Constructive Theory, Perceptual Systems, and Tacit Knowledge

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In preparing my comments on Mace's paper I found myself in the pleasant position of having nothing to criticize. I am sympathetic to Gibson's (1966) theory of perception and it seems to me that Mace's comments on Gibson and the constructivist alternative are both justified and well put. I will therefore use this opportunity to touch upon three topics which are related, if only tangentially, to the issues discussed by Mace. First, I will make some additional comments on constructive theory with special reference to the domain of such a theory; second, I will address myself to the idea that "perceptual systems" as defined by Gibson can play several different roles in the perceptual process; and third, I will comment on analysis-by-synthesis for the purpose of drawing a distinction between tacit and explicit identification along the lines suggested by Michael Polanyi (1964, 1966).

Constructive Theory and Linguistic Perception

Constructive theory assumes that perceptual experience is not a direct response to stimulation. Rather, the perceptual experience is constructed or created out of a number of ingredients, only some of which are provided by the sensory stimulation. Other ingredients in a perception recipe are provided by our expectations, our biases, and our knowledge of the world in general.

In view of most students of the constructivist leaning all perceptual experiences are constructed...from fleeting fragmentary scraps of data signalled by the senses and drawn from the brain's memory banks—themselves constructions from snippets of the past" (Gregory, 1972). The extreme constructivist position expressed in this quote (and criticized by Mace) is conveniently satirized in an analogy drawn by Gilbert Ryle (1949). A prisoner has been held in solitary confinement since birth. His cell has no windows but there are some cracks in the walls through which occasional flickers of light may be seen, and

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through the stones occasional tappings and scratchings may be heard. On the basis of these snippets of light and sound our prisoner-hero becomes apprised of unobserved happenings outside his cell such as football games, beauty pageants, and the layout of edges and surfaces. In order for our prisoner to perceive these things he must, of course, know something about them in advance. But we should ask how he could ever come to know anything about, say, football games except by having perceived one in the first place?

Ryle's analogy underscores the fact that constructivism in its extreme form takes as its departure point traditional image optics rather than Gibson's (1966) ecological optics; it denies the richness and variety of stimulation at the receptors and consequently denies the elaborateness of the perceptual apparatus. But if we accept Gibson's arguments for information in stimulation and for perceptual machinery capable of detecting that information then the extreme constructivist view is unnecessary. Thus, for example, given Mace's arguments and demonstrations we do not have to interpret Wallach and O'Connell's (1953) kinetic depth effect as a perception synthesized out of information collected over a period of time (cf. Neisser, 1968, 1970). That is to say we do not have to interpret the perceptual experience of a rigid, three-dimensional rotating object as being the result of combining successive retinal snapshots of a two-dimensional form. The constructivist interpretation of the kinetic depth effect arises, in part, from the failure to appreciate that transformations of patterns are probably more stimulating and informative than the static patterns themselves.

The main thrust of Gibson's theory, vis-a-vis constructivism, is that there are complex variables of stimulation which specify directly the properties of the world. Perception of the environment corresponds simply and solely to the detection of these variables of stimulation and there are no intermediary intellectual steps needed to construct perception out of what is detected. Gibson, of course, does not argue that all perception is of this kind; that is, he does not argue that all experiences called perceptual are a direct function of stimulation. Indeed, he admits that some of the experiences called perceptual are not a function of stimulation at all (Gibson, 1959:466). However, he does believe that perception is exclusively a function of stimulation where conditions of stimulation permit.

