THE FUNCTION OF NON-VERBAL ELEMENTS IN SCIENTIFIC DISCOURSE

Silvia Gutiérrez
U.A.M.-Xochimilco

Cuando leemos un libro científico una de las características sobresalientes que uno nota es la gran cantidad de visuales que estos contienen. Estos visuales por lo general, toman la forma de gráficas, diagramas, mapas, dibujos, fotografías o mapas que complementan o ilustran el texto escrito. Dichos componentes visuales generalmente han sido considerados como meras ilustraciones que el autor utiliza para ejemplificar su mensaje. Sin embargo, la ilustración no es la única función que desempeñan.

El propósito de este artículo es mostrar que los elementos no verbales en el discurso científico no deben ser considerados simplemente como ilustraciones que "dan vida" a un texto, sino como componentes del discurso que desempeñan diferentes funciones comunicativas. Este artículo no reporta sobre los resultados sobre análisis de texto para determinar la frecuencia de aparición de características formales del lenguaje científico en el discurso escrito. Ofrece un reporte de los resultados de un análisis de discurso dirigido a revelar los actos comunicativos realizados por el escritor en el uso de elementos no verbales.

Inicialmente se discuten algunas consideraciones teóricas. Después se presenta una taxonomía tentativa de las diferentes combinaciones de los elementos verbales y no verbales a través de los cuales es escritor pue_ de organizar su mensaje. En la última sección se trata el uso retórico de las ilustraciones, y al final se sugieren y se apoyan otras funciones que pueden desempeñar estos elementos.

When reading a biology or chemistry textbook one of the salient characteristics one might notice, is the great amount of visuals contained in them. These visuals usually take the form of charts, diagrams, drawings, photographs, graphs or tables to complement or illustrate the written text, ouch visual components have generally been considered merely as "illustrations" which the writer uses in order to exemplify his message. However, illustration is not their only function.

It is the purpose of this paper to show that non-verbal elements in written scientific discourse should not be considered simply as iI lust rations that bring "life" to the text, but as components of discourse which fulfill different communicative functions. This paper does not report results of a *text analysis to do tannine the frequency of occurrence of certain formal features of the scientific language in written discourse. It reports the results of a discourse analysis aimed at revealing the communicative acts which are performed by the writer in the use of non-verbal elements.*

Initially, some theoretical considerations arc discussed. Then, a tentative taxonomy is presented of the different combinations of verbal and non-verbal elements through which the Writer can organize his message. The last section deals with the rhetorical use of illustrations; and, finally, other functions, which non-verbal elements can fulfill are suggested and supported.

I. Theoretical background.

If we are to view language as communication and reading as an interactive process in which the reader and writer interact with each other, then we recognize that the writer in the process of writing has communicative intentions, i.e. he wants to report certain events, develop an argument, describe certain states of affairs and so on. Although such communicative intentions are usually performed through the written mode, communication is not restricted to written textualization; there are several non-verbal elements which help the writer to communicate his intentions. That is why, as Widdowson (1978:155) has pointed out, "if one is really interested in the teaching of language as communication, then one cannot ignore that communication is not restricted to the verbal textualization. A good deal of written discourse makes use of non-verbal modes of communication and an understanding of how this function in association with the verbal text is often crucial for interpretation".

Analyses of the structure of lectures and practical demonstrations (see Murphy 1976 and Hutchinson 1977) have pointed towards the importance of the relationship between the non-verbal components in these media of instruction. For example, Murphy (1976:28) in his report on "Engineering Discourse and Listening Comprehension" suggests that "the visual elements in leo-

tures are closely integrated with the (spoken) text and play a crucial part in the development and explanation of the information exchange."

Non-verbal communication is a topic that has interested several linguists recently; amongst these are Poyatos and Riley. Poyatos has based his studies of non-verbal components prin cipally on face to face interaction, in which he has identified three major components:

> a) the verbal component, b) the paralinguistic component and c) the non-verbal component. (Poyatos 1985:6)

He considers that interaction is a system and that the verbal component is only one of the elements in the system. He feels that if we really want to understand the nature of communi cation, we must take into account all three components.

The verbal component he has defined as having features +verbal and +vocal. It includes the "audible non- autonomous vocal system formed by segmental lexical structures and their essential suprasegmental patterns of stress, pitch and juncture". The paralinguistic compo- nent has been defined as being +vocal and -verbal. This component contains the "audible non autonomous system whether respiratory or not, formed by extreme variations of the suprasegment al patterns of stress, pitch and jucture". The third component, the non-verbal one, has the feature of -verbal and -vocal and includes "other acoustic, visual, olfactory and tactile means of conveying information and eliciting interaction" (Poyatos 1975:4).

He has also worked on the study of the non-verbal elements in written discourse, most specifically in the novel, where he has found the equivalent of the three components present in face-to-face interaction.

López (1979) in his analysis of the func- tion of the non-verbal elements in technical writing, specifically in the instructional se- quence, has tried to relate Poyato's work on

the novel to that of the language of instructions. He considers that the non-verbal component in that area takes the form of: 1) printer's graphic devices (e.g. symbols and underlining). 2) illustrations (e.g. photographs, charts, diagrams) and 3) kinegraphs (e.g. non-verbal descriptions of kinesic behaviour).

Throughout this study. the concept of the non-verbal element will refer to any visual which is used by the writer, that is any diagram, line drawing, photograph, chart or graph. The emphasis will be on the function of all non-verbal elements which are found in written scientific discourse. Within the visuals* themselves there can be verbal elements in the form of titles, labels or legends, or anything that accompanies the visual and constitutes part of it. Legends are considered part of the visuals, since they are vital parts of the diagram, graph or chart which carry essential information for the understanding of the message.

Ways in which a Message can be Conveyed.

