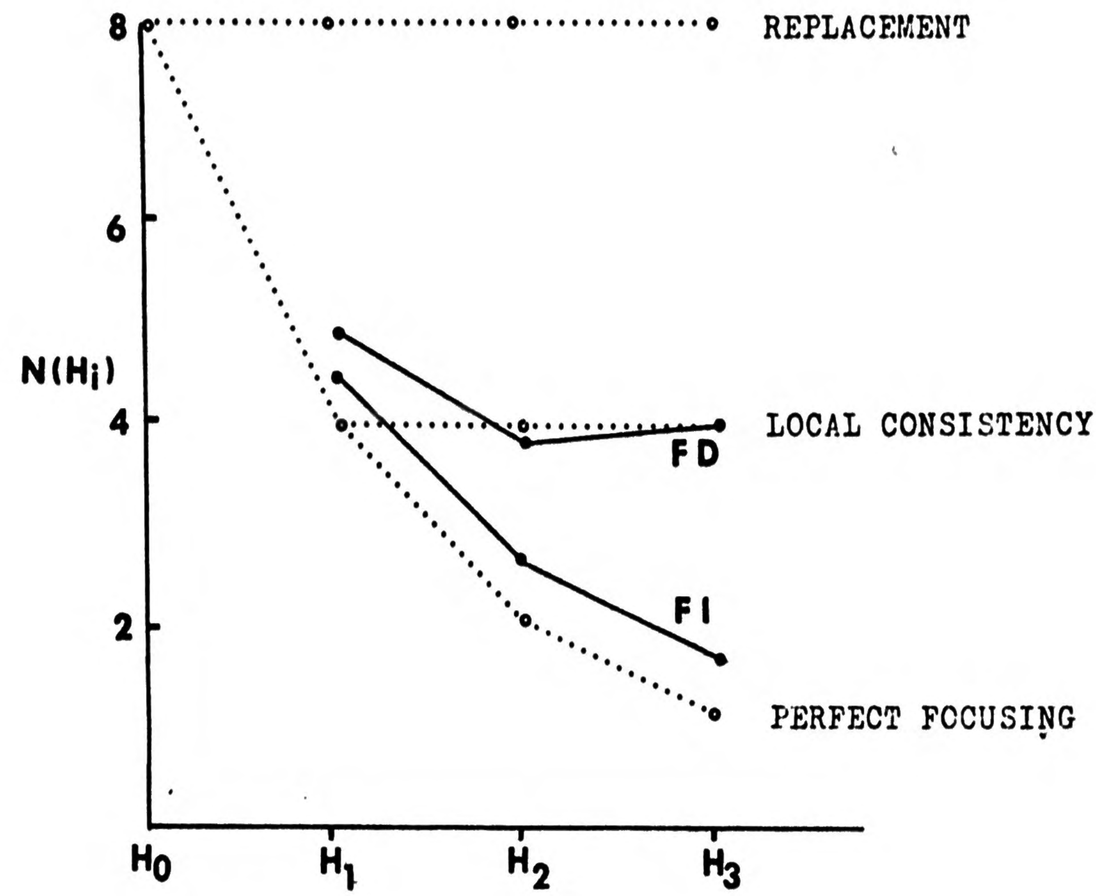


Figure 2. The size of the hypothesis set, $N(H_i)$ from which a subject is sampling after a negative outcome trial as a function of cognitive style (FI vs. FD) and the blank-trial sequence ($H_1$, $H_2$, $H_3$).