One apparent exception to Gibson's principle of direct perception is the perception of either the spoken or the written language. Given what we know about speech perception in particular, (Liberman, Cooper, Shankweiler, and Studdert-Kennedy, 1967) and language perception in general, we can state in a paraphrase of Gibson that the conditions of linguistic stimulation do not permit direct perception. It is quite evident that the comprehension of linguistic items received by ear and by eye relies heavily on the context in which the items are occurring. The perception of both spoken and written language proceeds faster than it should and it is remarkably unaffected by a variety of omissions and errors. Thus, our interpretation of a verbal item in normal spoken or written discourse is in some part dependent on our prediction of what the event might be and is not simply dependent on the stimulation provided by the item itself. Our predictions of—or expectations about—a linguistic event derive from three major sources: our knowledge of what has just been perceived; our internal model of the language, i.e., our knowledge of the various linguistic rules; and our knowledge of the world.
Of course, what I have just described characterizes the approach to perception known as analysis-by-synthesis, an approach which has assumed a central role in modern constructivist theory (see Neisser, 1967). Yet while analysis-by-synthesis and constructive theory may prove to be useful to our understanding of the perception of linguistic information by ear and by eye (although it goes without saying that not everybody necessarily agrees; see Corcoran, 1971) they may not prove particularly useful, or even relevant, to other kinds of perception. There are many good reasons for believing that speech perception and reading are rather special perceptual activities and that they may not be representative of how perception occurs in general. To begin with, speech perception appears to involve an articulatory model--i.e., a production model (see Liberman et al., 1967). Both experiment (e.g., Corcoran, 1966; Klapp, 1971) and clinical observation (e.g., Geschwind, 1970) suggest that reading is at least in part parasitic upon the mechanisms of speech. There is no compelling evidence to suggest that other forms of perception proceed by reference to a production model. The special character of linguistic perception is further supported by Mattingly's (1972) argument that grammar emerged as an interface between two mismatched nonlinguistic systems which had evolved separately. On the one hand we have the mechanisms concerned with transmission--the ear and the vocal apparatus--and on the other we have an intellect which represents, rather amorphously I suspect, the world of experience (i.e., the mechanism of long-term memory). Grammatical codes, therefore, convert representations of experience into a form suitable for efficient acoustical transmission, or they convert phonetic events into a form suitable for long-term storage (Liberman, Mattingly, and Turvey, 1972). [And surely this kind of radical conversion is at the heart of constructivist theory; both linguistic perception and linguistic memory are restructurings of stimulation. But we should ask, as Liberman (1972) has, whether such radical conversions occur in other perceptual situations.]

It is perhaps instructive to note that hemispheric damage which results in the reading impairment generally referred to as word-blindness or alexia, may leave unimpaired the ability to name objects (Howes, 1962). But more important to our present concerns is the observation that alexic patients generally have no difficulty perceiving the spatial aspects of things such as distance, shape, size, and movement, that is, the properties of stimulation Gibson is primarily concerned with. We should also note a rather perplexing observation reported by Kohler (1951) concerning the Innsbruck investigations on the reversal of the visual world by means of prisms. After several weeks or months of wearing prisms which reverse the visual world, the visual world may quite suddenly return to normal. But when this reversal of the visual world to normal occurs writing may remain reversed; the perception of written language apparently involves at some level a special visual process. The point is that answers to the question: "how do we perceive linguistically?" should not be viewed as answers to the question: "how do we perceive?"

Perceptual Systems Do More Than Register Invariances

Traditionally the senses have been conceptualized as passive conduits which transmit imperfect images from the retina to the brain where they are represented as collections of raw sensations and out of which perception is eventually fashioned. For each kind of sensory experience there is, reputedly, a special sense; thus, the special sense of vision is the source of visual sensation, the special sense of proprioception is the source of the sensations
of one's own movements, and so on. The convention, of course, has been to classify the senses by modes of conscious quality.

By contrast Gibson proposes that the senses are active systems which register the invariant structures of available stimulation furnished at the receptors and which afford to the observer direct knowledge of his environment. In this view, the "senses"—which Gibson prefers to call perceptual systems—detect information rather than yield sensations and are classified by modes of activity rather than by modes of consciousness. Thus looking and listening replace, respectively, the having of visual and auditory sensations. Of further importance is the idea that a particular kind of information is not necessarily the special domain of a particular perceptual system, but rather that different systems can detect the same information either singly or in combination.

Gibson's substitution of the concept of perceptual systems for that of the senses is a commendable one, and its far-reaching implications for a general theory of perception have been spelled out in the papers by Mace and Shaw² in this conference. What I wish to touch upon in the present discussion is the idea that perceptual systems are flexible machineries which can be put to uses other than that of discovering invariants in changing stimulation, although that is their primary function. Thus, in addition to detecting invariances perceptual systems can be generative devices which construct perceptual experiences of certain kinds. But we should guard against concluding that just because perceptual systems can construct, then the everyday perception of the everyday world is constructed. As I view it, relatively few perceptual experiences are constructed. While there is certainly an intimate and theoretically provocative relation between the workings of a perceptual system as a detector of invariances and the workings of a perceptual system as a generative device, I do not think that the relation is one of identity.

