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ABSTRACT

Organized in three sections, this report presents the first case study from a project aimed at developing prototypes of ideal textbook chapters. The report (1) discusses the Ideal Text Project, in which a number of researchers in instructional science have been challenged to design a textbook chapter that incorporates the design features they think an ideal text should contain; (2) includes the first prototype chapter developed (a tenth grade biology text chapter on the brain); and (3) presents extensive commentary on the development of the chapter, including the text design framework, and text design features. (HOD)

THE IDEAL TEXT: CASE STUDY 1

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Abstract

This report presents the first case study from a project aimed at developing prototypes of ideal textbook chapters. The report includes an introductory presentation of the project, the first prototype chapter developed (a tenth grade biology text chapter), and the author's commentary on the prototype. The focus throughout is on the interplay between text design and the psychology of learning.

Note on the organization of the report

This report is organized in three sections, as such:

1. Introduction

2. Prototype chapter: the Brain

3. Commentary on case 1

INTRODUCTION

The Ideal Text project involved a creative process engaged in by a number of researchers in instructional science: a challenge was put to each of them (including myself) to design a textbook chapter which incorporates the design features which they think an ideal text should contain. The process was a creative one, for a chapter had to be developed from scratch. It was also one of translation, in the specific sense that the theoretical views which one held had to be translated into an actual product of potential use to students. Therein lies the challenge, for while theoretical systems may appear complete, explicit and even straightforward when examined as systems, their translation into concrete designs in the world of practice, textbook design in this case, is rarely unambiguous.

These two levels, theory and design, are thus confronted in this project. The confrontation lies in the translation process, the issue being not whether inconsistencies appear in this process, but rather the extent to which theoretical perspectives as such can be readily translated into practice.

The challenge was both a serious one and a difficult one. Serious because of the often wide gulf separating the research world from the text design world, and the intent of building a bridge (admittedly but an initial one) between these two worlds. It was also a difficult one because of the very applied nature of the task.

It is not unusual of course in the design profession to offer examples of excellence. Graphic design magazines (Graphis, Communication Arts) and architechtural ones as well (Architechtural Record) consider this their prime function. Design fields such as these however do not offer a process of translation which is in any large way explicit. Their art, for that is the appropriate term in this context, responds more to sensibilities than to theoretical perspectives (not that this matter should be exaggerated however).

Textbook design, in contrast, partakes much more of what Simon (1969) has called the 'sciences of the artificial'. It must be responsive to the learning needs of the students; that is its primary orientation. A text which does not teach is useless. This pragmatic imperative is and must always be the foremost consideration for the textbook publisher (without being, needless to say, the only one). And here lies one serious aspect of the design problem, for the 'learnability' of a text is not so easy to establish as might first appear (as will become evident in the discussion below).

Textbook design is, in this respect, very different from what is known in the design field as book design. The latter is rather close in meaning to graphic design, the primary aim of the process being to create an attractive design (within the constraints imposed by the technology of bookmaking). A textbook of course does also respond to aesthetic motivations, but in a much more secondary way.

Juggling the numerous and varied constraints which set the brief for a textbook author to work from is in essence the creative effort involved in textbook design. And hence, that too was the effort which went into the "ideal text" chapter presented here.

There is of course no such thing as an ideal text. Such a notion (preposterous really!) could indeed not withstand any number of criticisms, for it is but a vague formulation. And that is exactly how it was used in this project, merely as something to be reached for, while fully realizing the limitations of the quest.

Given that the author represented here is a psychologist interested in instructional research, the ideal takes on an orientation primarily colored by the demands of learning. This is rather unsurprising, too, given that we are dealing with textbooks and not with novels, reference books or other forms of publication.

This does not exclude other considerations, of course, for book design itself does enter into textbook design. Bookmaking after all is a field with a long tradition, and while it may lack a theoretical basis (which is certainly the case when compared to learning), it still exhibits some strong principles and practical guidelines (Lee, 1979; Williamson, 1966).

Once again, though, the prime imperative is "learnability" where textbooks are concerned. And again, while learnability may sound rather straightforward, especially to a lay audience, it is just not so easy to characterize. Educational researchers know the perils of comparing different curricula, or different media, or different teaching methods. They know the difficulties, not immediately apparent to the non-specialist, of establishing norms of learnability. For in the majority of cases, one approach will be optimal for reaching certain outcomes but by the same token, will show deficiencies in reaching others. And there is little agreement on which mix of outcomes is best (back to the notion of 'ideal'!), or even on how to define the outcomes in explicit terms. Such is the nature of the educational enterprise.

How does the research translation process come through in all this? Not easily, it must be admitted. The research enterprise can be categorized into two broad areas of investigation, often termed respectively research and development. In the one, learning processes are investigated under rigorous conditions of experimental control in order to develop theoretical insights which might then be generalized to practical (and definitionally messy) educational situations. In the other, instructional designs (which are by definition complex and hence messy) are investigated in terms of their learning outcomes. I am of course oversimplifying what is in reality a continuum within the R & D enterprise and a constant interplay of ideas within this continuum. The aim of this simplification however is to point out that there exists no solid middle ground from which textbook design principles can be derived which could directly and unequivocally lead to an ideal text. Once again, there is no ideal text, only various conceptions of what an ideal text might be. Hence the translation problem.

There are, of course, a number of learning theories which might underlie various solutions to textook design tasks. The confrontation of a practical design task however soon demonstrates its complexity (hence the 'art' of the instructional designer) and perforce the practical limitations of any one theory. This only points out the circumscribed domain of any theory and must lead inevitably to an eclectic theoretical view of learning. The translation process thus i volves in the end, for the textbook author, a selection of what he or she considers to be the best features of each theory. The designer thus has theoretical viewpoints, and is not necessarily aligned with any one theory in particular. The point is simple: theories are selective and a designer profits from being eclectic in outlook. Instruction is not a science, hence the diversity of viewpoints one may encounter.

As indicated earlier, there are also strong design traditions and principles which continually influence book design. There have been in the past serious and valuable attempts to interface these two domains of practice (book design and learning theory) although little in this new filled labelled the technology of text (Jonassen, 1982), is yet well established or widely accepted. Early efforts concentrated heavily on the consequences of typographic options (Tinker, 1963). Later efforts were larger in scope and dealt directly with the problems of the interface (Macdonald-Ross and Waller, 1985; Hartley, 1978; Anderson and Armbruster, 1980).

There are today a number of groups working at the interface between text design and learning psychology, both in Europe and America. Instructional text design is profiting from creative inputs from numerous fields of enquiry, including the psychology of learning and memory, the examination of study strategies, instructional research on various textual adjunct aids and textual organization factors. Instructional text design is a problem-centered area of enquiry which, in wishing to serve a practical concern, draws upon and interrelates many other areas of concern. It is an area which is coming into its own and which will likely see fruitful developments in the future.

The concern in this project with identifying and implementing the characteristics of an ideal text is one approach to addressing the concerns of this field of enquiry. Another approach is to focus on problems of text design (the polar opposite approach), one which may be easier but also useful. Yet another is the traditional experimental approach derived from psychology. Each approach has strengths and limitations. Each makes a contribution to a better understanding of instructional text design, both as an applied science and as an art.

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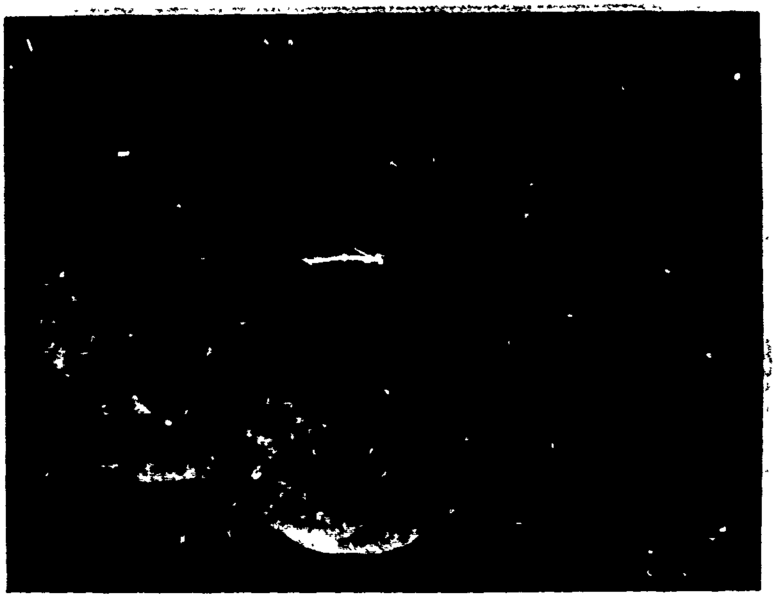
15 THE BRAIN

QUESTIONS STUDIED IN THIS CHAPTER

- o What is the role of the brain?
- o What are its different parts?
- o What is it made up of?
- o How does it work?
- o How do our brains compare to those of other animals?
- o How do scientists study the brain?
- o How can the brain malfunction?
- o What is the mind?