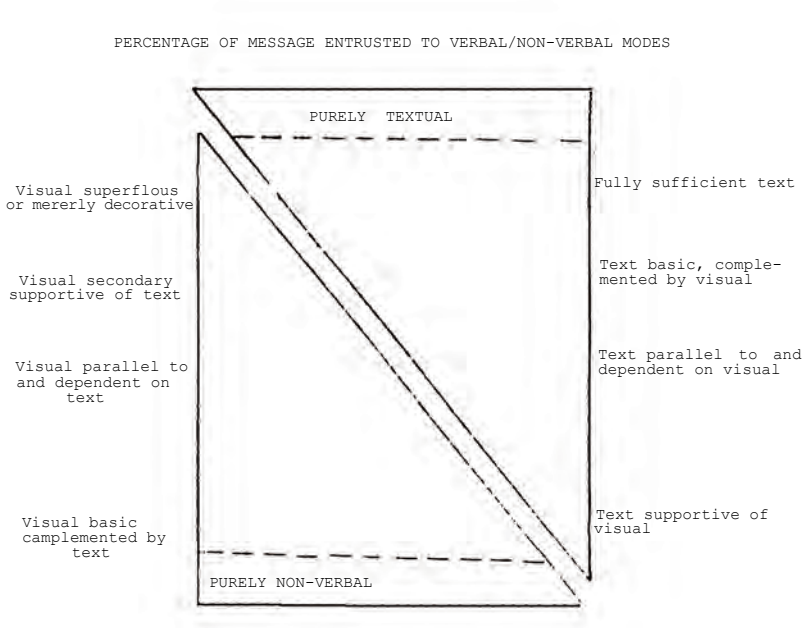
As pointed out the writer, in the process of writing, has communicative intentions, i.e. he wants to communicate a message to his reader. Since communication is not restricted to the verbal textualization only, he can also make use of non-verbal modes of communication. The range of possibilities for communicating his message is extensive, ranging from the use of purely verbal elements to purely non-verbal ones.

Although the different ways in which the writer can communicate his message represent the writer's view of optimal combination, there are certain principles to be observed, which might determine his choices. However, the

*The words "visuals" and "illustrations" will be used indistinctly to refer to the non-verbal elements.

options are there and it seems useful to identify them and try to explain the possible effects they might achieve.

The following diagram illustrates the dij[ferent ways in which the writer can communicate his message.



Varying combinations of verbal and non-verbal elements form a continuum which goes from the use of purely verbal to purely non-verbal elements. Since they form a continuum, it is not possible obviously to state exactly where one combination ends and another starts, although some characteristics of these possible combinations can be described.

In this study the entire range of possibilities through which the writer can organize

his message were not found. In written scientij: ic discourse* five combinations were identi- fied: 1) purely textual; 2) fully sufficient text/visual decorative or superfluous; 3) prima rily textual/complementarily non-verbal; 4) ver bal; 4) verbal/non-verbal equally important and 5) primarily non-verbal/complementarily textual.

Although I am aware that judgement of wheth er a visual is of itself self-explanatory or not depends greatly on the previous knowledge that the reader might have and the shared con- ventions about the nature of the subject, I think it is useful to identify the character- istics of the different combinations which are available to the writer and the reasons that might have led him to choose a certain combina- tion rather than another. This analysis there- fore, presupposes an ideal reader with basic knowledge of the subject.

2.1. Type 1: Purely Textual

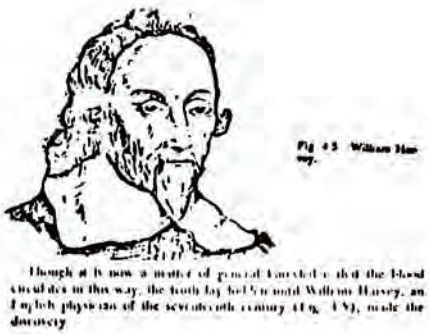
It is unnecessary to illustrate this pat- tern used by a writer for communicating a mes- sage; if clear and precise, he is unlikely to feel the need to use a visual in order to avoid ambiguity. I wish to point out here that the unit of analysis I have followed is that of a piece of information which has the purpose of communicating a message. I have not considered chapters or whole sections as my units of analy- sis. This clarification is important since one could argue that, in written scientific dis- course there are no textbooks which are written in the purely textual mode. However, this does not impxy that the writer does not use the pure ly textual component to convey his message.

* The scientific discourse analyzed in this study was that of the biological sciences.

2.2. Type 2: Visual Superfluous/Fully Sufficient Text.

The type of illustration that belongs to this combination is one which is used merely to bring "life" to the text, is part of the text, or at least was considered to be so by the writer, is referred to in the text, but could easily be left out and the text would still be clear and complete. In this case, the visual will simply be a decorative device used by the writer to break the monotony of the text.

An example of this type of visual would be:



(The Living Body p. 119)

In this sample, it is clear that the visual has been used by the writer simply to bring life to the text. It does not help the reader at all to have a visual idea of what Harvey looked like.

2.6. Type 3; Primarily textual/Complementarily Non Verbal

In this type of combination the text is basic and vital for the understanding of the message; it contains almost all the information necessary for the conveying of the message, but needs the visual to complement it. The visual thus complements the text by visualizing elements which might be difficult to convey by words alone. But the text does not depend on the visual to convey the message. The visual

facilitates the communication, but is not a vital component. The following text and diagram illustrate this type of combination.

The reticulo-endothelial cells of the general connective tissues are of exceptionally large size. They play a prominent role in the body's defense against invasion by microorganisms. These cells are actively motile and phagocytic, ingesting bacteria and any other foreign material which may be introduced into the tissues. For example, after the injection of India ink (which consists of a suspension of carbon grains) into an animal, these *macrophages.*" as they are called, gorge themselves with the foreign partic les. They are thus made conspicuous beneath the microscope (Fig. 3.23). In inflammatory conditions, they gather in large numbers around and within the inflamed part. In the lung, macrophages are active in the removal of foreign particles (e.g., dust, carbon particles) which have been carried into the alveoli by the inspired air.

