Originally published in J. Requin (Ed.), *Attention and Performance VII* (chapter 6, pp. 89-111). Hillsdale, NJ: Erlbaum, 1978. Reproduced here by kind permission from the publisher Lawrence Erlbaum, with minor corrections.

The Making of the Present: A Tutorial Review

John A. Michon

Institute for Experimental Psychology
University of Groningen The Netherlands

ABSTRACT

The core concept in this paper is the psychological present, commonly under-stood as a time interval in which sensory information, internal processing, and concurrent behavior appear to be integrated within the same span of attention. Understanding the relation between the temporal structure of input information and the processes that determine the dynamics of the present will also make it possible to understand the way in which conscious temporal experience (time perception) is shaped.

The present, in this conception, is a highly flexible tuning process that is dynamically fitting the temporal width of the field of attention and its phase relations to the sequential structure of the pattern of events. Thus, it serves an important function in enabling the organism to optimalize its in-formation processing activities. It is an active, or constructive process; this necessitates the assumption that temporal information can be extracted from event sequences that is structurally independent of the nontemporal dimensions of information (viz., spatial and categorical attributes of stimuli).

Because the present is so highly adaptive, no fixed parameter values can be expected to describe it adequately. Only under certain boundary or rest conditions may we expect the parameters of the process to adopt certain values, related to the properties of the information processing mechanisms (scanning rate, precategorical storage, STM, etc.). Some of the procedures that the organism has available for extracting and parsing temporal information have become known in recent years, and some attempts at formally describing these procedures have been made. At the same time, there is some psychophysiological evidence to support the view that the tuning process may be controlled by phasic changes in alertness and allocation of effort.

This conception of the role and significance of the present adds a new dimension to the age-old problem of the subjective flow of time. There is a considerable argument about what causes subjective time to accelerate. [**90**] While it is fairly common to attribute such changes to the number and complexity of events or to the processing effort involved, some contradictions remain.

I. INTRODUCTION

This chapter will consider some topics in time psychology from the standpoint of performance theory. Time psychology has been concerned with studying the human experience of time and duration for more than a century, but to a considerable extent it has done so only at a phenomenological and descriptive level. Current ways of thinking about process and structure in human performance and in cognition have only recently started to have some impact on time psychology.

It is as part of this development that I shall relate the subjective experience of what has been called the *conscious* or *specious present* to the processing of temporal information in situations in which the subject deals with sequential patterns of events at varying degrees of complication.

A sequential pattern can be defined as “a finite string of symbols that states the rules governing the indefinite continuation of a non-terminating sequence” (Simon, 1972). In other words, a sequential pattern is a (relatively compact) description of a series of events that may in principle be extended indefinitely; the description summarizes the invariant aspects of the series over time. Events in a sequential series may he regularly distributed in time, or they may occur at irregular or random instants. If, however, the description of the sequence contains rules that determine the exact temporal loci of successive events, then we may speak of a temporally specified pattern. *Temporal patterns in* the restricted sense constitute a special class of *sequential patterns, viz.,* the class of patterns in which only the temporal structure of the event series is specified. We may take music as an example in which meter and rhythm are independent of, although coextensive and generally correlated with, melody, harmony, and dynamics. Thus, while meter taken by itself is a temporal pattern in the restricted sense, in music it generally appears as one aspect of a sequential pattern.

II. THE CONSCIOUS PRESENT

A. The Basic Proposition

The fundamental proposition of this paper is that the process of discovering or constructing the temporal pattern of a sequence of events is consciously experienced as the *specious present.* The specious present is understood in the sense defined by James (1890) as the time interval, a few seconds in length, in which we experience the flow of events as being simultaneously available to perceptual or cognitive analysis. In other words, the thesis proposed is the [**91**] following: if, and only if, the temporal structure of a series of events is focally attended, consciousness is in a processing mode that is reflected in experience as the “specious present” (from now on I shall frequently speak of *present,* for short). As a corollary, I maintain that the actual state of the experienced present (its perceived width, persistence, etc.) will reflect the ongoing search for pattern.

B. Consciousness Regained

This invocation of conscious experience, which would have been considered unduly mentalistic 10 years ago, recently has been taken up by a number of authors (Mandler, 1975; Posner, 1975; Shallice, 1972).

Mandler defines consciousness as “a mode of processing that affects the state of a (mental) structure. Given that consciousness mode, the ‘contents’ of consciousness are those structures and their products that arc in the conscious state” (Mandler, 1975, p. 45). Consciousness is considered as a limited-capacity attentional process, which serves such functions as evaluation, choice, grouping, and pattern recognition. Shallice (1972), who describes consciousness as the process of selecting a “dominant action system” (i.e., a dominant plan for action appropriate under the prevailing circumstances), points out that consciousness will become active only in case of conflicting lower order action systems. For instance, if a situation arises for which no appropriate action system is available, one will be constructed consciously (e.g., LaBerge, 1974). With practice such a system will gradually become inaccessible to consciousness (Mandler, 1962).

C. The Specious Present

That aspect of consciousness called the *present* has a certain width. We can still "perceive" the first two sounds of a clock striking three as "having sounded just before" when actually the third sound is *now* in progress. In other words, one main characteristic of events in the present is their availability to our attention in real time, although this is a qualified availability rather than a simultaneity. Moreover, the -width of the present varies with the direction of this attention (Fraisse, 1967; James, 1890).

