CHAPTER 3

BRAIN MATURATION, INTELLECTUAL DEVELOPMENT AND DESCRIPTIVE CONCEPT CONSTRUCTION

1. INTRODUCTION

Thus far we have found the pattern of hypothetico-predictive reasoning at work in our attempts to draw in a mirror, in the behavior of Piaget's son Laurent learning to orient his bottle to suck milk, in the case of the unlit barbecue, in both visual and auditory information processing, and in the solution of a proportions problem by adolescents. Is the same pattern at work in students' reasoning during descriptive concept construction? Consider for example the creatures called Mellinarks in the first row of Figure 7. Why do you suppose these are Mellinarks while the creatures in the second row are not Mellinarks? In other words, what makes a Mellinark a Mellinark? Can you use the information in the figure to find out? If so, which creatures in row three are Mellinarks? How do you know? In other words, how do you define a Mellinark and how did you arrive at that definition? What were the steps in your reasoning? Take a few minutes to try to answer these questions before reading on.

To gain insight into the reasoning used by students to solve the Mellinark Task, several students tried the task and told us about their reasoning. Consider, for example, the following remarks of a student who identified creatures one, two, and six in row three as Mellinarks (Lawson, McElrath, Burton, James, Doyle, Woodward, Kellerman & Snyder, 1991, p. 967):

> Number one, two, and six are Mellinarks.
>
> OK, how did you figure that out?
>
> Um. Well, the first thing I started looking for was just overall shape, whether it's straight, looks like a dumbbell, but this doesn't really work, because some of these (row two) are similar in overall body shape. So I ruled that out. Well, then I said, all of these are spotted (row one). But some of these (row two) are spotted and these aren't Mellinarks, so that can't be the only thing. So I looked back at these (row one) and noticed that they all have a tail. But some of these have a tail (row two), so that can't be the only thing either. And so then I was sort of confused and had to look back, and think about what else it was. Then I saw the big dot. So all of these (row one) have all three things, but none of these (row two) have all three.

According to the student, she first generated the idea that overall shape is a critical feature. But as she tells us, this idea was quickly rejected because some of the creatures in row two are similar in overall shape. Thus, at the outset, the student may have reasoned like this:

If...overall shape is a critical feature of Mellinarks, (descriptive hypothesis)
and...I look closely at the non-Mellinarks in row two, (behavioral test)
then...none should be similar in overall shape to the Mellinarks in row one. (prediction)
But...some of the non-Mellinarks in row two are similar in overall shape. (observed result)
Therefore..."I ruled that out," i.e., I concluded that my initial idea was wrong. (conclusion)

Of course this is the same pattern of reasoning that we have seen before. Some logicians call this pattern "reasoning to a contradiction" or "reductio absurdum" (e.g., Ambrose & Lazerowitz, 1948). And as we can see in the remainder of the student's comments, the pattern appears to have been recycled until all contradictions were eliminated. So after rejecting her initial descriptive hypothesis, the student seems to have quickly generated others (e.g., spots are the key feature, a tail is the key feature) and presumably tested them in the same fashion until she eventually found a combination of features (spots, tail, big dot) that led to predictions that were not contradicted, i.e.,

If...Mellinarks are creatures that have spots, a tail, and one big dot, (descriptive hypothesis)
and...I check out all the creatures in rows one and two, (test)
then...all those in row one should have all three "things" and none in row two should have all three "things." (prediction)
And...this is what I see. (observed result)
and six in row three have all three "things" so they are Mellinarks). (conclusion)

Did you also conclude that creatures one, two, and six of row three are Mellinarks? If so, did your reasoning look something like the above? How do you suppose a sample of high school students would do on a series of Mellinark-type tasks? Would they also use this reasoning pattern? Or would they use something else and run into difficulties? To find out, Lawson, et al. (1991) administered a series of Mellinark-type tasks to 314 high school students. Interestingly, not only did many students experience difficulties, their performance was highly correlated with performance on a measure of scientific and mathematical reasoning (i.e., developmental level).

Difficulties experienced by students who presumably failed to employ cycles of hypothetico-predictive reasoning to solve the tasks were exemplified by the following discussion with a student following her failed attempt:

Suppose I define a Mellinark as being a creature with a tail. How could I test that idea? Is there any information here that would tell me if that idea is right or wrong?

...Um...you could um...huh...a...just look to see if the other creatures have the same tails...or, I mean...you know...characteristics of the creatures...with the tails and the points and the dots and stuff to see if they are...you know...all the same or close to...and then...um...heh...I don't know...heh.

OK, let's look at the second row. We know that none of these are Mellinarks. So what would you expect about these with regard to tails? I mean, if it's true that Mellinarks are creatures with tails then what would you expect to find in row two with regard to tails?

Um...they would a...they would be some different kind of creature with tails...I don't know...they would um...I don't know...they would just...they don't have the dots on `em. And then...um...they are more...I don't know.

OK. Let's go back. Once again, I'm going to say that Mellinarks are creatures with tails and I look down here (row two) and I see that this non-Mellinark has a tail. See that tail right there?

Yeah

And I know that is not a Mellinark. So I would conclude from that my definition must be wrong.

Yeah...well they could have classified 'em wrong. It could have been a mistake. These would have been up with the other Mellinarks.

Although this sort of response and the quantitative data reported by Lawson et al. (1991) reveal clear difficulties by many high school students, a question remains as to the cause(s) of the difficulties. Perhaps the difficulties stem from students' lack of hypothetico-predictive reasoning skill. Suppose like Piaget (e.g., Piaget, 1964), we assume that such reasoning skill is the product of intellectual development (i.e., the product of physical and social experience, neural maturation and self-regulation). If this is true, then brief verbal training in the use of such reasoning should not be successful in provoking students to solve Mellinark-type tasks. In other words, the training should fail because, in theory, the necessary reasoning skill results from the long-term process of intellectual development, not from short-term training.

Consequently, research was initiated in which six Mellinark-type tasks were constructed and a brief verbal training session was used to point out potentially relevant features (i.e., provide descriptive hypotheses to be tested) and to explain to students how to use cycles of *If/then/Therefore* reasoning to test those features and solve the tasks. More specifically, the reasoning guiding the research can be stated as follows:

If...the difficulties experienced high school students are caused by lack developmentally derived, hypothetico-predictive reasoning skill needed to construct descriptive concepts, (developmental hypothesis)

http://www.springer.com/978-1-4020-1180-1

The Neurological Basis of Learning, Development and Discovery
Implications for Science and Mathematics Instruction
Lawson, A.E.
2003, XVI, 285 p., Hardcover
ISBN: 978-1-4020-1180-1