Fig. 3.23 Macrophages containing phagocylosed carbon grains (left) and a red blood corpusele (*right*).

(The Living Body p.517

In this example the visual helps to visualize what macrophages look like when they are injected with foreign particles.

2.4. Type 4; Visual and Text Equally Important.

Probably the most commonly used type of illustration is that which is closely related

to the text and which requires the written text in order to be fully understood. The text itself also needs the visual since, although the message the writer wants to communicate might be clear and precise, there are elements which only the illustration can communicate. This is because certain elements are difficult to visualize and keep in mind unless illustrated in a diagram, photograph or chart.

Huggins, in his book Iotm'ixt Comnuri'Luation (1974), illustates the way in which the interaction between linguistics (represented in this case by the text) and iconic messages (the diagram or charts) takes place. He states that:

> A diagram of an electric circuit in an engineering text displays some meanings easily conveyed by the text, but also communicates other meanings that are expressed by language only with great difficulty. On reading that a circuit has five nodes, A through E, interconnected AB, AC, AE, CD, one has all the information to draw the circuit's configuration. Yet without the drawing, the information is hard to hold in mind and process. Strictly speaking, the drawing is a complete equivalent of the verbal description. The drawing adds no new semantic content to the message at its source, but does make it easier for most receivers to recover the message (1974:10).

If one looks carefully at the following diagram one cannot really follow the process that the diagram is illustrating.

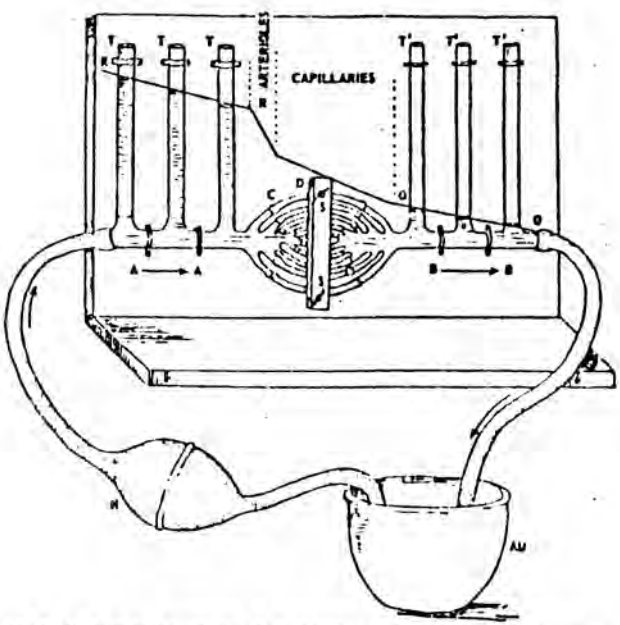


Fig. 4.12 Circulation scheme. A model composed of glass and rubber tubes, and a hand bulb, H, to illustrate certain facts in the circulation of the blood. (Description in text)

Nor would the text just by itself be self explanatory.

la Figure 4 12 is shown a piece of apparatus made to represent the systemic circulation and consisting of two horizontal glass tubes. AA and BB. from each of which a scries of vertical side lubes of smaller caliber, T. T. T. and T'. T'. T'. are given off. The two systems of tubes are connected by finer tubes of elastic rubber. The hand bulb. H. is so valved as to direct a flow of fluid as indicated by the arrows. It represents the left ventricle of the heart; the tube, AA, represents the aorta, and the vertical tubes. T, T. and T. represent some of its main branches. The system on the right corresponds to the venous system, in which DB are the larger veins (venae cavae) opening into the right auricle, Au. and the vertical lubes T'. T'. and T'. their larger tributaries. The smaller rubber tubes, C, connecting the two systems represent the minute vessels, arterioles, capillaries, and venules. When the bulb, H, is alternately compressed and released at a suitable rate, it acts as a pump and. drawing fluid from the part of the system representing the auricle, Au. and the large veins, BB,

forces it along AA. Tlie fluid rises in the vertical side tubes, T, and its height in any lube indicates the pressure in ceniimcleis of water at the point in lire horizontal lube where that tube is given oil. At every beat of the pump, the fluid in each side tube will be seen to fluctuate above, and then fall below, a certain mean level.' It will also be observed-that the pressure (height) of the fluid in the side tubes falls progressively from lube to tube, as indicated by the slanting lines, R-K and O O. This slope of pressure is due to the loss of energy caused by the frictional resistance offered to the flow of fluid along the horizontal lubes; for with a given amout of energy (transmitted to the fluid through the hand bulb), the greater the proportion of that energy which is expended in driving the fluid against resistance along the horizontal tubes, the smaller will be the proportion exhibited as pressure.

(The Living Body p.484)

2.b. Type 5: Visual Basic/Complemented by Text.

The type of visual belonging to this category are almost self-explanatory units which simply by having a title, a short legend or even isolated words (which in this study are considered part of the visual) can convey the writer's message. In other words, the visual carries almost all the information that needs to be communicated and the text merely complements this information. This is the counterpart of Type 2, where the roles of the visual and the textual components are exactly the opposite .

However, it must be pointed out that judge ment of whether visuals in this category can of themselves fully communicate the message or not is greatly dependant on the reader's previous knowledge.
The following example illustrates this type.

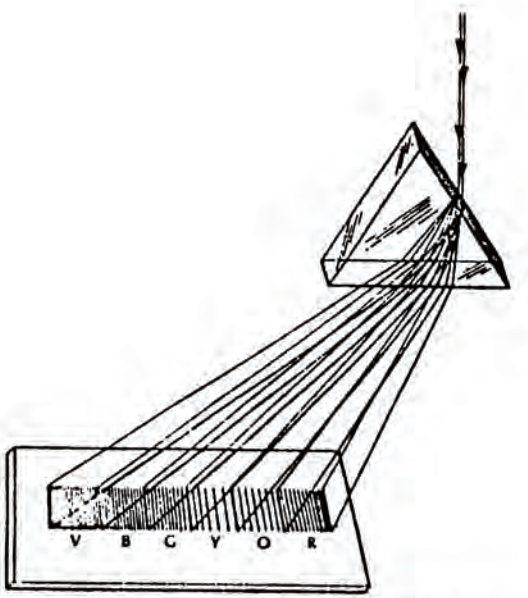


Figure 2-1 A three-dimensional view of the refraction of light by a glass prism. Note [illegible] bends the shorter wavelengths more than the longer wavelengths.