There is certainly nothing novel in the idea that a perceptual system can be generative. Indeed, B. F. Skinner (1963) has elegantly expressed this notion in his choice phrase describing the behaviorist position on conscious experience: "seeing does not imply something seen." If I understand Skinner correctly he is saying that seeing is (can be?) a behavior and therefore seeing a Rolls-Royce, for example, is an activity which can be evoked (given the right contingencies) even though no Rolls-Royce is present to be seen. It is instructive to note that the statement which Skinner finds so admirably descriptive of the behaviorist viewpoint is the very kind of statement which expresses the position advanced by constructivists (Gregory, 1972; Kolers, 1968; Neisser, 1967), although I suspect that Skinner and the constructivists find this statement appropriate for different reasons. In any event, the idea that a perceptual system may yield an experience in the absence of stimulation has been well recognized. Thus, dreaming, hallucinating, illusioning, and imaging may all be considered as examples of this characteristic of perceptual systems. But while it is reasonable to propose that a person who is seeing or hearing or smelling things that are not present must be generating them for himself, we need not be convinced by this that the generative mechanisms he uses overlap with the normal mechanisms of seeing, hearing, and smelling. Fortunately there are more solid grounds for inferring the overlap.

²Shaw, R. Algoristic foundations of cognitive psychology.
In a signal detection experiment a subject is asked to image something and to indicate when he has a good image. At that point a signal is either presented or not and the subject is required to report whether the signal did or did not occur. If the subject was entertaining an auditory image and the signal was auditory then sensitivity (measured as d') is poorer than if a visual image had been entertained. Similarly, the detection of a visual signal is impaired more significantly by concurrent visual imagery than by concurrent auditory imagery (Segal and Fusella, 1970, 1971). The interpretation given to this outcome is that detecting, say, a visual signal and generating a visual image require the services of a common mechanism.

A similar conclusion can be drawn from the work of Brooks (1968). A subject is required to recall (image) a block F that he has recently studied. With the block F in mind he must signal its corners, signaling those at the bottom and top by "yes" those in between by "no" and starting, say, at the bottom right hand corner. The task is far more difficult if he must signal the sequence of yeses and nos by pointing at an array of yeses and nos than if he signals the sequence verbally. The inference is that imaging the block F and pointing at the visually displayed words both depend on the system for seeing. By way of contrast we can ask the subject to learn a short sentence ("A bird in the hand is not in the bush," ) and then to go through the sentence mentally indicating each noun by "yes" and every word that is not a noun by "no." In this case, signaling the yeses and nos by pointing is superior to saying the yeses and nos aloud, presumably because the speech imagery required to maintain the sentence and to go through the sentence conflicts with speaking the yeses and nos.

In a similarly motivated experiment (Brooks, 1967) the subject is instructed about the arrangement of digits in a matrix. The subject is told to image the matrix and then to allocate the digits in the matrix according to the instructions which are presented to him either in a written form or aurally. His subsequent recall of the location of the digits in the matrix is poorer in the reading condition than in the listening condition. The inference in this case is that reading a message is antagonistic to the simultaneous representation of spatial relations, whereas listening to a message is not.

Other experiments have pointed to this dependence of memory on the perceptual apparatus relevant to the to-be-remembered material. Thus Atwood (1971) showed that an irrelevant visual perception interfered more with verbal learning by means of imagery than did an irrelevant auditory task. Den Heyer and Barret (1971) showed that the short-term retention of the digits in a matrix was interfered with more by a verbal interpolated task than by a visual interpolated task, while the reverse was true for the retention of the spatial location of the digits.

On this evidence we may conclude that perceiving and imaging engage the same neural apparatus, at least at some level, and that memory sustaining operations (such as rehearsal) and acts of remembering (such as imaging) are carried out within the perceptual system most related to the memory material. In other words, there is support for the argument that a perceptual system is also a generative system.
It is commonplace to regard imagery and hallucinating experiences and the like as the arousal of stored representations. The use of nouns such as "image, hallucination, dream," etc., commits us to the idea of something—an object or a scene—which is recalled or rearoused or constructed and which then—like a real object or scene—is viewed or experienced by an observer. Alternatively we could argue that it is the act of imaging or dreaming or hallucinating that is experienced, and that (following Skinner, 1963) imaging, dreaming, and hallucinating do not imply things imaged, dreamt, or hallucinated. On this argument, which I happen to prefer, it is true to say that I am imaging my grandmother, but it is not true to say that I have an image of my grandmother in my head.