The brain is another fascinating part of your body. It is an organ that just seems to sit there within your skull. It has no moving parts, like your heart for instance, and it does not produce any fluids like your glands do. But it does an awful lot for you: it lets you think, it lets you sleep and dream, it lets you listen and talk and, in fact, it controls most of what you do. And all this happens in what really looks like a big blob of wrinkled, gray jelly that we carry around in our head (take a look at figure 15.1).



15.1 Photograph of the brain. This wrinkled mass of grey matter is the control center of your body.

Your brain is what makes you intelligent, but that is only part of what it does. It also controls a lot of important but less exciting processes like regulating your breathing, making you fall asleep and wake up, keeping you balanced so you don't fall over, and so on. The brain is in fact a control center, and all animals have one.

ROLE OF THE BRAIN

Your brain is much like a big powerful computer. A computer may for instance help a bank keep track of its customer's deposits and let the bank teller know whether there is enough money in a client's account to cover a withdrawal request. The computer thus helps regulate the bank's activities. Your brain serves a similar purpose: it helps you to regulate your activities. If a friend says hello to you in the street, you yourself reply immediately with a friendly hello. If, however, it is not a friend, but rather someone you dislike and want to avoid, you might simply walk by without saying anything. In either case, your brain analyzes the situation and leads you to act in a certain way. All this happens so quickly that you hardly have time to think about it. But your brain is extremely active, analyzing the situation and deciding on a reaction.

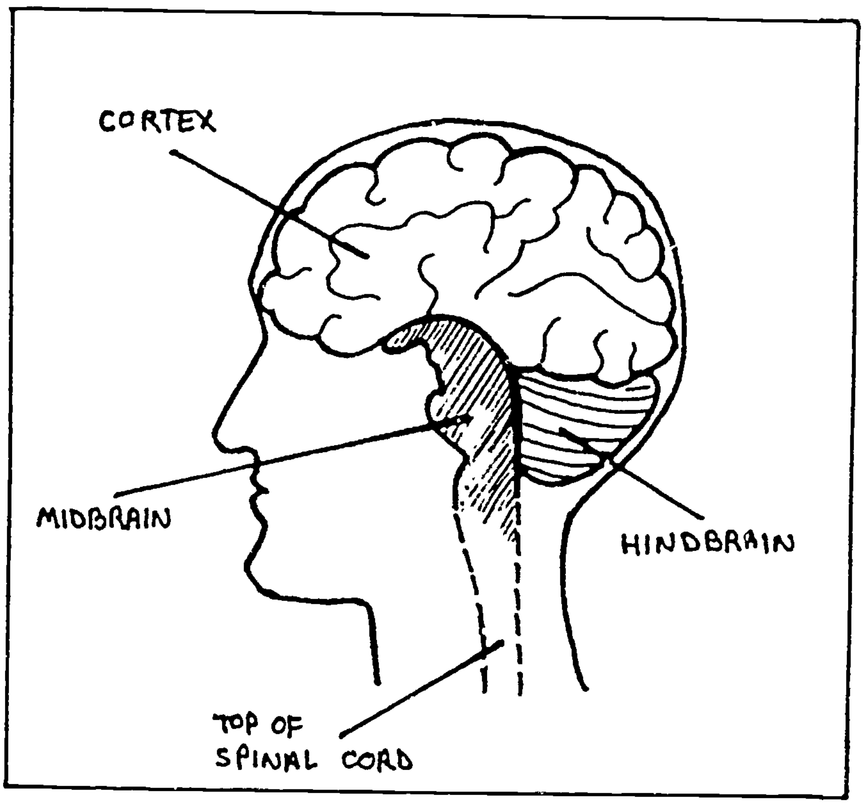
Here is another example of how the brain regulates your activity. You buy something at the store and the salesclerk tells you the bill comes to $6.73. This information is transformed in your ears into a set of pulses which are rapidly transmitted to your brain. You hand the clerk a $10 bill and meanwhile your brain mentally figures out how much change you should get back so that you can be sure the clerk does not make an error. The information processing the brain does in this example is not automatic, and unless you are truly terrific in math, your brain will take quite a few seconds to figure out the proper change.

In both examples, the brain processes some information and leads you to act in some way. It is in fact a very sophisticated system which can do many different kinds of things. It does involve specialization though: different parts of the brain regulate different activities. Let's see how that happens.

Figure 15.2 shows the different parts of the brain. The lower parts are the midbrain and the hindbrain). They handle tasks such as regulating your breathing and smoothing out muscular movements, tasks that are usually fairly automatic for you. For instance, you breathe without thinking about it. And if you sometimes need more air (as when you run or exercise), your respiration rate increases. It is your midbrain that regulates the process, increasing or decreasing the rate as needed. It also regulates your heartrate and many other processes.

Your hindbrain coordinates muscle movements, making sure they all work together. For instance, when you jump over a puddle, the many muscles in your legs have to act together; and that's not all: your back arches and your arms go out as you leap. All these muscles are involved in one movement, which is coordinated by the hindbrain. All this happens pretty automatically.

It is the upper part of the brain which is especially interesting, however, because here is where feelings and thought occur. The whole upper part of the brain is a tightly packed layer of matter full of ridges. This part of the brain is called the cortex (cortex means "covering," and indeed it does sort of cover up the rest of the brain).

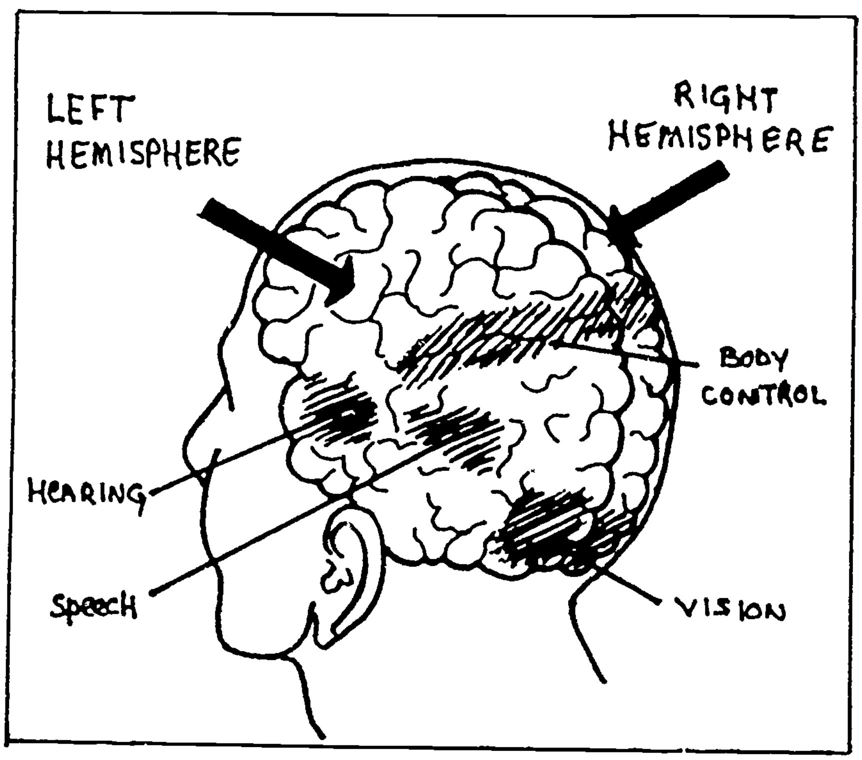


15.2 Main parts of the brain (as seen if the brain were cut down the middle from front to back).

The brain is connected to the rest of your body through the spinal cord and a great number of nerves which extend out from the spinal cord. Every part of your body is thus connected to your brain.