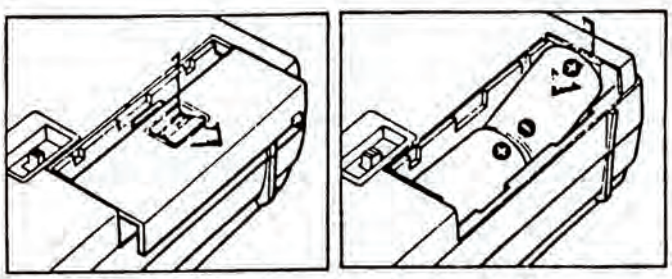
(Photosynthesis p.16)

Although the visual by itself is a clear representation of the refraction phenomenon, the purpose of the diagram is not obvious unless one reads the legend. The information contained in the legend is sufficient for understanding what the visual represents. However, if this information is not sufficient, it can be complemented by the information offered in the text.

2.6. The Non-Existence of a Purely Non-Verbal Component.

This analysis does not conform with the idea of having a purely non-verbal component in scientific discourse (or at least in the fields with which this study has been concerned). The concept of non-verbal components in this study has been used in a somewhat broader sense than that used by Poyatos or López. This makes it more difficult to accept the existence of purely non-verbal element in the area of English concerned. Since such a concept is used to refer to any visual in the form of a diagram, chart, photograph and so on which is always accompanied by a legend, labels, title, etc., it does not leave the acceptance of a purely non-verbal component open.

The case of technical manuals is somewhat different, since (in this area of English) there are non-verbal elements which can communi cate the writer's message. However, this is due to the fact that in these diagrams or charts there arc some kinesic and paralinguistic elements which fulfill the same function as that of labels, titles or legends in scientific discourse. In technical manuals, arrows, circles, symbols or graphic devices are used by the writer, to help him communicate what the visual really stands for and what the reader is expect; ed to do. Here is an example:



(Sony CF instructions manual)

The only area of communication I would consider as purely non-verbal is that of art(painting, sculpture, graphic arts, etc.). There one can argue that the visual image alone communicates the writer's message without the need of any written language, since the purpose of these branches of art is to communicate a message through an imago.

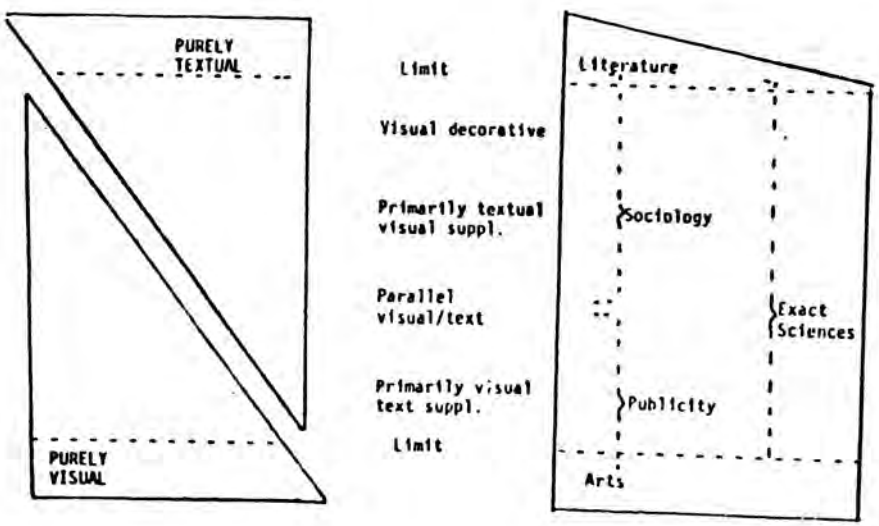
3. Variables which Affect the Use of Non-Verbal Elements

Having attempted to arrive at a taxonomy of the main combinations of verbal and non-verbal elements used by the writer to communicate a message, and having described these, I wish to make a few comments on the choice of certain combinations.

It has been pointed out that the assumed knowledge the reader might have of the subject sets certain constraints, since the writer must have an ideal reader in mind and, according to that notion, he organizes his message to try to suit his addressee. This is a very important factor which influences the way the writer decides to convey his message.

The area of discourse which the writer is dealing with is also very important, since the subject which he is concerned with might determine his choice of verbal and non-verbal components. Although it is not the aim of this study to make a contrastive analysis of the different areas of discourse, it seems useful to make some general comments on the influence that such areas might have.

The following diagram* takes into account the various areas of discourse and allows for a more accurate classification of the combination of verbal and non-verbal elements. Other fields have been used to contrast the relative frequency or importance which each area of dis course is likely to assign to t:hc role of visuals



* I wish to acknowledge F. Silva for his suggestions on how to plot a graph to show these relationships.

Along the continuum that goes from the merely textual mode to the purely visual, different combinations are most likely to be used, according to the field the writer is dealing with. The idea of having a limit in the purely textual and the purely visual is based on the fact that there are fields which can communicate messages in one extreme or the other. Literature could be said to use the purely textual mode, since in novels or plays no illustration is used. However, that area is also in a cline, since, as Poyatos has pointed out, there are some non-verbal elements in the novel, which are not graphically put into an image, but which are described in such a way that they create a visual image in the reader's mind.