Related to the generative capability of perceptual systems is a rather important use for at least one perceptual system, the visual perceptual system: to model or imitate external events. In a sense, all acts of construction carried out by a perceptual system are imitative acts, but what I have in mind here is the idea of the visual perceptual system functioning as an analog spatial model in which orderly, physical operations can be conducted vicariously (cf. Attneave, 1972). This characterization of the visual system is similar to Craik's (1943) thesis that the brain is essentially a complex machine which can parallel or model physical processes, a capability of neural machinery which Craik views as the fundamental feature of thought and explanation.

Evidence that the visual perceptual system can model physical space, i.e., that it can exhibit processes which have a similar relation structure to physical space (cf. Craik, 1943) is to be found in experiments conducted by Shepard and his colleagues. In one experiment (Shepard and Metzler, 1971) subjects were shown a pair of two-dimensional portrayals of three-dimensional objects and were asked to decide as quickly as possible whether one of the objects could be rotated into the other. The decision latency was shown to be an increasing linear function of the angular difference in the portrayed orientation of the two objects. At 0° difference the latency was 1 sec while at 180° difference the latency was 4 or 5 sec. Each additional degree of rotation added approximately 16 msec to the latency of recognition and this was essentially so whether the rotation was in the plane of the picture or in depth. In a further experiment (Shepard and Feng, 1972) subjects were given a picture of one of the patterns of six connected squares which is produced when the faces of a cube are unfolded and laid out flat. Their task was to decide with minimal delay whether two marked edges of two different squares would meet if the square was folded back into the cube. The time to reach a decision increased linearly with the sum of the number of squares that would have been involved if the folding up operation were actually performed.

In these experiments of Shepard's the subject is apparently imitating covertly those operations which he would perform if he were actually to rotate a physical object or actually to fold up a physical pattern of squares into a cube. Moreover, these covert motor activities parallel actual motor activities in that they are performed in a continuous space and in real time. On the evidence we should argue that the neural spatial representation which is afforded by the visual perceptual system and in which these covert performances occur is a model of, or an analogue of, physical space.
From other experiments we can infer an interesting complicity between other perceptual systems and the visual one where spatial properties are involved. Auditory localization (Warren, 1970) has been shown to be better with the eyes open than with the eyes closed; learning responses to tactile stimuli delivered in fixed locations is better with unrestricted than with restricted vision (Atteave and Benson, 1969); and the short-term retention of a spatial arrangement of tactile stimulation is impaired significantly more by an irrelevant arithmetic task presented visually than by that same task presented auditorily (Sullivan, in preparation). What these experiments imply is that information about location is mapped into the spatial analogue system provided by vision even when the location information is received or detected by other perceptual systems.

Knowing About Things You Do Not Know You Know About

As I have commented above, analysis-by-synthesis and constructive theory have much in common. The idea of synthesis is a slippery one but we can come to terms with it if we consider the way in which a blindfolded man might attempt to recognize a solid triangular figure by moving his finger around the outline. (The example is taken from an early discussion of synthesis by Mackay, 1963.) To our blindfolded man the concept of triangularity is defined by and symmetrical with the sequence of elementary responses necessary in the act of replicating the outline of a triangle. Now we may presume that the recognition of any sensory event is in some sense an act of replication of the stimuli received. In other words, replicas of the input are generated until there is a significant degree of resemblance between a synthetic replica and the input. Of course the input which the replicating or synthesizing mechanism is dealing with is in quite a different physical form from the original input to the sensory receptors. It is probably in the form of neuroelectrical activity of some spatial-temporal specificity. In any event, to identify a triangle I do not have to synthesize triangles; to identify a smell I do not have to synthesize odors.

