Inductive Reasoning Strategies

We have found that the training program is only as good as the trainer. Although some specific suggestions will follow, we cannot anticipate all possible questions that may arise. We have found however, if trainers have a working knowledge of the basic processes being trained, they can handle almost any questions that occur. Consequently, each of the six basic processes are functionally described with examples from the program being provided. The examples provide an indication of the type of problem used to teach each process.

Six Basic Procedures

In the following discussions of basic thinking procedures (core structures), reference to problems identified by number are from the training program.

Generalization (GE)

Generalization is characterized by the need to establish similarity of attributes for different objects making up a group. These objects differ from one another, but share at least one common attribute. Problems involving the generalization process occur in three forms.

- Class construction (see problem #5)
- Class completion (see problem #6)
- Finding similarities (see problem #4)
Picture problem #5 shows five objects: boot, lady's hat, socks, shoe, and slipper. Questions asked are "Which three belong together?" Five objects are given: "Which three form a class?" The solution strategy consists in noting an attribute common to each object. This is best accomplished by making comparisons among all objects. The search is for an attribute that several objects have in common. The constraint that exactly three objects show a commonality must be taken into consideration. Hat and socks are textiles, but this accounts for only two, not three, of the objects. Three other objects have something in common, they are all types of shoes. As a monitoring strategy, a reverse check is made to ensure that the excluded items do not possess the attribute used for grouping. The lady's hat is clear; it is not footwear. But what about the socks? They are not shoes.

Picture problem #6 demonstrates completion of a class. Here it is clear that objects in the upper part of the picture form a class (or group) and that one object from below also fits in the same class. Therefore, an object is sought which belongs to a class already defined. Problem solution involves determining what attribute the upper objects have in common with only one object from below. Monitoring consists of checking to make sure that no other objects have the same attribute.

Picture problem #4 requires only the discovery of common attributes. Even here it is sensible to do more than just list the attributes (the butterfly is alive, has two wings, etc.). Rather, it is helpful when describing an attribute to draw comparisons with other objects. All of the objects in the picture problem can fly. As with all problems, it is important to see to it that training proceeds in the following manner:

- The children proceed analytically, i.e., they compare properties of objects rather than form global, comparative opinions.
- They proceed systematically, e.g., from left to right (see problem #6) or to make certain that nothing is overlooked in problem #5.
- They do not lose sight of the problem question, and they also make good use of "limits" or constraints.

At the same time it is important to make the structure of a problem so clear that children recognize when to use a particular procedure. Finally, children must learn to distinguish between solution
and monitoring strategies. This latter point provides the basis for
development of reasoning and problem solving competencies.

**Discrimination (D1)**

Discrimination is the process of noting differences among objects
with respect to attributes. There is only one problem form here,
identification of the object that doesn’t belong (see problem # 32).
Whenever problems of this type are given, it is again necessary to
look for a common attribute. Here, however, the constraint is that
all, except one, have the same attribute. Again, objects are not
judged independently, but in a comparative manner considering all
of the objects in the problem set. In the case of problem # 32, note
that the spade is made partly of wood, partly of metal, is heavy, is
used in the garden, has a handle, etc. Both watering cans and tel-
ephones are made of plastic. The constraint here consists in finding
three objects that have something in common, which the fourth
does not possess. In this case, the telephone is out of place because
it is not used in the garden. The other objects are all used when
gardening. Again, the comparative procedure provides the basis for
a check on the hypothesis that the telephone is different. This is of
course an instance of metacognitive monitoring.

**Cross Classification (CC)**

One will recognize cross classification as the four-fold classification
scheme used to identify four permutations of two attributes
considered two at a time. Expanded schemes can be developed.
Cross classification is concerned with a classification scheme in
which at least two attributes must be considered simultaneously.
Picture problem # 52 requires processing that meets the definition
of cross classification. Adjacent is an object (X) and the question
is asked “In which box does this object belong?” The general
structure of a cross classification problem looks like this:
As can be seen, cross classification requires a determination of both common and different attributes. The advantage of cross classification resides in the fact that all combinations which are possible will occur: similarity in both features, dissimilarity in both features, similarity of feature A with differences in feature B and vice versa. Picture problem #52 is used here as a demonstration. Everything shown in the upper half of the scheme is edible; everything shown in the lower half is not edible. The columns are not differentiable on the basis of the material, but rather on their form. At left are round objects; on the right, more elongated forms. A solution strategy requires first the development of a classification system and in fact one which keeps in mind the object to be arranged, the banana. It is clear here: The banana is a fruit, but is not round, rather elongated. It follows that it belongs with the pear. Monitoring poses the check: The object associated with the pear cannot be round and inedible, but must be edible.