In the previous section, I tried to arrive at a taxonomy of the different combinations of verbal/non-verbal elements through which the writer might organize his message. Taxonomies are useful devices for classifying information, but one needs to go beyond the information that a taxonomy offers. From the linguistic point of view, it would be like remaining at the syntatic and probably semantic levels without considering the pragmatic level. Since I am not interested merely in classifying the relationships between the verbal and non-verbal elements, I will try to go beyond this taxonomy and suggest other relationships, which exist in those combinations and which are not envisaged in the taxonomy.

Although I cannot generalize on the basis of an analysis of ten different textbooks, I can at least suggest that the fact that the writer explicitly refers to the illustration in the text marks the importance that the writer assigns to the visual. Generally, when the writer explicitly refers to the visual, this reference shows that the writer considers the illustration as a vital component in the organization of his message. If one of the purposes of illustrations is to avoid ambiguity and to

visualize elements which are difficult to encode, the fact that the writer explicitly refers to the illustration shows that he believes that his message could not be communicated without the help of a visual component.

In the following example, the writer explicitly refers to the illustration and uses it as the point of reference for his description.

Let us now examine briefly the successive stages, making use of the photomicrograph of the whitefish embryo (Figs. 19 and 20) and of the diagram (Fig. 21) in onler tu visualize the process.

1. The Inlterphase. This is the stage characteristic of cells in nongrowing tissue The terms resting stage is also applied to it since no visible nuclear changes arc taking plate, although, of course, the cell may be

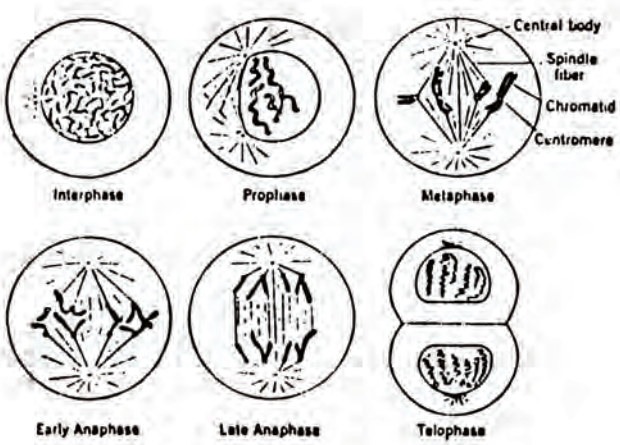


Figure 21. Diagram of the successive stages of mitosis in a species having two parts of chromosoines.

(Elements of Genetics
p.66)

There are other instances in which the reference to the illustration is implicit. That is to say, the writer will refer to the illustration in what could be called a parenthetic way (through the use of brackets). One could argue that this type of reference has the function of signaling an aside, i.e. information that the

writer provides which he considers not to be part of the main code of the message. In this case, the illustration would not be an essentia] component of the message. Here is an example:

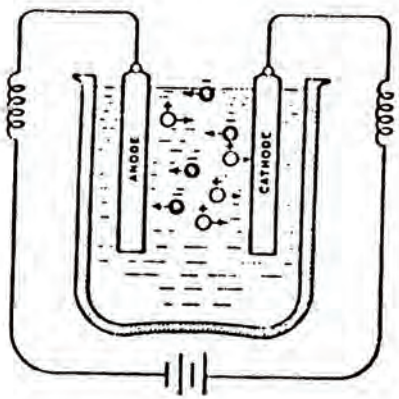


Fig 1.7 Illustrating electrolysis. When an electric current is passed through a solution of an elctrolyte (e.g., sodium chloride). the positively charged ions (cations) move to the cathode and the negatively charged ions (anions) to the anode.

Ionization or dissociation. Certain compounds, such as *hydrochloric acid* (HCI), *nitric acid* (HNO_3), *phosphoric acid* (H_3PO_4), *sulfuric acid* (H_2SO_4), *carbonic acid* (H_2CO_3) *sodium, potassium, calcium*, and *ammonium hydroxides (NaOH. KOH, CalOH), and NH,OH,* respectively), *sodium* and *pottasium chlorides* (N. C I and KC I), copper sulfate ($CuSO_4$), and a great number of others when in aqueous solution, separate into their constituent atoms or gronp of atoms. The separated atoms are elctrically changed and are called tons (GK) *ion*, going, traveling), because when an electric current is passed through an aqueous solution of one of these compounds they move at a ecrtain definite velocity toward one or other pole of the battery (Fig. 1.7). This properly of molecules to break up into electrically charged atoms is called *ionization or dissociation.*

(The Living Body p.66)

The fact that the writer refers to the visual, either in an implicit or explicit way, might indicate the type of function he assigns to the visual. If he refers explicitly to the visual, it is an essential component in the conveyance of the message. If he does it implicitly, then the visual might not be essential

4. The Different Rhetorical Functions that Non-Verbal Elements Fulfill.

In has been pointed out before that one of the aims of this study is to analyze the different functions that the non-verbal elements can fulfill in the area of written scientific discourse analyzed. Having described the different combinations which the writer can use to convey his message and the relationship that exists between them, I would like to suggest and support further functions, apart from that of illustration, which the non-verbal elements can fulfill.

In this study a "text pragmatics" approach was followed. This approach views the text as a type of conventionalized interaction between writer and reader and attempts to analyze it in terms of a string of "discourse functions" e.g. exemplification, justification, and so on. There is of course a danger that the application of functional labels, since there is no clear theoretical basis for establishing a hierarchy of functions, nor the limits between one and the other, might become a heedless scattering of labels. However, it might be useful to try to attempt to recognize some of the functions that illustrations might have.

For example he can use them to describe a process or apparatus, to support evidence of the plausibility of the hypotheses or conclusions, to demonstrate an experiment, to compare different states of affairs, different appara-

tuses or processes, he can also use them to suit marize an argument or a sequence of information or to conclude.

4.1 Describing.

One of the most common functions of illustrations is when they are used by the writer to describe a process or an apparatus. Illustrations are very often used as the point of reference for the descriptions. When the writer feels that his message will be difficult to com municate by words alone, he uses the illustration to help him convey his message.