Take a close look at the cortex shown in figure 15.3. The cortex consists of two halves, or hemispheres. Generally, the right side of our body is controlled in the left hemisphere and the left side of our body is controlled in the right hemisphere. For example, when you pick up a book with your right hand, this action is controlled in your left hemisphere. This is a curious arrangement and is still unexplained by scientists. Later we will see other aspects of the brain which also involve the left or right hemisphere.

As you might guess from picture 15.3, different types of activity are controlled in different parts of the cortex. For example, what you see with your eyes is interpreted by the part of the cortex which is toward the rear of your head. When you speak, the way you put words together is regulated by the speech area (see where it is on the figure). And so on for other specialized activities. This specialization is called localization of function, which simply means that different activities are regulated by different areas in the brain. Localization of function becomes important in the case of a person who suffers a brain injury. If that person's speech area is damaged, speaking might become difficult or impossible, although vision, hearing, and the other functions would not be affected.



15.3 Diagonal view of the cortex showing some of the specialized areas. The midbrain and hindbrain are not shown in this picture (they would be below the cortex).

Notice in Figure 15.3 that many areas of the cortex are not labelled. That is because localization of function is only partial. Many cortical areas are not specialized but serve instead for general thinking activities. For instance, when you were figuring out the change from the $10 bill earlier on, that mental activity probably took place in the front part of your cortex, which is a general thinking area.

In summary, the lower parts of your brain (midbrain and hindbrain) keep your body functioning properly by regulating your breathing, heart rate, muscle coordination and so on. The cortex interprets the messages coming in from your senses and controls your actions. This occurs in specialized areas in the cortex. Other areas of the cortex are not specialized. These are used for general thinking activities.

FUNCTIONING OF THE BRAIN

Remember that the brain is essentially an information processing system, just like a computer is. It receives information from the senses (for instance, from the eyes), interprets this information, and then sends other information to muscles in order to act. Consider the following example: you are riding a bicycle down the street and suddenly you see a car pull out not too far ahead in your line of travel. The scene registers in your eyes and it is transformed into a message in the back of the your eyes; this message travels along the nerves which connect to the visual area of your cortex; the information is interpreted, and the situation is evaluated (through a lot of activity in other parts of the cortex). In the end, you realize the situation is a dangerous one and that you must act in order to avoid an accident. The body control area in your cortex fires off a message to your arm muscles which make them grab the brakes and turn the handlebars to the left. Notice that all this happens very quickly. The hindbrain helps to smooth out these muscular movements.

Here is another example: a friend tells you that he cannot pick you up to go to the skating rink as planned. The sound waves enter your ears, where they are transformed into a message that is sent on to the hearing area in your brain (see where that is in Figure 15.3). Here they are interpreted and evaluated in relation to the knowledge and the plans you already have in your brain. This involves a great many interactions between numerous brain cells in the front part of your cortex. You realize right away that no immediate action is needed, and you start thinking about the situation: "Do I really want to go? What other ways are there for getting there? Who else will be there?" and so on. Eventually, you will decide on some course of action, and carry it through.

These two examples illustrate the complex task the brain has: to regulate our body in interaction with its environment. Some regulations are quick and straightforward (as in the bicycle example), others involve a great deal of thought and are thus far from automatic. In each case, though, the brain's task is the same: to receive information, evaluate the situation, and make the body react in some way which will be best for it.

NEURONS

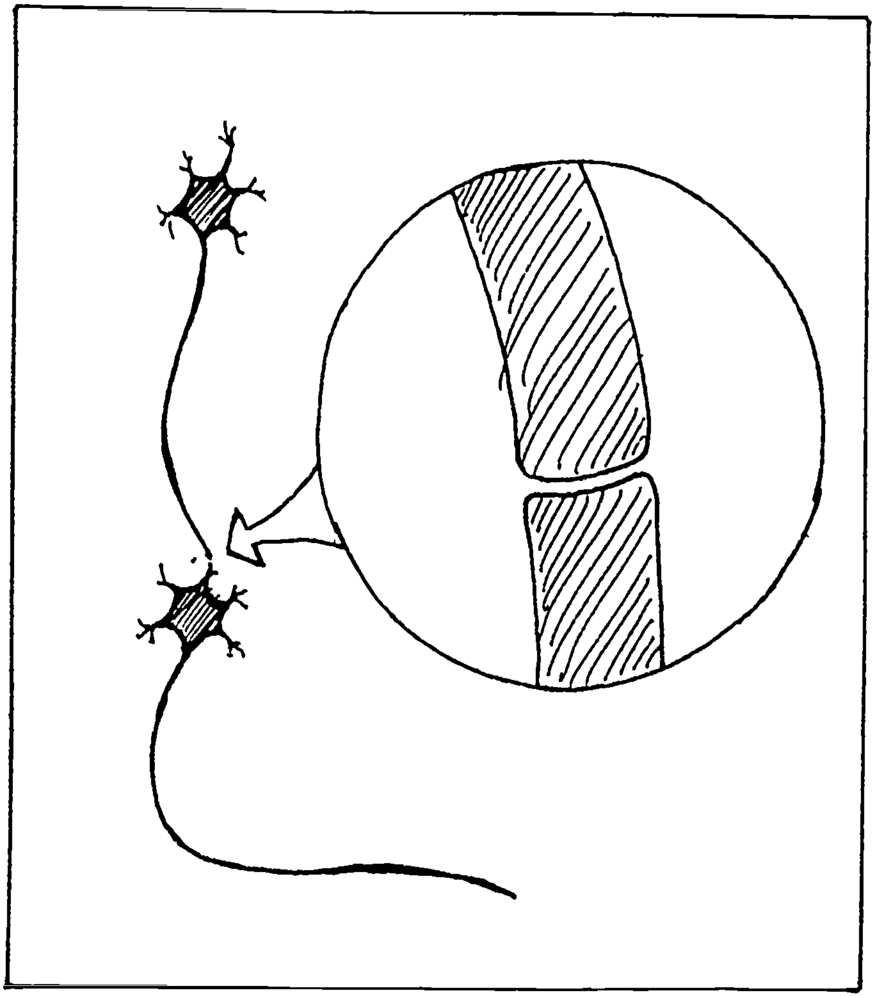
To accomplish its task, the brain handles a lot of information. This is done by cells called neurons. The brain is made up of 30 billion of these cells. The spinal cord and nerves also consist of neurons.

Neurons are specialized cells with one function only: to transmit information in the form of brief impulses. These impulses are little bursts of electricity and they work just like in a telephone line. When you speak into a telephone, your voice is transformed into electrical pulses which travel along the telephone line and then are transformed back into voice at the other end. The same thing happens in your brain. For instance, when someone says hello to you, your ears transform the sound into electrical impulses; these travel along neurons to your brain where the sound is evaluated; then your decision to reply goes from your brain to your mouth (in the form of impulses once again) and your mouth muscles contract in the appropriate way to reply.

Neurons have a special shape and are connected to one another in a special way (see Figure 15.4). Each neuron is composed of a cell body, plus a number of short extensions around the cell body and one long extension.

There are many, many billions of connections between neurons in the brain, but only one connection is shown in Figure 15.4. Neurons never actually touch one another: there is always a little gap between the end of a neuron and the beginning of another neuron.