Recognition of Relationships (RR)

Associations or relationships are possible when at least two objects are present. In the training program, problems typically contain more than two objects. However, most relationships can be inferred by using a paired-comparison strategy when using the comparison procedure. Problems involving the process of recognizing relationships require the identification of similarity among relationships. The nature of the relationship is more varied and complex than is the case when recognizing common attributes of objects. Attributes are commonly considered to be surface characteristics of objects. However, relationships may share common characteristics that pertain to function, type of relationship (cause/effect, part/whole, etc.), or something unique to the problem set. Consequently, problems involving relationships typically require greater effort in terms of working memory capacity and processing load. These types of problems are typically viewed as more abstract in nature than attribute problems. Relationship recognition occurs in three problem forms in the training program:
- Complete a series (problem #15).
- Arrange a series (problem #16).
- Analogy (problem #11).
Picture problem #15 shows a series. From among four possibilities one is chosen which will precisely complete the series. This problem is not one of similarities in attributes for individual objects but rather with similarities among relationships. We observe two adjacent figures and establish the relationship between them. We discover that, when seen from left to right, there is a relationship "... is fuller/thicker than ...". The solution strategy consists in sequentially checking the relationships that exist between the pairs of figures. A hypothesis can always be tested out on the next pair. Metacognitive monitoring can again be used to confirm a solution.

The ordering or arrangement of a series (picture problem #16) often makes use of such relations as "... directly follows ..." or "... causes ...". In #16 it is necessary to consider the experience of the child to determine which part of the story the child focuses on as the starting point. Then a solution strategy in the narrow sense can be employed to find pairs which occur in the relation "... follows directly after ...". A metacognitive monitoring check would involve making sure that no other picture immediately follows.

An analogy problem requires one to determine a specific relationship between a pair of objects that are provided as a standard for comparison. Often, many relationships might be possible. Then the solution strategy consists of mapping the relationship onto an incomplete pair in order to establish a new pair of objects that exhibit the same kind of relationship. In the training program, the standard pair is always presented in the two upper quadrants. The incomplete pair is presented in the lower quadrants. In picture problem #11, for example, it might be possible to establish the following relationship between fish and aquarium as "the fish is smaller than the aquarium." When this relation is mapped (applied) to the mouse and other possible answers, there is no clear-cut relationship. However, when the relationship "the fish lives in the aquarium" is considered, then the correct analogy is "the mouse lives in a mouse hole". A metacognitive monitoring check would indicate that no other choice (doghouse, bird's nest) maps the relation "... lives in ...".
Differentiating Relationships (DR)

Problems in differentiating relationships require the recognition of differences in relations. This is similar to discrimination in that it can only be done against a background of similar relationships. There is only one problem form, the disturbed series. However, this problem form can occur in two variations. In the first it is only necessary to reorder members of a problem set in order to define a correct series (see picture problem #41). In the second variation, one object must be excluded (see picture problem #40). In both cases, the solution strategy requires finding a relationship that occurs among the remaining objects enabling recognition of the object that disturbs the series. The metacognitive monitoring strategy used to check the correctness of a solution is to assess the overall similarity of a relationship among remaining objects or in the first case, reordered objects.

System Construction (SG)

System construction is concerned with establishing either equivalence or dissimilarity of relationships. In a sense it is a counterpart of the reasoning used to solve cross classification problems. With cross classification, there are at least two attributes. With system construction, there are at least two relationships in which similarity or dissimilarity are to be verified. There are two common problem forms, simple and extended matrices.

Simple Matrix

```
Object A  ---  Relationship 1  ---  Object B
|                  |                  |
Relationship 2    Relationship 2
|                  |                  |
Object C  ---  Relationship 1  ---  Object G
```

Which object belongs in the blank space?
- Object e
- Object f
- Object g

In contrast, a matrix can be extended to include more than four objects in a problem set. In the following matrix, five objects are connected through two relationships, R₁ and R₂. Since this is not
a quadratic matrix, relationships occur unequally (R₁ four times; R₂ three times).

Notice that in the following example, the rows involve a series (a, b, & c; d, e, & ?) while the columns involve pairs (a & d, b & e, c & ?). Obviously, in a 3 by 3 matrix, both rows and columns would be made up of a series of three objects. Again, the ability to map relationships successively provides the overall solution strategy.

**Extended Matrix**

```
    a -------- R₁ -------- b -------- R₁ -------- c
    |          |          |          |
    | R₂       | R₂       | R₂       |
    |          |          |          |
    d -------- R₁ -------- e -------- R₁ -------- ?
```

Which object belongs in the (?) space?
- object f
- object g
- object h
- object i

Each pair of objects has a common relationship with at least one other pair and this relationship is dissimilar from a relationship between at least one other pair. For a solution it is necessary to recognize where each relationship is operational and where similar and dissimilar ones exist. Picture problem #81 is a simple matrix, i.e., the simplest quadratic matrix. The relationships are: (1) a doubling of dots from top to bottom; and (2) from left to right, the left wing has one more dot. For a solution it is necessary to recognize both relationships and then to locate from among choices the correct object which will systematically maintain the relationships constructed among objects. The metacognitive monitoring strategy in this case would be a systematic rechecking for similarity of relationships among rows and columns — always starting in the upper left cell of the matrix.