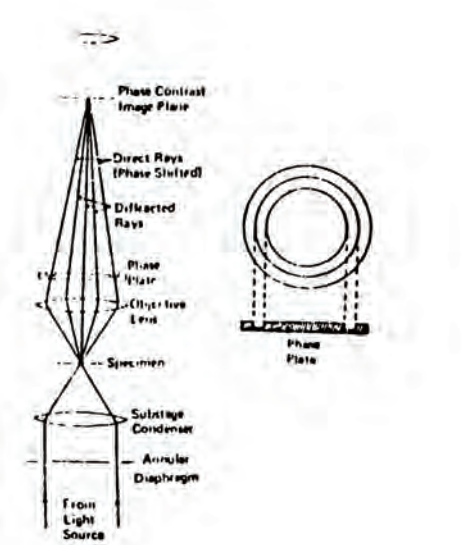


FIGURE 11-7. Schematic diagram of a phase endrasl microscope.

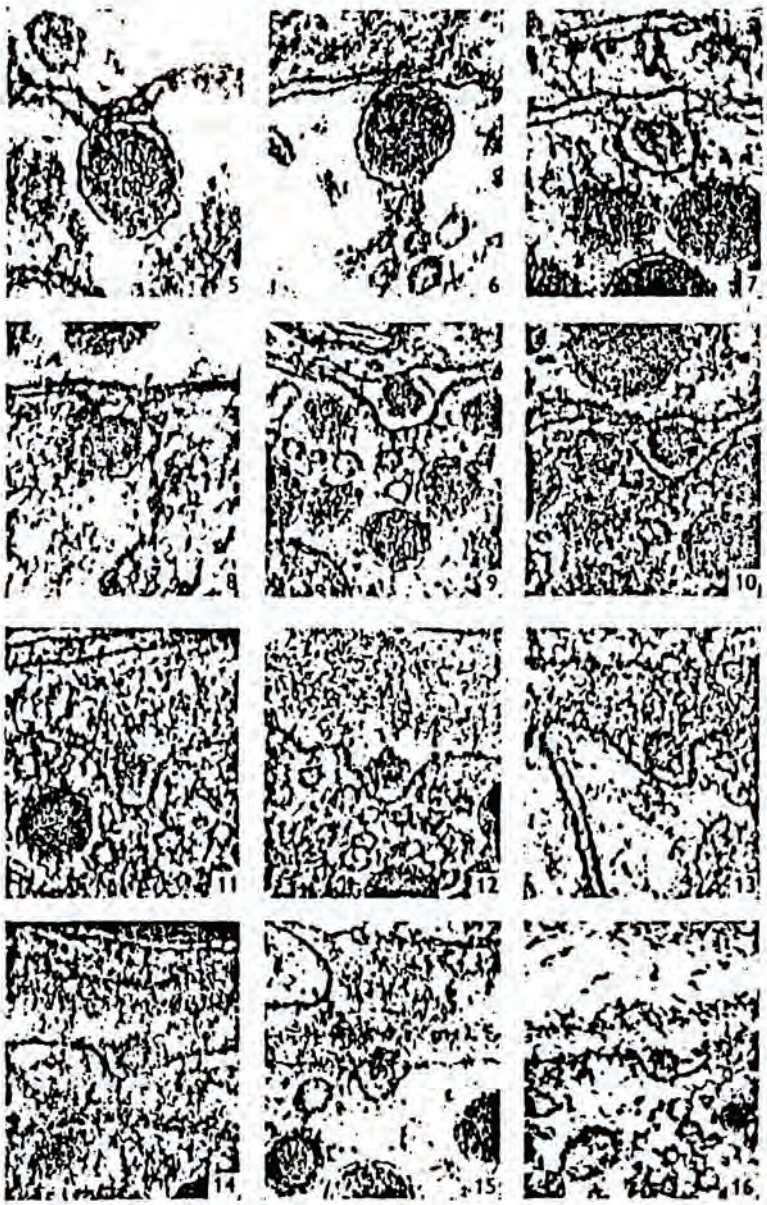
A sehematic phase contrast microscope is shown in Fig. 117. The phase variation process is begun by passing the direct light through an annular diaphragm below the sulestage condenser . This redriets the light illuminating the specimen to a hollow cone. After passing through the specimen, the light passes through the objetive and then through a *phase plate* place in the upper focal plane of the objective lens. The phase plate has a circular groove whose radians is deigned so that when it is in position, the groove coincides with the direct image of the annular condenser diaphragm. The groove of the phase plate has a depth and it that the path length lthrough the groove, is one quarter of a wavelength less than through the other regions of the plate. The undeviated beam passes through this groove and is advanced inphase by 90º (a quarter of a eyele) over those rays that are diffraeted or sea1 tered by the specimen and passes through the thicker portion of the phase plate. On arrival at the image pate of the objeetive lens, the phase shifted light interacts with the light difrated by the specimen to produce the phase contrasted image.

(Foundations of Biochemistry p.291)

4.2. Supporting Evidence.

One of the very interesting functions that illustrations can have in written scientific dis course is that where the writer uses the visual to prove or provide evidence of the plausibil- ity of his hyposetheses or conclusions. It seems to me that the utilization of the visual gives the writer the opportunity of proving graphically that his message is not a subjec- tive or far-fetched one, but that it is plausi- ble and can be proved to be so.

Plate 3



Figs 5-16. Images of exocytosis in neurosecretory terminals arrenged in a tentative sequential order (see text). Magnifications all x 80,000 except 5 and 7 (x 100,000) and 8 (x 60,000). All estimulatedsave 5 and 7 (60,000 ; 2.5 min and 1 min. (respectively) and 13 (electrical stind. go see). All hanster except 5, 6 and 15 (rat).