Generally speaking, analysis-by-synthesis models propose that identification lies in the act of achieving a reasonable facsimile of the input. But the constructivist view of perception, at least on my understanding of it, may wish to ascribe something more than "identification" to the replicative act. The stronger and preferred position is that the perceptual experience of something corresponds to the act of synthesizing that something. Thus, for example, with reference to the spontaneous reversal of perspective during "midflight" of a Necker cube set into oscillating apparent motion, Neisser (1967:144) comments: "...the reversal of perspective at that point emphasizes that figural synthesis is not a matter of cold-blooded inference but of genuine construction." The experiences of dreaming, hallucinating, and imaging are especially relevant; as I noted earlier, it seems reasonable to propose that a person who is seeing or hearing things that are not present is experiencing his own internal acts of synthesis. But on the constructivist view one wants to argue, in addition, that the perception of an actual event corresponds to an act of synthesis and this in my opinion raises a serious, and as far as I know, unanswered question. Is the act of synthesis which underlies the imaging of, say, a capital A or a loved one's face, the same kind of operation as that which underlies the identification of a capital A or a loved one when they are visually present?
I am aware of very little information which bears on this question. There are, however, a few hints from case studies of agnosia which suggest that the two operations I have referred to are not of the same kind. A patient who cannot read letters, i.e., cannot identify them when they are presented visually, may still be able to visualize them and describe their features. Conversely, a patient who can read letters may not be able to image them at all (Nielsen, 1962:35-40).

Let us hold this somewhat isolated observation in abeyance for a moment and turn to a more serious but related problem. If identification occurs in conjunction with the synthesizing of a reasonable match, and if perceptual experience corresponds to that successful act of synthesis then we should conclude as follows: the conscious perceptual experience of a sensory event is the earliest stage in the processing of that event at which the identification of that event can be said to have occurred. I intend to argue that this conclusion is false and that at least for certain kinds of linguistic material identification precedes the conscious experience and on occasion can be shown to occur in the absence of any conscious experience whatsoever. If my argument is correct then we should suppose that the processes underlying identification and those underlying conscious experience are quite different. To put this another way, the operations by which identification of a capital A (using our earlier example) proceeds and those by which the conscious experience of a capital A is expressed are not identical. Thus we should not be surprised to find, on occasion, brain-injured patients who cannot identify letters but can easily image them.

Michael Polanyi (1964, 1966) has for some time argued for distinguishing between two species of knowledge: tacit knowledge, about which we cannot speak, and explicit knowledge, about which we can. This distinction—adopted here in a rather diluted form—will prove fruitful to the ensuing discussion. I will attempt to show that we may know the identity of a verbal event tacitly, but a further operation—different from that underlying tacit identification—is needed if we are to know the identify of the event explicitly.

A good starting point is provided by the situation evident in visual masking. As you probably know, when two stimuli are presented to an observer in rapid succession perceptual impairment may result. Either the first or the second stimulus may be phenomenally obscured, or at least, not identifiable. One general principle of masking is especially relevant: when masking is of central origin (under conditions of dichoptic stimulation) the later-arriving stimulus is the one likely to be identified rather than the leading stimulus. In short, masking of central origin is primarily backward and this I propose is an important comment on the nature of central processes (Turvey, in press). We should also note that whether or not a lagging stimulus can centrally mask a leading stimulus is dependent on there being some geometric (and/or perhaps semantic) similarity between the two. By way of contrast, masking of peripheral origin can occur in the absence of any formal similarity; in the peripheral domain the comparative energies of the two stimuli are more important (see Turvey, in press).

Paul Kolers (1968) offers a useful analogy for backward masking of central origin. The idea is that the central processor may be likened to a clerk who
receives customers on an aperiodic schedule. When a customer enters the store the clerk asks him a variety of questions in order to determine the customer's dispositions and wants. However, if a second customer enters soon after the first the clerk may be hurried and, therefore, less thorough in his treatment of the first. Consequently, some things may be left undone. But we should note that the clerk has registered and responded to some of the first customer's requests. The analogy emphasizes that although processing of the first stimulus in a backward masking situation may not be completed and consequently an explicit account of the first may not be forthcoming, something about the first may well be known.

One kind of experiment in particular is a rather elegant demonstration of this point. We know that when a stimulus is decreased in physical energy, reaction time to its onset is increased proportionately. However, the reaction time to a backwardly masked stimulus, which may appear either phenomenally decreased in brightness or absent altogether is not so affected (Fehrer and Raab, 1962; Harrison and Fox, 1966; Schiller and Smith, 1966). Thus, we should suppose that in the presence of the masker those operations which determine the phenomenal appearance of the stimulus have been left relatively undone, but those which detect the occurrence of the stimulus and determine its intensity have been completed.