How does information travel along neurons? How do impulses travel from a sense receptor (for instance in an eye) up to the brain? Sense receptors are specialized neurons which fire off impulses under certain conditions. For instance, the sense receptors in the eye are triggered by light patterns. When light reaches such a sense receptor, the receptor fires an impulse. One neuron carries the impulse along its length toward another neuron up the line. But wouldn't the gap between neurons prevent the impulse from being passed along? At the gap, the impulse causes a small



15.4 Two neurons. The circle is a magnified picture showing a gap where the neurons meet.

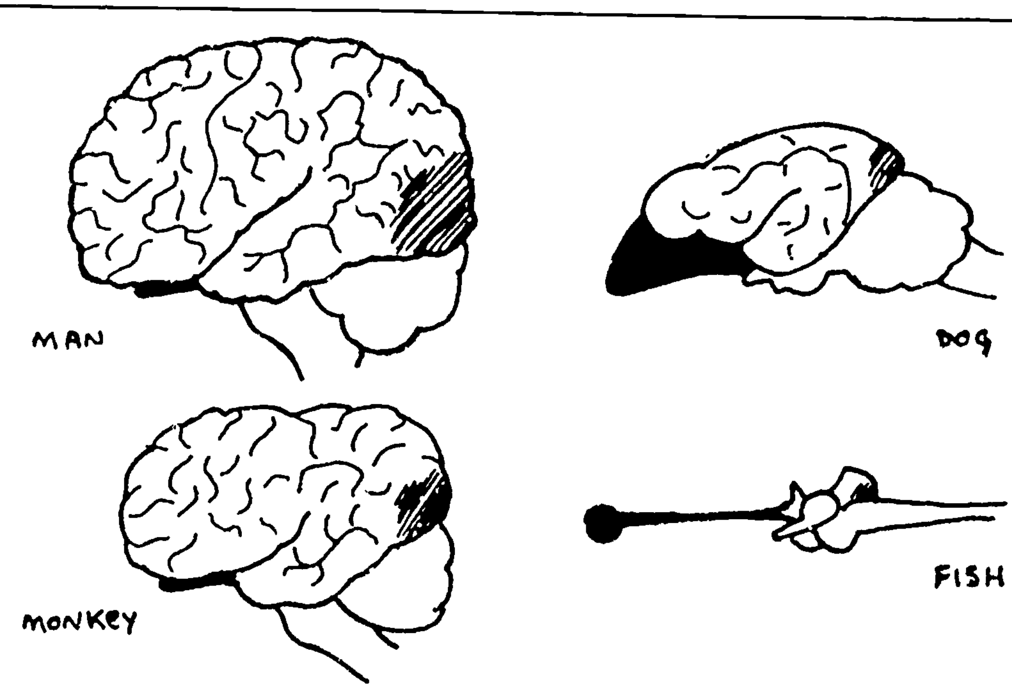
chemical reaction to take place. A chemical agent crosses the gap and in turn triggers a new impulse in the next neuron, and the information is thus passed on up the line.

The same process takes place in the brain itself and in the nerves which reach out to the muscles: electrical impulses travel along neurons and are passed on from one neuron to another via a chemical reaction. Activity in the brain is thus an electro-chemical process. And indeed, both electricity and chemicals can alter brain processing, as we shall see later.

How do we compare with other animals? All complex animals (from the reptiles on up) have a brain with the same basic parts as our own brain.

In mammals, the lower brain parts are pretty similar to our own. It is the large size of the cortex which distinquishes man (and other primates such as monkeys an apes) from animals lower in the evolutionary scale (see Figure 15.5). Your cortex occupies about 2/3 of your brain. In a dog, it is about 1/2, and it is much less in a fish.

Man does not have the largest brain (whales do), but the size of the brain relative to the whole body is largest in man. Your brain weights about 1/40 of your whole body. A whale's brain weighs 1/10000 of its body.



15.5 The brains of various animals. The fish brain is shown in true size, but the others have all been drawn in reduced size. The smell area in each case is black in the figure and the visual area is gray.

Thus, size of cortex and brain-body ratio are important differences between animal species. One other important difference is specialization: men and monkeys use their eyes a lot to interact with the world, but other mammals rely more heavily on their sense of smell. It so happens that man's smell area is quite small compared to other areas of his brain. In mammals, generally, it is quite large (see Figure 15.5 again).

How does man compare to monkeys in terms of brain structure? Their brains are very similar, except that the area of the cortex that deals with thinking is larger in man. That's why we are more intelligent than monkeys. Our greater intelligence allows us to react to the world in more varied ways than monkeys can. Monkeys in turn are more intelligent than dogs, and dogs are more intelligent than fish. Lower animals are more set in their ways: their actions follow set patterns rather than being intelligent reactions. For example, a bee which is trapped behind a glass pane in a partially open window will try to force its way out, hitting the glass again and again. Its cortext (and its intelligence) is so small that it cannot realize that a slight detour around the glass would let it get out. If it does eventually get out, it is by pure luck.

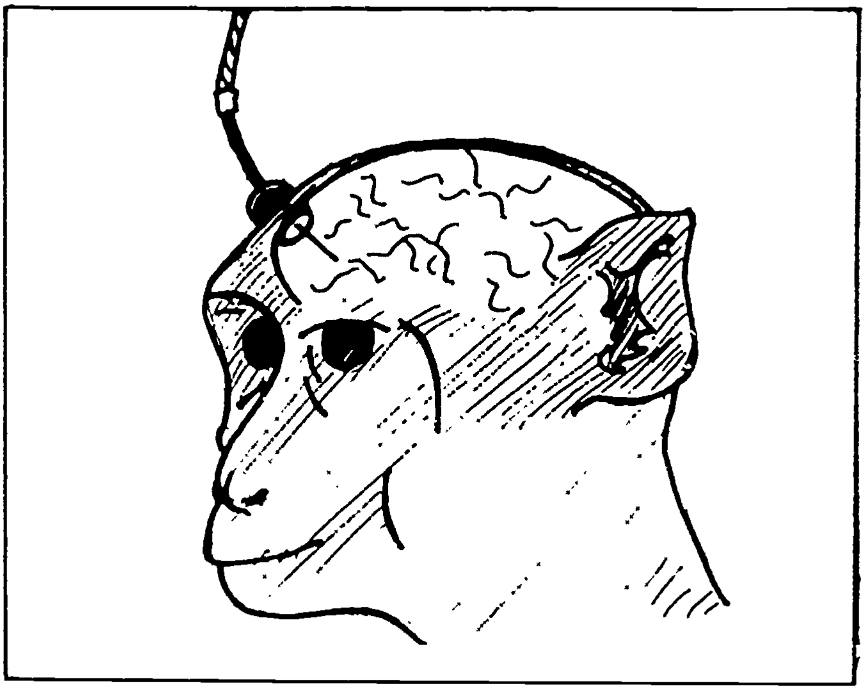
In summary, as animals evolved, both their bodies and their interactions with the world became more complex. Their brains thus became more important; so they grew in size, especially the cortex. Also, different animals adapted to their environment in different ways. How an animal adapted to the world gave more importance to some senses than to others, so animals also differ in brain specialization.

HOW THE BRAIN IS STUDIED

Scientists who study the brain are called neurobiologists (derived from the term 'neuron') and doctors who treat brain diseases are called neurologists. There are three general ways in which these specialists study the brain.

1. Surgery. Scientists can cut through certain connections in the brain of an animal, or even remove parts of the brain, and then examine how the animal functions. For instance, if the skull of a rat is opened up on the side and the area concerned with hearing removed, the rat will then be deaf even though nothing is wrong with its ears. Or else, if the connections between the two halves of the cortex (right and left hemisphere) are cut in a man's brain (this can be done to help certain severe diseases), some strange results may develop. In some cases, the patient will be able to recognize an object shown to him but not be able to name it. If you show him a flag of England for instance, he will recognize the country, but he won't be able to name it, even though he is very familiar with England. That is because names are remembered in the left hemisphere of our cortex and other information (non-verbal knowledge) is remembered in the right hemisphere. Once the connections between the two hemispheres are cut, the patient is said to have a split brain (it's like having two brains in one person).

2. Electrical stimulation and recording. Small wires called electrodes can be implanted (placed) in very precise locations in the brain (see Figure 15.6). These electrodes are then connected to an amplifier (an electronic machine) and will record the impulses travelling through the neurons in that area. They also permit the scientist to excite the neurons by sending a small electrical charge to the area. This may provoke a specific reaction on the part of the animal. For instance, if a specific group of neurons are stimulated by an electrode during surgery on a man's brain, the patient may suddenly remember a long forgotten childhood memory or suddenly remember the tune of an old song. Research with animals has even led to the discovery of an area which provokes extreme pleasure when stimulated in this way. This area has been called the 'pleasure center' of the brain (it is located in the middle of the brain, at the bottom of the cortex). It is research like this which has enabled scientists to identify the specific functions of different parts of the brain (see Figure 15.3 again).