On further search of the material it provod possible to assemble a series of images yielding, when arranged in appioprinte order, a sequence corresponding to the classical descriptions of enocytosis. This has been done in PL. 3, figs. 5-16.ft. The series begins (figs. 5,6) with granules fused lo the plasma membrane and opening tu the extracellular enviroment by narrow channels. It continues with images of the familiar 'omega' shape where the opening is larger (figs. 7, 8), and concludes (figs. 9-16) with images characterized by progressive flattening of the exocytotie pit and loss of the extruded electron-dense contents of the grannles.

Although our original hope was that acute stimulation, with excess potassium or electrical shocks, would increase the probability of finding exocytotic images, it was difficult to decide whether stimulation by excess K ' or electrical shocks had any effect on the numbers of images captured in the electron micrographs. These were not so numerous as to allow any easy quantitation. Although our impression was that stimulation tended to increase the convoluted appearance of the neorosecretory terminals, which we interpret as a consequence of exocytoticactivity, it did not facilitate the demonstration of the earlier phases of the pioccss. Indeed these earlier stages seemed best visualized in regions a little distance removed from the parenchymal basement membrane where the nerve terminal abutted on other cells such as in PL. 2, fig. 4. A similar observation had been made in neurosecretory fibres of insects by Normann (1965). Pherhaps, as he suggests, the extruding neurosecretory material disperses less readily at such sites and is more easily visualized. This then is our evidence for secretion of posterior pituitary hormones by exocytosis.

(The Biological Basis of Medicine p.324)

4.3. Demonstrating.

This function is closely related to that of "providing evidence" since the ultimate goal of both functions is to prove something. However, what I see as the difference between the two is that demonstration is an alternative way of proving the information being discussed. The way and the means by which one demonstrates something are different from those used when providing evidence.

The purpose of demonstrating is to show

clearly by giving proof (s) or examples that something really happened, or that the thing being dicussed or described actually takes place. Probably the best way to show the difference between these two functions will be through an example.

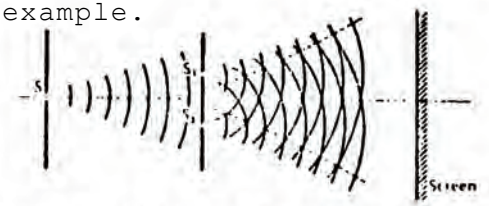


Figure 2-2 Thomas Young's experiment demonstrating that light can produce interference effects. See text for discussion.

In 1801 the English physicist

Thomas Young, succeeded in demostrating that light could produce interference effects that the corpuscular theory could not account for. Young, projected a narrow beams of light trhough tow closly spaced slits and on to a sc reen pla ced a short distance beta the slits spaced her of alternate light and dark bands were observed on the screen (Figure 2.2).

(Photosinthesis p.17)

4.4. Comparing.

Sometimes when there are things, which are difficult to compare just by purely verbal means, the writer makes use of the non-verbal component in order to give a clearer idea of the message he wants to convey. Processes, shapes, and sizes are difficult to compare by words alone. A visual image of the thing being contrasted always helps to give a better understanding of the information the writer wants to compare. Since one of the functions of illustrations is to avoid ambiguity or obscurity, the writer makes use of the non-verbal elements, in order to contrast characteristics or features, which are easier to encode/decode through the use of an illustration.

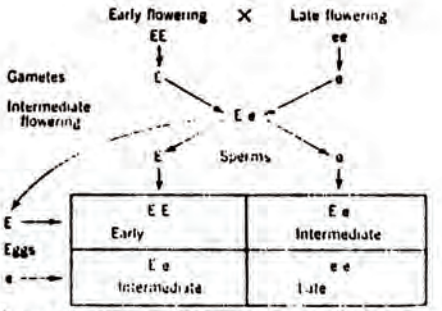


Figure 12. Diagram showing a 1:2:1 ratio among the offspring from hybrids in a case of lack of dominance (1 early: 2 intermediate: 1 late).

The diagram illustrating the distribution of the genes in the above case (Fig. 12) is obviously identical with the diagram for complete dominance (page 13). The difference in the two cases lies entirely in the expression of the contrasting characters of the hybrids. Here the hybrid is intermediate, and therefore distinguishable from both parents. The observable ratio among the offspring of the hybrids is therefore 1:2:1 instead of 3:1.

(Elements of Genetics p. 72)

4.5. Summarizing.

When the writer wants to summarize information which is either difficult to convey by purely textual means or which could be more easily shown through a visual, he uses the illustration to fulfill that function. The chart, graph, photograph or diagram usually recapitulates the information which the writer has communicated. In other words, the visual enables the writer to present his information in a way in which it is easy to understand and decode. I think this is one of the specific characteristics of scientific discourse, which we do not find in some other areas of discourse.

Here is an example to illustrate this function.

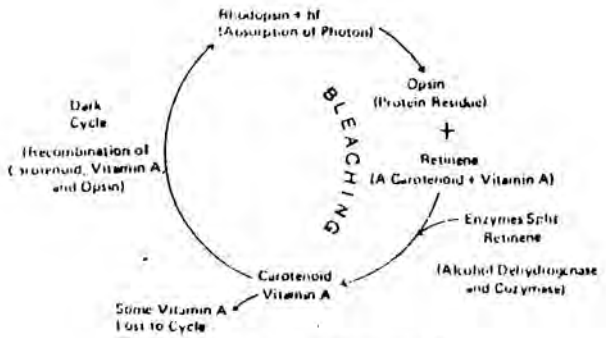


FIGURE 7-25 The rhodopsin cycle.

Upon exposure to light, rhodopsin begins u long eyele of chemical reactions that finally reconstitutes rhodopsin again. The more important steps in the rhodopsin cycle are summarized in Figure 7-25. Upon absorption of a photon, rhodopsin breaks apart into a purely protein residue called *opsin,* and a carotenoid (a chemical similar to carotene, the yellow pigment we see in many autumn leaves) called retinene. Chemically, retinene is an aldehyde of vitamin A, and the enzymes *alcohol dehydrogenase* and *cezymase* convert retinene to vitamin A. The process to this point is called the *bleaching* of thodopsin because the visual purple turns to a pale yellow during the process. It is during the bleaching, which is a very fast process, that the action potential is excited on the rod and is transmitted to the brain. The details of the excitation are not known at the present time.