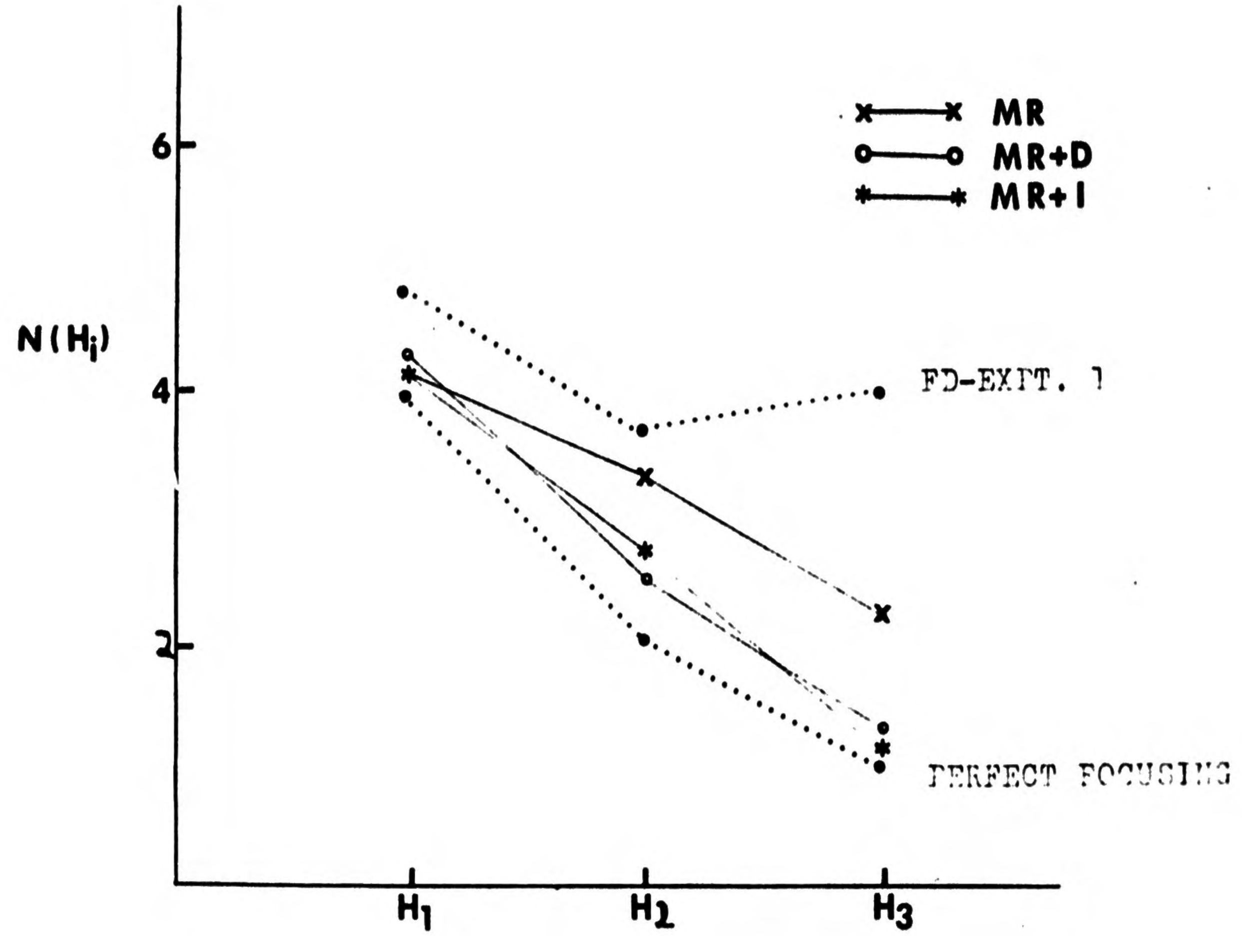


Figure 3. The size of the H set, N ($H_i$) from which a subject is sampling after a negative outcome trial as of function of treatments (MR, MR+D, MR+I) and the blank-trial sequence ($H_1$, $H_2$, $H_3$). Also presented is the function predicted for a perfect focusing model and that obtained for the FD group of Experiment 1.

Table 1

Mean Percentages of Hs Consistent with Positive (0+) or Negative (0-) Outcome Trials Immediately Preceeding (C-0), One Step Removed (C-1) or Two Steps Removed (C-2) from the Measured H.

| Group | C-C | | C-1 | | C-2 | |
|---|---|---|---|---|---|---|
| | 0+ | 0- | 0+ | 0- | 0+ | 0- |
| Field-independent | 100 | 89 | 93 | 74 | 88 | 60 |
| Field-dependent | 87 | 78 | 75 | 44 | 65 | 24 |

Table 2

Mean percentage of $\underline{h}$s on the four binary dimensions ordered from 1 to 4 where: D1 = the dimension responded to most often and D4 = the dimension responded to least often.

| Group | Stimulus Dimensions D1 | D2 | D3 | D4 |
|---|---|---|---|---|
| Field-independent | 43 | 28 | 20 | 10 |
| Field-dependent | 57 | 25 | 13 | 5 |

Table 3

Mean Percentages of Hs Consistent with Positive (0+) or Negative (0-) Outcome Trials Immediately Preceding (C-0), One Step Removed (C-1) or Two Steps Removed (C-2) from the Measured H as a Function of the Treatment Groups.

| Group | C-0 | | C-1 | | C-2 | |
|---|---|---|---|---|---|---|
| | 0+ | 0- | 0+ | 0- | 0+ | 0- |
| MR | 94 | 93 | 81 | 62 | 60 | 41 |
| MR+D | 96 | 91 | 87 | 83 | 84 | 75 |
| MR+I | 99 | 93 | 97 | 85 | 97 | 93 |