15.6 Electrical stimulation through an electrode implanted in the brain. The animal feels no pain when this is done.

3. Behavioral research. Scientists conduct many experiments in which they present an animal (or human) with a stimulus (a situation) and then observe its responses (its reactions). For instance, various colors can be shown to people to see if they can distinguish between them. It is possible in this way to determine how many of us are color-blind. About 2% of men, but very few women, are color-blind. Technically, this means only that they cannot distinguish

between red and green; they do however perceive other colors. Such experiments have shown that many animals (including dogs and cats) are fully color blind: they see the world in black and white only, just as it is for us when we watch a black and white TV set.

BRAIN MALFUNCTIONS

As with any other body organ, something can go wrong in the brain. Some parts of the brain may not develop properly (which might lead for instance to blindness or deafness at birth). Or they may be injured, for instance by a gunshot. Or a chemical imbalance may occur, which could lead to a psychological disorder. All of these fortunately are very rare. Some of them will be presented briefly here.

1. Memory loss. Some people start losing their memory in old age. This is due to a breakdown in certain neurons as the brain ages. At times, a young person may lose his memory as well, perhaps due to a severe shock. This is called amnesia.

2. Epilepsy. Persons suffering from epilepsy completely lose control of their bodies for brief periods of time. An oversurge of electrical activity in their brain causes temporary loss of consciousness and uncontrolled muscular reactions. No permanent damage is done however.

15.7 Part of a painting by Edvard Munch: The Scream.

3. Paralysis. When certain specific locations of the brain are injured, loss of particular functions may result. If a person's body control area in the cortex is injured, a set of muscles (for example, the legs) may be paralyzed. Or, if the speech area is injured, the person may lose the ability to speak.

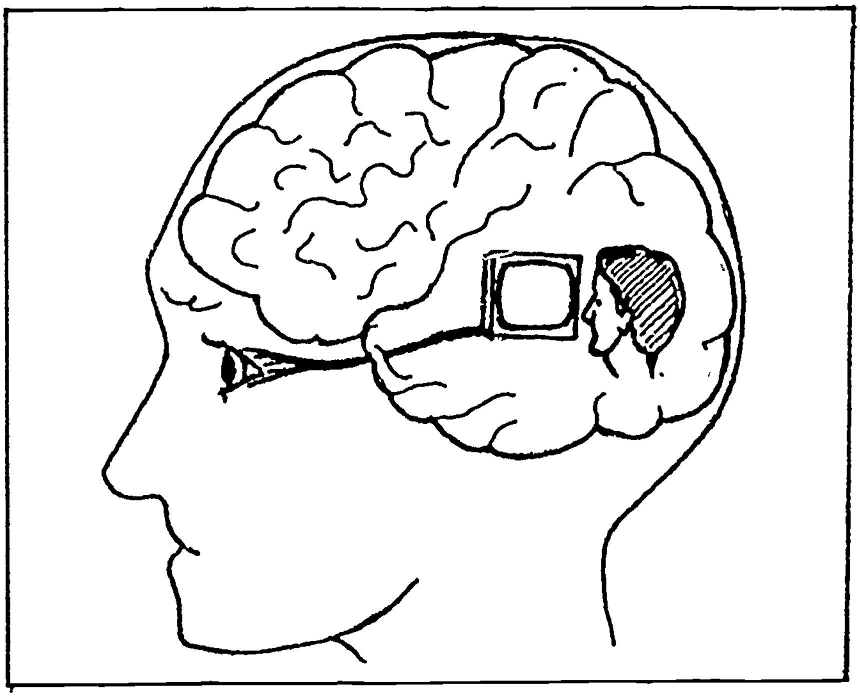
4. Psychological disorders. A variety of mental problems can result from either life experiences which are too difficult for the person to handle or from the brain's chemistry getting out of tune (see Figure 15.7). These problems are treated by specialists called clinical psychologists or psychiatrists. Methods of treatment include both chemo-therapy (through the use of drugs) and psycho-therapy (through psychological treatments).

Some brain malfunctions affect the control of our body (epilepsy and paralysis), other malfunctions affect our interaction with the world (memory loss and psychological disorders).

Brain impairments can result from many causes and show themselves in many ways and to various degrees. Much remains to be learned by science in this area, but fortunately severe impairments of the brain are rare.

The brain is a body organ that lets us interact with the world around us. Through our senses, it perceives the world, analyzes what is going on around us, stores information (that is what learning is) and allows us to reexperience past events (memory). Finally, it lets us manipulate and play around with all this information (intelligence and imagination) and lets us plan and coordinate how we will react to the world. It is a complex organ indeed!

One troubling question, though, is how we are aware of all this. When I look at a pencil that I am holding in my hand, the light reflecting off the pencil triggers various sensory neurons in my eyes. These in turn send impulses back to my cortex and I experience the sight of the pencil. But how does this occur? There is no little person inside my brain who watches the impulses being displayed on some kind of television screen (see Figure 15.8). In fact, the experience of seeing a pencil is simply a pattern of impulses going through my brain at that time. The pattern for a pencil is a little different from the pattern for a pen, very different from the pattern for a baseball bat and even more different from the pattern for a basketball. Still, all our perceptions and thoughts are only patterns of impulses in various parts of our brain.



15.8 An inaccurate view of the brain. If there were a little person in my brain, there would have to be a little person in his brain, and so on, and on, and on ...

If that is so, could we one day build an artificial brain, just as now we can build artificial limbs and artificial hearts? Some scientists think so, although it will be hard to match the great complexity of our own brains. In fact, computers are rudimentary brains of sort, because they do store and manipulate information and solve problems. But that is only part of what our own brains can do. And we even have to instruct computers on what to do, by programming them.

Our own brain manipulates information and it also decides what to do next. But who decides? Once again, there is no little person inside. Is it a pattern of impulses that decides, or is it something else? This question has led most people to believe that each person has a mind, something in our brain which is not made up of matter.

The mind is the collection of all our knowledge and of all our abilities, something which is related to the physical brain but which is not itself physical. Many of these questions about the brain have no definite answers. It is up to each of us to ponder them and come up with our own answers. Perplexing, isn't it? But also fascinating!

SUMMARY

The brain is the body organ which regulates our body functions and controls our interaction with the world around us. It interprets the messages coming from our senses, controls our muscular movements, and decides how to react to complex situations through the activity of thinking.

The brain is composed of neurons, which are special cells whose function is simply to transmit impulses. Our perceptions, our thinking, and our reactions are all patterns of impulses within the brain. How these patterns make us aware of our own thinking is not scientifically explained, which leads many people to explain it in terms of the concept of mind.

The brain is composed of different parts. The lower parts of the brain (midbrain and hindbrain) mainly control automatic functions. In higher animals, and especially in humans, the cortex is the most interesting part. Some areas of the cortex serve specialized functions (seeing, hearing, speaking . . .) but most of the cortex in man is not specialized and serves general thinking. In different species, brain functions and the size of different brain areas vary according to the evolutionary level of the species and its adaptation to the world.

The brain is studied through techniques such as surgery, electrical stimulation, and behavioral methods. Because of its complexity, the brain can malfunction in many ways although severe impairments are rare. Many disorders can be treated, either physically (through surgery or medication) or psychologically (through psychotherapy).

TECHNICAL TERMS

You should know the meaning of each of these terms.

- Cortex
- Neuron
- Impulse
- Hemispheres
- Localization of function
- Psychotherapy
- Neurologist
- Electrode
- Amnesia
- Epilepsy

REVIEW QUESTIONS

Your should now be able to answer all of these questions. Try answering each one for yourself (there is no need to write out the answers). If you are unsure about an answer, check the relevant section once again.