But other experiments are more relevant to the distinction that I seek to draw between tacit and explicit identification. First is an experiment reported by Wickens (1972) which shows that an observer may have some knowledge of the meaning of a masked word even though he might be unable to report the actual identity of the word. In this experiment a word was briefly exposed and followed by a patterned mask. Then the subject was given one of two possible words and asked to guess whether it was similar in some way to the masked and nonidentified word. This second word was never identical to the masked word but it was, half of the time, similar on some dimension to the masked word. The other half of the time it was dissimilar. For some dimensions at least—the semantic differential, taxonomic categories, and synonymy—the subject was likely (better than chance) to identify the semantically related word. The conclusion we may draw from this experiment of Wickens is that one can have tacit knowledge about the meaning of a word in advance of explicit knowledge about its identity. This is also the conclusion I think we should draw from the experiments of Reicher (1969) and Wheeler (1970). Those experiments showed that under identical conditions of backward masking, with careful controls for response-bias effects, a letter could be more accurately recognized if it was part of a word than if it was part of a nonword, or presented singly (cf. Smith and Haviland, 1972). It has always seemed to me that the simplest interpretation of this result is that meaningfulness (and/or familiarity) affects the time taken to process (cf. Eichelman, 1970). But if this is true then we are faced with trying to understand how meaningfulness or familiarity can assist speed and accuracy of identification since we should argue, on the conventional view, that sensory data have to make contact with long-term storage, i.e., have to be identified, before their meaning or familiarity can be ascertained.

This issue is similarly exposed in those experiments which demonstrate a direct relation between the number of syllables or pronounceable units in a verbal event and the time taken to identify it. Thus, for example, Klapp (1971) has shown that the time taken to press a key to indicate that a pair of two-
syllable numbers, e.g., 15 and 15, or 80 and 80, were the same was measurably shorter than the time needed to indicate the sameness of a pair of three-syllable numbers, e.g., 28 and 28, or 70 and 70. The question we should ask of this startling result is: how can the number of syllables affect the time to identify, since surely one must first identify an optical pattern such as 15 or 70 before one can know how to pronounce it?

In a similar vein there is evidence that the category, letter or digit, to which a character belongs can be known before its identity is determined (Brand, 1971; Ingling, 1972; Posner, 1970). In short, we can know that a character is a letter or a digit before we know which letter or digit it is. On Ingling's (1972) data in particular we should have to argue that determining category membership is not based on any simple or obvious feature analysis. In passing we should also note that these demonstrations are in concert with the special cases of visual alexia reported by Dejerine (1892) and Ettlinger (1967). Here injury to the left hemisphere results in an inability to read letters but leaves unimpaired the ability to read arabic numerals. And it is not that the patient has necessarily forgotten the names because he might be able to identify letters conveyed to him tactualy. Nor is his problem that of being unable to discriminate letter features since he can sort letters into groups where each group represents one particular letter.

By way of summary, there is good reason to propose that with respect to certain events one can be said to know something about the identity of an event before one knows that event's identity. This seeming paradox, alluded to elsewhere by Coltheart (1972a, 1972b), can be resolved if we distinguish between tacit and explicit identification and view the latter as preceded by and shaped by the former. An experiment by Worthington (1964) shows that one can have tacit knowledge of the semantic character of an event in the absence of any awareness, i.e., explicit knowledge, of its presence. On the surface at least, Worthington's experiment had to do with the time course of dark adaptation. Light adapted subjects seated in a black room were requested to view a designated area in which would appear a dim white light. Their task was simply that of pressing a button as soon as they saw anything in the specified area. Pressing the button turned the light off and the dependent measure was the time elapsed before the button was pressed. Unbeknown to the subjects, the dim light was a disc with a word printed on it in black. The word could be either an obscene word or a geometrically similar neutral word. Worthington found that the average button-pressing latency was determined by the semantic status of the word, with the obscene words yielding longer elapsed times. It is important to note that no subject ever reported seeing anything in the white light.

Further support for the tacit/explicit distinction is to be found in the literature on selective attention in audition, particularly in two experiments. Both use the technique of dichotic stimulation with the shadowing of one of the two concurrent messages. The general finding with this paradigm is that the subject knows little about the unattended message. But I should choose my terms more carefully; the general finding is that the subject knows very little explicitly about the unattended message. At all events, as Cherry (1953) initially observed and as many have confirmed since (e.g., Triesman and Geffen, 1967) a subject may be able to give a relatively detailed account of the physical character of the unattended message but may be sorely limited in his
ability to report on the semantic content of the message. We shall see, however, that the subject knows a great deal more about the unattended message than he can tell.