(Biochemistry p,52)

4.6. Concluding.

Illustration can sometimes fulfill the function of providing data from which the writer can draw a conclusion. In other words, the writer presents the visual elements which contain the information he needs in order to be able to draw conclusions about the functioning or existence of the thing being discussed. The writer presents his information visually, usually in the form of a graph or a table, and then takes this information as the basis for his conclusion.

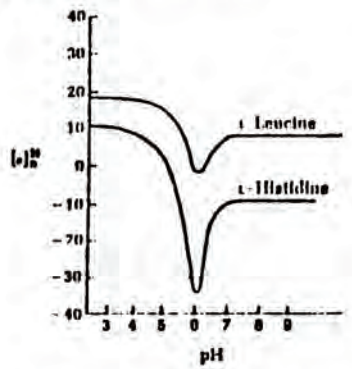


Table 4-3 Specific rotation of some amino acids isolated from proteins (L stereoisomers) in aqueous solution

Amino acid	Specific rotation [α]D
L-Alanine	+1.8
L-Arginine	+12.5
L-Leucine	+11.0
L-Isoleucine	+12.4
L-Phenylalanine	−34.5
L-Glutamic acid	+12.0
L-Histidine	−38.5
L-Aspartic acid	+5.0
L-Methionine	−10.0
L-Lysine	+13.5
L-Serine	−7.5
L-Proline	−86.2
L-Threonine	−28.5
L-Tryptophan	−33.7
L-Valine	+5.6

(-). Figure 4-11 shows that the specific rotation of an amino acid varies with the pH at which it is measured; in general, a monoamino monocarboxylic amino acid is at its most levorotatory when it is in its isoelectric form. From the data in Table 4-3, we can also conclude that the specific rotation of an amino acid depends on the nature of its R group.

(Biochemistry p.52)

The information included in table 4-3 provides the data the writer needs in order to con elude that the specific rotation of amino acids depends on the nature of its R group. Here the

writer, through the use of the table and the graph, is explicitly performing the function of concluding.

5. Some Pedagogical Implications

Following the view of reading as the under standing of discourse one needs to recognize that this understanding does not simply involve the recognition of what words and sentences mean when performing acts of communication but also the recognition of the value they take on in association with each other as elements of discourse. The same claim could be made if we agree that communication does not only take place through the written mode but that a lot of communication is also transmitted through the non-verbal mode. An understanding of how the verbal and non-verbal modes relate to each other is needed. Since the communicative abilities of language operate on everything that is communicated in the discourse as a whole, the non-verbal components, which also .form part of the discourse, need to be studied as well.

If we are really interested in teaching our students to understand the rhetorical functioning of language and in recognising the discoursal organization of the information communicated then we must make them aware that the writ ten mode is not the only medium through which the writer performs acts of communication. We have to point out to them that quite a lot of communication also takes place through the non-verbal mode. This mode which finds realization through charts, graphs, photographs, diagrams and tables constitutes a universal set of symbolic devices which convey the concepts ana procedures of some disciplines. In the disciplines chosen for this study it could be argued that the non-verbal component constitutes a fundamental part of the discourse. It has been suggested that in all the textbooks of Chemistry, Biology and Medicine, a lot of information is

transmitted through the non-verbal elements contained in them and that it would be difficult in fact to conceive a textbook of such disciplines which would contain no illustrations at all.

We should also make our students aware of the fact that the function of illustration is not the only one that the non-verbal component ful. fill. The different functions they also fulfill and which have been pointed out in this study, must also be shown to them. They have to become aware that the illustrations can sometimes fulfill the functions of describing, summarizing, comparing and so on. This aspect is particulary important if we follow an approach which concentrates on teaching the students to recognize the rhetorical functions of the language of science.

REFERENCES

Huggins, W.H. and D. Entwistle (1974) *Iconic Communication.* The John Hopkins University Press.

Hutchinson, T. (1977) *The practical demostrations.* University of Lancaster: M.A. Thesis (unpublished).

López, E. (1979) "Move it upwards and downwards as shown in figure 2: An analysis of the form and function of non-verbal elements in technical English with special reference to the language of instruction". University of Lancaster: Discourse Analysis proj ect.

Murphy, D. (1976) "Engineering discourse and listening comprehension". Research report for the King Abdul Aziz English for special purposes project,' under the supervision of Christopher Candlin, Univer sity of Lancaster.

Poyatos, F. (1975) "Verbal and non-verbal expressions in interaction". Paper presented at the IV International Congress of Applied Linguistics-Communication Theory. Stuttgart. August, pp. 1-31.

_____ (1977) "Verbal communication in the novel- a new perspective of the author-character - reader relationship". In *Lh-aniolica* 21:3/4.

Riley, P. (1976) "Discursive and communicative function of non-verbal communication" In *Mei anger. / 'citagogiques,* Volume 5. p. 2-18.

Widdowson, H.G. (197 3) *An Applied '¡.linguistics Approach to Discourse Analysis.* University of Edinburgh (Unpublished Ph.D. Thesis).

_____ (1978) *Teaching Language as Communication.* Oxford University Press.

EXAMPLES TAKEN FROM:

Best, C.H. and N.B. Taylor (1958) *The Living Body.* Chapman and Hall Ltd.

Bitter, E.E. and Bitter (1968) *The Biological Bar, in of Mi'die'inc.* Academic Press.

Colin, E.C. (1956) *Fle.ments if Monet ic:;.* McGraw Hill Book COmpany.

Bevlin, R.M. and Barker (1971) */ hotosynthesis.* Van Nostrand Reinhild Company.

Lehninger, E.L. (1975) *Biochemistry. The Molecular Basis of Cell Btructura and Fundi on.* Woth Publisher.

Stanford, A.ju. (1975) *Foundations of Biophysics.* Academic Press.