1. A. What is the main function of the brain? (p. 2)
   B. Give an example (p. 2)

2. A. List the 3 main parts of the brain. (p. 3)
   B. Explain the function of each part. (p. 3)

3. A. What does localization of function mean? (p. 4)
   B. Give an example. (p. 4)
   C. Where does thinking occur? (p. 5)

4. A. What are brain cells called? (p. 6)
   B. What do they look like? (p. 7)
   C. How do they work? (p. 6)
   D. What kind of process is involved? (p. 6)

5. Describe what happens in your brain when a car suddenly pulls out in front of you. (p. 5)

6. A. How does our brain compare to the brains of other animals? (p. 8)
   B. How are we different from monkeys? (p. 8)

7. Describe 3 ways how scientists study the brain. (p. 9)

8. Describe a few brain malfunctions and indicate what might have caused them. (p. 11)

9. What leads people to talk about the mind? (p. 12)

THOUGHT QUESTIONS

These are optional questions that you might like to think about. There are no direct answers in the chapter itself, but based on what you know, you might guess what proper answers are. Try answering each question for yourself (in your head). Then compare your answer with the one provided on the next page.

1. Why do you think the cortex is all wrinkled?
2. Why is our brain located in our head, instead of in the middle of our body like the heart?
3. If you get up on the tip of your toes and balance yourself there, what part of the brain regulates this action?
4. If a mosquito bites you on the left foot, where does this register in the brain?
5. When you choose between doing one thing or another, what part of the brain is involved?
6. How do drugs affect brain activity?
7. Remember the example in the chapter describing what happened when you were riding your bicycle and a car pulled out in front of you? Try to describe what happens when you come to an intersection and the traffic light suddenly turns from green to yellow.
8. Since a whale's brain is larger than our own brain, why aren't whales more intelligent than us?
9. What happens when a neurologist cuts the connections between the left and right hemisphere of a man's brain and the patient is then shown the word "Scotland?"
10. If a neurobiologist wanted to study how the brain regulates an animal's digestive system, in what part of the brain would he implant electrodes?
11. If a brain tumour develops in a person's brain at the back of his cortex, what might happen? A tumour is an unusual swelling of the cells in a specific region.
12. Robots in science fiction movies often have sophisticated brains. Do you think they also have a mind?

Chapter 15 - The Brain

1. As man evolved from animals, his cortex became more and more important and grew in size. The cortex, though, is rather thin (it is only about as thick as the sole of a shoe) and if it were spread out flat on a table, it would take up an area about as large as an open newspaper. The evolutionary problem was the skull: it is quite small and the brain had to fit into it. So, as the cortex grew, it simply kept folding over on itself, hence the wrinkles.

2. The brain processes information which comes in from our senses, and our main senses are our eyes and ears. So the brain is close to them. If vision, and hearing, and smell did not exist, then perhaps the brain might well have developed elsewhere in the body.

3. It is the area of the cortex which specializes in body control. This area is shown in Figure 15.3. If your senses tell your brain that you are starting to tip over, this area will send impulses down to your leg muscles and make them flex slightly, so that you will straighten up again. The hindbrain also helps by coordinating all these little muscle movements.

4. In the body control area once again, but only in the right hemisphere (since the sensation comes from the left foot). Remember that the left side of your body is controlled by your right hemisphere, and vice versa.

5. Your cortex, because thinking is involved. There is no specialized area in the cortex for thinking, so it could occur in many areas of the cortex (in any of the white areas in Figure 15.3).

6. They can do so in many ways. Some drugs slow down the brain processes, others speed them up. Many drugs have complex affects on the brain, which are not always well understood. We often think of the brain as a computer, but brain activity is both electrical and chemical. It is a living thing, unlike a computer.

7. Your eyes see the light change and they send impulses to your cortex (actually to the visual area in the back of your cortex - see Figure 15.3). Then your cortex evaluates the situation: "Do I have time to go through the intersection, or should I stop?" You make a decision, and your body control area sends impulses either to your legs to keep on pedalling or to your hands to put on the brakes. And as you know, all this happens very quickly.

8. Intelligence does not depend on the size of the brain, but on the size of the cortex and on specialization. The whale's cortex is not very large and most of it is specialized for body control. Man's body control area is quite small and most of his cortex is unspecialized (and hence available for thinking).

9. It is the left hemisphere which handles our knowledge of words, so "Scotland" will be recognized there. The patient will be able to respond "Scotland." But he would not be able to point to Scotland on a map, because non-verbal knowledge (spatial knowledge in this case) is in the right hemisphere. This is a case of the split-brain phenomenon.

10. Electrodes would be implanted in the midbrain. Remember that body functioning (heart rate, respiration, etc.) is regulated by the midbrain. The cortex, on the other hand, handles things which are not automatic and which might require some thinking.

11. His vision would be affected. The cells would press against one another and interfere with the person's ability to see. Nothing would be wrong with the eyes, but the impulses the eyes send to the brain would not be decoded into patterns which are recognized. The eyes only capture patterns of light, and it is the brain which makes sense out of these patterns.

12. It might be possible, although no one knows for sure. Robots might have all the parts needed for a brain, but would they just respond in an automatic way (as they were programmed), or would they actually know and feel things like we do? Is the mind more than just the ability to perceive the world and make decisions? There is no scientific answer to this question.

<u>COMMENTARY ON CASE 1: THE BRAIN</u>

Philippe Duchastel

The basic aim of any textbook chapter (and indeed more generally of any teacher) is to interest the student in the topic being taught. Another aim is to impart information, but that aim should be secondary to the basic aim of developing interest. This is the overall viewpoint which guided the development of my chapter on the brain, and which I shall elaborate upon here.

A textbook chapter is an organized presentation of information, a communication of facts and ideas. This has led many to the view that a textbook is primarily a condensed communication of information in a particular field. Some undoubtedly also see it all too simply as a straightforward source of information, a compendium of sorts, even if more accessible than a reference book. A text can play some of these roles for some people at some times, but its main purpose, which is to interest the student in the topic, must not be overshadowed by these other roles.

The challenge of authoring a text is a difficult one, for the author must satisfy a number of imperatives. Her task is to produce a product (a text) which has the following characteristics:

- it will interest the student;
- it will allow him to develop an appropriate model of the topic (and of the subtopics) being presented;
- it will do so in an impressive enough way that the knowledge developed will be remembered for some time.

These should be, in that order, the three guiding aims of any text development effort, and they shall serve later in this commentary as a framework for discussing my chapter on the brain.

It is necessary, however, to first consider a larger framework in order to examine the curricular and instructional context of any instructional text. For while the primary obligation of an author lies towards the student, other obligations also exist. An author which is developing an instructional text must also be oriented to the following concerns:

- oriented to learning objectives;
- oriented to learning processes;
- oriented to an instructional system.

One's orientation to learning objectives is focused on the "what" of teaching: what is it beneficial for students to know?; what is considered necessary knowledge?; in the end, what should the text (or chapter) in fact teach? These are crucial and difficult questions, and as we shall see later, they are concerns which interact with one's orientation to learning processes. On the one hand, the student should only be exposed to interesting and relevant material; on the other hand, the official curriculum may call for a certain degree of breadth and depth which goes beyond that level. These conflicting demands have to be worked out by the author in a satisfactory way.

One's orientation to learning processes is of course the crucial one, for the success of a text lies foremost in how well students learn from it and become interested in the topic. This is where text design comes in. How is the material structured? How difficult is the vocabulary? At what level is the text written? What design features facilitate learning? It is questions such as these which will be discussed in the section below on text design.

Finally, one's orientation to an instructional system must be considered. If the text is to be used primarily by students studying on their own, as in distance-teaching situations, then the text should be tutorial in nature. Many of the features of a tutorial text are discussed in Rowntree and Connors (1979), wh_ incidentally is an excellent source on text desig. more generally. If, on the other hand, the text is to be used in a traditional teaching situation (with a teacher in a classroom), fewer interactive elements such as self-assessment questions need be included in the text itself, although these must be provided in some form for the teacher. The teacher's manual, or the teacher's special edition of the text, usually includes these elements, as well as other elements such as elaborations of interesting points, laboratory activities, teaching tips, and so on.