In one experiment (Lewis, 1970) pairs of words were presented simultaneously such that the unattended message words were associatively related, semantically related, or unrelated to their partners in the shadowed message. Although the subjects were unable to report the words on the unattended channel, it was shown that shadowing reaction time was slower when the word presented in the nonattended message was synonymous with its pair on the shadowed ear. In short, the unattended words were identified but their identification apparently was not made explicit. Similar evidence is provided in a recent experiment by Corteen and Wood (1972). In this experiment certain words were first associated with shock to establish skin-conductance change to these words alone. The shock-associated words were then embedded in the unattended message along with words from the same class (cities) as the shock-associated words, and with control words. Both the shock-associated and nonshock-associated city names produced a significant number of autonomic responses even though the subjects (according to the criteria of awareness employed) were not aware of them.

We should suppose, as I did earlier, that there are important distinctions to be drawn between the processes by which we tacitly know and those by which we explicitly know. To begin with, I suspect that the operations of tacit and explicit identification differ in that the former, unlike the latter, do not make demands on our limited processing capacity. Support for this idea can be drawn from several sources: recent experimental and theoretical analyses of attentional components (Posner and Boies, 1971), attempts to determine the locus of the Stroop effect (Keele, 1972; Hintzman, Carre, Eskridge, Owens, Shaff, and Sparks, 1972), and investigations into the relation between central processing capacity and iconic memory (Doost and Turvey, 1971). Essentially these sources hold that selective attention and limited capacity effects operate after a sensory event has made contact with long-term store (cf. Norman, 1968; Posner and Warren, 1972).

The argument has been made that certain variables which affect identification, such as meaning and familiarity, can only influence the course of perception after contact with long-term store. Thus, in an experiment such as Klapp's (1971) contact between an optical pattern, say, "17," and long-term store, must precede the determination of how that pattern is to be pronounced. Therefore, it must be argued that the number of syllables in the verbalization of the pattern cannot affect the course of tacit identification. On the contrary, the number of syllables can only affect the temporal course of explicit identification. By the same token, it is the conversion from tacit to explicit identification rather than the process of contacting long-term store which is sensitive to meaning and familiarity.

A nonlinguistic analog of the Reicher-Wheeler phenomenon has been reported by Biederman (1972). Essentially, the experiment showed that an object was more accurately identified when part of a briefly exposed real-world scene than when it was part of a jumbled version of that scene, exposed equally briefly. And this was true even when the subject was instructed, prior to exposure, where to look and what to look for. Biederman's discovery implies that the coherency and symmetry of the real-world scene affected the explicit
identification of the particulars of its composition. In a somewhat related experiment Eichelman (1970) has shown that a physical match (see Posner and Mitchell, 1967) is made faster between two words than between two nonwords (cf. Kreuger, 1970).

The question we should ask of all these experiments is: how can "higher order" properties of stimulation, such as symmetry, familiarity, and meaning, affect the identification of the "lower order" properties from which the "higher order" properties are apparently derived? On the present view, the answer to this question is that these higher-order properties are detected by relatively direct means (analogous, perhaps to Gibson's idea of "resonance"), and that explicit knowledge about the particulars, and other kinds of information embodied in the stimulation, is accessible only after such tacit identification.

In sum, pattern recognition can be said to consist of two rather broadly defined stages. The first is that in which stimulation contacts long-term store and the second is that in which the tacit identification afforded by the first stage is converted into explicit knowledge. It would appear on the evidence that the processes involved in the two stages are quite different. Moreover, it would appear that much of what we know about "pattern recognition" is related to the class of operations by which things come out of long-term store, i.e., the tacit-to-explicit conversion, rather than to the manner in which patterns of stimulation contact long-term store in the first place. In short, the "Hoffding Step" (Hoffding, 1891; Neisser, 1967) remains very much a mystery.