The three orientations introduced above are the three global constraints which an author must keep in mind as she develops a text or text chapter. Decisions as to the resolution of potential conflicts between these constraints are an essential aspect of instructional text development. I shall indicate here how these constraints affected my own efforts.

In developing my chapter on the brain, I was little concerned with any official syllabus. My choice of content was essentially motivated by two considerations: one based on an informal needs assessment, the other based on a prime orientation to learning processes.

How one derives goals for an instructional text is a complex and imprecise question (some of the issues involved in goal formulation have been discussed in Duchastel and Steve, 1983). The question I started with in developing the brain chapter was the following one: What would it be desirable for an intelligent adult to know about the brain? Notice that an assumption is immediately made in formulating this question: that the text chapter I was writing would be the only formal educational exposure many of the students would ever have with this topic. In other words, I was not seeking to prepare students for further formal study in the field; rather, I was hoping to provide them with some understanding of the brain which they would carry with them later in life. My assumption was that most of the 10th-grade students who would study this chapter either would not go to college after High School, or if they did do so, would not take a further course in biology (or one in which the brain was much discussed). This was an important assumption in that it tied in closely with my prime orientation to learning processes. Had the chapter been part of a text used mainly to develop a basis for further study in the area, it would have been quite different, e.g. it would have taught to a much greater extent a technical vocabulary, and so on. My informal needs assessment led me instead to limiting the introduction of technical terms, to the inclusion of particular topics such as brain impairments and the relation between brain and mind, and to a strong emphasis on the role played by the brain in life.

As for my orientation to learning processes, it is derived from an eclectic view of learning which is discussed in the next section.

Finally, my orientation to an instructional system was rather straightforward: since I had chosen to develop a chapter for a biology text suitable for the High School level, I assumed it would be used in a classroom situation in which a teacher would provide guidance, activities and projects, and assessment. Direction in these matters for the teacher would be provided in an accompanying teacher manual.

TEXT DESIGN

Having set the context in which I developed the chapter, I shall now turn to the primary orientation which guided its development, my orientation to learning processes. There are many theories of learning which can be espoused in developing instructional materials (see for instance Entwistle and Hounsell, 1975, for a variety of theoretical bases, and Jonassen, 1982, for a collection of more applied ones). My own approach does not ally itself with any particular theory but seeks instead an eclectic solution geared to minimizing student learning difficulties and to using the full potential of text design features (many of which I have discussed in some detail elsewhere, Duchastel, 1982).

My approach is based on the three characteristics which I believe underlie a successful text: high interest, clear exposition, strong memorability. My belief in the importance of these three characteristics was developed in the context of considering the roles which illustrations can play in text (Duchastel, 1978; see also Sless, 1981). Their importance extends, however, to text design more generally and they will serve as a framework for my discussion of learning processes and text features. In essence any text chapter must have each of the following in order to be successful:

- attentional value: it must be interesting;
- explicative value: it must be clear;
- retentional value: it must be memorable.

I shall examine each of these three characteristics in turn.

Attention.

As indicated in the introduction to this commentary, I believe that a text's attentional value is its prime characteristic. If a text fails to grab the student's interest, it will not be read. Alternatively, if it is required reading (for instance, in expectation of a forthcoming test), it may well be read reluctantly, and then will only support many students' conviction that the subject is boring, and perhaps more generally, that school as a whole is boring.

Making a text interesting is mostly a matter of content selection. As indicated in the previous section, two tendencies often conflict in the process of selecting content: the author's desire to present material which is academically acceptable (in scope, comprehensiveness, detail, and accuracy); and her desire to interest the readers of the text.

At the extreme, there are two types of text: the academic text and the leisure text (my labels for these two types of text are purely arbitrary). The academic text is a condensation of a topic; it respects the integrity of the topic and is written for people who already have some background in the field. It provides an overview of the topic, but assumes that the reader already has enough intimacy with the field that he can handle the sometimes elaborate terminology, as well as being able to handle the often abstract and comprehensive structure of the topic without being overwhelmed.

The leisure text on the other hand is little concerned with academic rigor: details may not be absolutely accurate, and certain subtopics can be skipped altogether if they are felt to lack interest. As long as the text does not impart gross misrepresentations, it can be considered successful.

An instructional text intended for secondary school students must lie somewhere in between these extremes. A text which is more on the academic side of the dimension may be more accurate and comprehensive in reflecting the topic as experts see it, but it will obtain less of a positive emotional response from the student. Conversely, a text which leans to the leisure side of the dimension may appear to many as lacking proper school content.

My own inclination is to err on the side of interest if one must err (and indeed, it is not always easy to properly gauge what the proper level should be for a given audience). My chapter on the brain reflects this inclination. For instance, I have attempted to keep technical vocabulary to a minimum, to present important points with colloquial examples, and to include topics which might be particularly interesting to students (for instance, electrical stimulation of the brain and the size of man's brain compared to other animals).

Another means of enhancing the interest of a text is somewhat more superficial: using text design to make it attractive. Eyecatching and uncomplicated illustrations serve this purpose, as well as an open layout which appears uncluttered and straightforward. This is the book design aspect of text design.

In summary then, let me repeat what I consider to be an essential point: lack of interest will lead to lack of learning.

Explication.

Clear exposition is the most recognized characteristic of a good text. If the student cannot fully understand what is written, he will not develop a proper representation of the point being made. Additionally, lack of comprehension will lead to eventual lack of interest.

Kintsch and Vipond (1979; Vipond, 1980) have introduced a framework which greatly helps to understand comprehension processes in learning from text. These processes lie in two domains: microprocesses and macroprocesses.

Microprocesses relate to comprehension at the sentence or paragraph level. They concern such things as the readability of the text (mainly vocabulary usage and sentence structure and length), the use of examples, the completeness of explanation, etc. This is an area where deficiencies are often quite apparent to teachers and other text evaluators, although not always.

Macroprocesses, in turn, relate to comprehension at the topic level. They concern such things as how the text fits the readers' prior knowledge of the area and how the ideas within the topic fit together as a whole.

Comprehension is the process of making sense out of new information by using the information one already has. Where prior knowledge is inadequate to the task, the reader much fill in the holes with guesswork. This happens for instance when the meaning of an unfamiliar term is left undefined and must be inferred from the context within which it is introduced. Inferential processing though can only be successful to some extent. If the holes are too large (the explication being too minimal), the reader will lack closure of comprehension and will feel that the topic is not properly understood.

Comprehension problems are often difficult to predict since they stem so much from a mismatch between the information presented and prior knowledge. Furthermore, the author's cognitive structure (knowledge of the topic) is so much more elaborate than the eventual readers' cognitive structures. This is the principal reason why formative evaluation can be so important in instructional text development (an excellent source in this area is Nathenson and Henderson, 1980).

An area of particular concern with school-level students is their ability to apply abstract reasoning to novel topics. There is concern in particular among science educators that (1) most adolescents in America have not attained Piaget's stage of formal operations where abstract reasoning is possible; and (2) that a good part of the secondary school scientific curriculum calls for such reasoning (Chiappetta, 1976; Cantu and Herron, 1978; Renner, Grant, and Sutherland, 1978). The potential for comprehension problems is evident. Scientific writing for the High School must therefore be as concrete as possible, emphasize examples, and avoid abstract discussions.

There do exist a priori guidelines which can be employed in text design to enhance comprehension (see Jonassen, 1982, for a discussion of many of these). At the level of microprocesses of comprehension, readability is an important consideration, although its determination in expository texts (as opposed to narrative texts) is a controversial issue (see Redish, 1981). The use of explicative illustrations in text (Duchastel and Waller, 1979) is another means of enhancing comprehension, as is also typographical highlighting of technical terms (Duchastel, 1982).

These guidelines have generally seen expression in my chapter on the brain. For instance, a number of explicative illustrations were included in the chapter, technical terms were highlighted and presented in a "recap" section following the chapter summary. The writing was kept simple; readability indices, for what they are worth, indicated that the text was at the appropriate level. Examples were made an explicit part of the chapter, attempting generally to avoid abstract reasoning (this may have been only partly successful in some sections, such as the one on the mind). Finally, the text was tried out and evaluated in two 10th-grade classes to determine where there might be comprehension problems.

Many textual features have been proposed to assist comprehension at the macro-level. Among these are advance organizers, overviews and summaries, concept maps, marginal notes, headings and subheadings, and not least, the typographical layout of the text itself (many of these text features are discussed and illustrated in Jonassen, 1982). Two important roles are served by this type of text feature: (1) they provide the student with a global and structural perception of the topic as a whole, thus providing a structure within which individual ideas can be assimilated and interrelated; (2) they provide an access structure to the text elements (Waller, 1980) by which the student can study in a more flexible manner and thus depart from the often limiting serial reading strategy which is all too common.

My chapter on the brain has employed some of these text features to enhance macroprocessing. A chapter summary, for instance, was considered essential, but not sufficient to emphasize the main points. So many sections conclude with a short summary where this was felt to be needed. The main points throughout the chapter were also highlighted typographically to indicate their status and to facilitate review. Finally, the chapter topics are clearly deliminated spatially, make use of straightforward headings, and are initially introduced as a framework for study in the form of "questions to be studied in this chapter."

Retention.

It is a troubling fact of education that so much of what is learned in school is soon forgotten once the academic year is over. A large measure of this problem possibly lies with what is taught rather than with how it is taught. The pedagogic attitude that students should be exposed to given ideas even if they are unlikely to remember them is probably much more prevalent than it should be. This problem is one reason why a thoughtful needs analysis of what should be taught, no matter how informal it may be, is a prime consideration in developing an instructional text. It is also one reason why much of what is usually found in current biology textbooks (such as for instance, the technical terms associated with a good number of brain parts) was not included in my own chapter.

Beyond the problem of content selection, there are a number of text features which can, in principle at least, enhance retention. For a start, those which assist macroprocessing of the text (introduced in the last section) should also influence retention, on the grounds that a more firmly structured internal representation of the topic will be better remembered.

One theoretical perspective (Duchastel, 1978), which is based on Paivio's dual-coding theory (1975), also ascribes to illustrations a potential role in enhancing retention. The fact that illustrations are better remembered than verbal materials provides them with the capability of serving, later on while attempting to remember the details of a topic, as cues which can prompt the recall of the verbal materials themselves. This role of illustrations in text entered into my selection of the illustrations which appear in my chapter. One intent, not fully realized because of practical constraints, was to include in the chapter one illustration for each major topic.

Another very powerful means of increasing retention is through testing (Duchastel, 1979). Generally speaking, such testing is a feature not of the text itself, but of the larger instructional system within which the text is used. The teacher's manual which would accompany my brain chapter, for instance, would include a set of review questions for the teacher to use as a quiz at the end of her lesson on the brain. It should be noted that the role of the quiz as proposed here is not student assessment, but rather the enhancement of retention itself (see Duchastel, 1981, for an explicit expression of this rationale). The review questions placed at the end of my chapter serve that same purpose, as well as the more evident one of self-assessment.

The insertion of questions in the text itself is of course an important feature of self-instructional texts (Rowntree and Connors, 1979). In a more traditional instructional system, as the one I envisaged for my chapter on the brain, it would usually be for the teacher to present questions during the lesson, rather than for the text to take on that role.

The focusing (selective attention) effect engendered by inserted questions is of some importance in text learning. Given that a student's potential memory for the ideas presented will be limited, text features that can assist the student in prioritizing text elements (i.e., in attaching mental importance tags to them) are likely to enhance retention. Inserted questions are among these features, as are learning objectives and typographical highlighting (see Duchastel, 1982). The use of these features, however, must be coordinated in a text chapter in such a way as to be easy to use. I have opted for initial epistemic questions and typographical highlighting (rather than objectives or inserted questions) because of their directness and ease of use. Alternative options are of course always open to text designers.

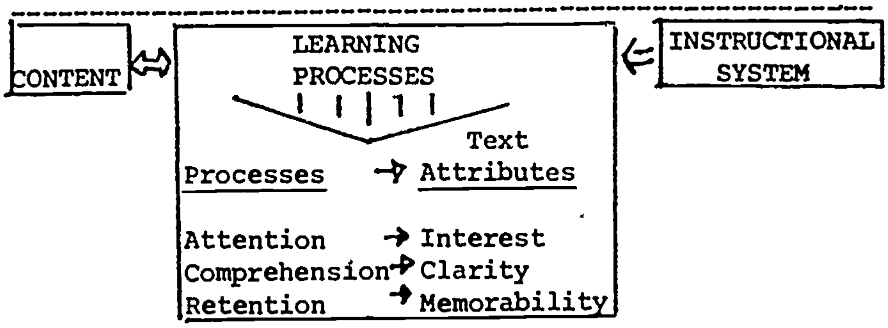
CONCLUSION

It is useful at this point to bring together some of the strands of thinking expressed in the previous sections in my attempt to explicate the motivations underlying the various design decisions I made as I prepared my chapter on the brain. I shall also list what I consider to be the design features of the chapter and indicate briefly the results of its formative evaluation.

While there exist explicit models of instructional design to guide educational development efforts (e.g., Briggs and Wager, 1981, or Melton, 1982, among others), the process of text design is rarely so formal as to constrain itself to these models. Perhaps this is so because the formal models can only provide very general guidance, or perhaps it is a question of conflict between the assumptions underlying the various approaches to design and learning theory. At any rate, the current state of the art of learning psychology encourages a wide and eclectic perspective when engaging in the design of textual materials dealing with complex topics for relatively immature students. This is the context within which I had chosen to operate in this text design project. I do feel, though, that the issues I encountered have a fair degree of generality beyond this particular context.

The framework within which my design efforts unfolded and which was later explicated in the present commentary is globally depicted in Figure 1. The first box concerns what is to be presented, while the second and third deal with factors of presentation, the third serving as the context within which the second is molded and to which it must conform. Learning processes are conceptually partitioned into three major functional areas (this being no more than a theoretical choice) to which are associated corresponding text attributes which guide design considerations.

Figure 1
TEXT DESIGN FRAMEWORK



The framework is not a design model (in which processes would have to be articulated) but rather a conceptual space within which such processes can take place. The most important aspect of the framework which was evident to me in designing my chapter on the brain was the interconnection of its elements, in particular the influence of learning processes on the selection of content. It is not the place here however to further explore and formalize this framework. It is merely presented as the informal context within which the chapter was developed and the conceptual one within which I have attempted to explain its design.

To further attempt to synthesize this commentary, Table 1 presents the design features which I view as characterizing the brain chapter. This is merely a convenient (and personal) list of such features.

Table 1
TEXT DESIGN FEATURES IN THE BRAIN CHAPTER

- Initial orienting questions (a questions approach to knowledge
- Topics of particular interest to students
- Direct writing style (e.g., "your brain")
- Appropriate readability
- Avoidance of technical terms
- Open layout and clearly distinguished topics
- Illustrations (many but selected and simple)
- Typographic highlighting (main points and technical terms
- Concrete examples
- Topical (in-text) summaries
- List of technical terms (checklist)
- Chapter summary
- Review questions with page references
- Thought questions with model answers

Finally, I want to briefly relate the reactions of the students who studied this chapter during its development. The value of developmental testing is generally highly accepted in instructional design. It can not only confirm an author's initial suspicions, but also point out unsuspected problems and decisions to be reconsidered.

The two groups of students who studied the chapter generally liked it (30 did so, versus 9 who disliked it, for various reasons). Thirty-one students felt the difficulty level was just right, five thought it was too simple, and three too difficult. The topics the students reported as most interesting were anatomy of the brain, how it is studied, and brain malfunctions. The topic reported as least interesting was neurons. Most students indicated that all topics were clearly presented, but five singled out neurons as still unclear (and two more the brain and mind topic). Given these reactions, the section on neurons was largely rewritten in order to make it more concrete and more interesting.

On the whole then, the chapter seems to have been well received. This does not certify it in any way as an ideal chapter (much more enters into such a judgement), but at least it indicates to me that my prime aim of interesting the student (most students) in the topic seems to have been successful.

This, I repeat, is what I consider to be the prime characteristic of an ideal text.

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