In view of the foregoing we might also speculate that the form of knowledge at the tacit level differs from that at the explicit level. This is, of course, the essence of Polanyi's (1964, 1966) argument. Here we should take it to mean that the explicit account of an event and the tacit account of that same event may look quite different, even radically so. Consider if you will the phenomenon in the short-term memory literature known as release from proactive interference (PI). On successive short-term memory tests of the distractor kind (Brown, 1958; Peterson and Peterson, 1959) a subject is given short lists of maybe three words to retain, a new list for each test. If the words presented on the successive tests are drawn from the same category recall performance across the successive tests will decline precipitously. If we now present words on a short-term memory test which have been drawn from a category conceptually different from that used in the immediately preceding tests then there is an abrupt recovery in recall performance. For example, if a subject received three successive tests with digits as the to-be-remembered material and then on the fourth test he was given letters to retain, performance on the fourth test would be equivalent to that on the first and substantially superior to that on the third. Wickens (1970) has proposed that the PI release procedure identifies "psychological" categories. We can assume that there is a common way of encoding within a class (accounting for the decline in recall) which differs between classes (accounting in turn for the increase in recall with shift in class).

Table 1 shows two distant classes of material as defined by PI release. The set of words in the left column consists of a random arrangement of three words drawn from the evaluative dimension, three words from the potency dimension and three words from the activity dimension of the semantic differential (Osgood, Suci, and Tannenbaum, 1957). Each word rates high on one dimension.
TABLE 1

<table>
<thead>
<tr>
<th>farm</th>
<th>wife</th>
</tr>
</thead>
<tbody>
<tr>
<td>prevent</td>
<td>burn</td>
</tr>
<tr>
<td>uncle</td>
<td>silence</td>
</tr>
<tr>
<td>sea</td>
<td>debt</td>
</tr>
<tr>
<td>car</td>
<td>sing</td>
</tr>
<tr>
<td>play</td>
<td>young</td>
</tr>
<tr>
<td>religious</td>
<td>disease</td>
</tr>
<tr>
<td>action</td>
<td>alone</td>
</tr>
<tr>
<td>develop</td>
<td>serious</td>
</tr>
</tbody>
</table>

and is relatively neutral on the other two. The right column of words is similarly constructed. The difference between the two columns is that the left-hand column words are drawn from the positive pole of their respective dimensions and the right-hand column words are drawn from the negative pole of their respective dimensions (all words were selected from Reisse, 1965). The experimental evidence is that shifting across dimensions within the same polarity does not yield a release from PI; on the other hand, a highly significant improvement in recall occurs following a change in polarity either within or between dimensions (Turvey and Fertig, 1970; Turvey, Fertig, and Kravetz, 1969). In brief, it has been shown that the polarities are orthogonal but the dimensions are not. What I should like to argue is that this distinction between positive and negative polarity is made only tacitly. In the PI release situation a distinction is obviously being made, and without effort, between the two polarities. But I submit that close examination of Table 1 and careful perusal of the individual words will not lead you to conclude that the two columns differ in any sensible way. Imagine if the words in the two columns were simply mixed together and you were ignorant of the semantic differential (as were the subjects in the experiments). I doubt if you could even begin to sort them into the two categories I have described.

In other words, you can make a distinction tacitly that you cannot readily make explicitly. Quite to the contrary is the situation with nouns and verbs. A shift from nouns to verbs or vice versa does not lead to a release from PI (Wickens, 1970), but one can with some facility distinguish nouns from verbs if one is asked to do so. In the Lewis (1970) experiment referred to above, synonymy between attended and unattended words exerted a marked effect on the reaction time to attended words, but associative relations based on associative norms did not. We might argue from this result that associative norms reflect explicit distinctions but are themselves not isomorphic with the structure of tacit knowledge. Similarly, we can argue that the structure of tacit knowledge does not incorporate images. On the evidence, a distinction is not made tacitly between high-imagery concrete words and low-imagery abstract words, although such a distinction is clearly made explicitly. Wickens and Engle (1970) failed to find PI release with a shift from concrete to abstract words, and vice versa, even though the imagery variable is known to be important in free-recall and paired-associate learning (Paivio, 1969). Imaging, we might suppose, is constructing from tacit knowledge.

Assuming, therefore, that my interpretation of the PI release situation is not too far off the mark, we may draw the following, highly speculative but
intriguing conclusion: you may make distinctions tacitly that you cannot make explicitly, and, conversely, you may make distinctions explicitly that are not furnished tacitly. In this latter case we should assume that such explicit distinctions are constructed.

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