Sometimes the present has been described as a continuum, much like a shift-register, picking up information on one side and dropping it at the far end (James, 1890). But as Fraisse (1967) correctly noted, this is not a good description of the state of affairs: if we listen to the tic-tac of a clock we do not perceive a "tic-tac" first and then a "tac-tic" one moment later. This points to a second phenomenal characteristic of the present, which we may call segmentation. Apparently the stream of consciousness is chopped up into meaningful, or at least structurally coherent, segments. In relation to this it is observed that the content of the present is organized in ways that may be suggested by the stimuli themselves, but also as part of an integrative process, which incorporates the [**92**] context (the situational present) and the implicit knowledge about the events. This was brought out, for instance, in the penetrating phenomenological analysis by the philosopher Husserl (1964) of the contents of the present.

One of the observations Husserl made was that a tone now sounding will continually exhibit a different phase in consciousness. That is, we first perceive it as about to begin (when we expect it), then as beginning, as having just begun, being nearly over, and so forth. In this process each earlier phase is retained in each later phase; it is integrated in the perspective of that later phase until after some time the event is "cut loose," and from then on is only experienced as being potentially retrievable. This particular form of retention should be distinguished from memory, according to Husserl. It is not open to the type of operations that we can perform on memory contents, such as rehearsing, picking out certain episodes, or "sweeping glances" with their concomitant loss of detail. Consequently, the present cannot be subject to the types of errors that our memories can show; it has the quality of the uninterpreted, and proceeds as it comes, in real time. This, in short, is a presentation very much akin to the ideas of James, and surprisingly close to what our present cognitive stance would accept as good doctrine.

D. Summary of Properties of the Present

We may summarize the phenomenal qualities of the conscious present as they emerge from more than one hundred years of empirical studies, in the following way:

1. It has a width that is highly variable and that seems to have an upper limit of 7 or 8 s, although its average seems to be of the order of 2 or 3 s. Its perceived width depends on the number and the sequential structure of the events in it.
2. Constituent events, in order to be perceived as independent, must be separated by at least 150—250 milliseconds. That is, when more than five or six events per second occur, they will fuse into higher order perceived transients or dynamic events.
3. Events display a pronounced and almost irresistible tendency for temporal structure when they are between 250 and 900 ms apart, while an optimum near 600 ms is reported most often.

4. The information contained in a present is a discrete segment; its boundaries are determined by various temporal and nontemporal structural properties. When no external structure is present in the stimulus, segmentation will be imposed subjectively (grouping).

5. The contents of a present are simultaneously available and are as such continuously open for restructuring; that is, the information contained in it is open to revision under different cognitive (or at least higher order) interpretive hypotheses.[**93**]

Two other qualities commonly associated with the conscious present, orientation towards past (as in shadowing), or future (anticipating), and the fine grain (time quantum) have been studied, but here opinions vary considerably, especially with regards to the time quantum.

III. PROCESSING SEQUENTIAL INFORMATION

A. Time Constants and Processes

In this section a number of facets of sequential information processing will be discussed, which will bring out the importance of temporal pattern in the organization of behavior. This discussion is limited to such phenomena as, I think, are reflected in the contents of the present, and therefore may be said to be involved in the making of the present. The following paragraphs follow the phenomenal qualities of the present as they were summarized in the previous section. Some of those processes play a considerable role in performance theory; frequently the parameters of a number of perceptual phenomena seem to converge on the same process. In other cases there is speculation to a much greater extent. Admittedly, there is a considerable oversimplification, which in part is based on the indestructible optimism of the author, who believes that the fairly narrow range displayed by some time constants under various task conditions reveal some common underlying process.

1. The time quantum

Starting at the short end, we meet the boundary between simultaneity and order perception, which may be estimated at approximately 25 ms (Hirsch & Sherrick, 1961). This must be a fairly general mechanism as it is independent of modality.

These, and similar results (as, for instance, the subjective interference patterns that can be observed in a line scan visual presentation [Allport, 19681), have given rise to the concept of the time quantum. Thus, time is partitioned into a discrete series of episodes by an internal clock that is either triggered internally, or is driven by external events. The literature on the search for the time quantum incorporates many effects and several values (see Pöppel [1978] for a summary; also discussions by Kristofferson [1973] and Vroon [1974]). Most of the more recent studies seem to converge on the value between 20 and 30 ms. This, incidentally, compares very well with the information rates of between 30 and 50 ms hypothesized on the basis of feature scanning experiments such as Sternberg's (Cavanagh, 1972; Sternberg, 1975).

Yet the matter is still open, as no direct observations of the time quantum have been made, and also because much of the evidence is suspect, in particular [**94**] that on multimodal reaction time distributions that have been taken as a primary source of evidence in the past (see Vroon [1974] for a discussion and Luce & Green [1974j for an opinion).

Although the fine grain of time plays a considerable role in the perception of sequential stimulation, as is illustrated by the delicate timing relations in speech (Huggins, 1972; Klatt, 1976; Nooteboom, 1972), these temporal relations do not concern *separate* independent events. As was stressed by Bouma (1976), Massaro (1974), and others, we are dealing in this case with dynamic changes of the signal under concern, rather than with the temporal relations between successive independent events.

2. Precategorical storage

What constitutes an independent event in time must be processed without competition of other events, which means that such an event must be allowed to occupy precategorical storage without interference. Recent work on this storage mechanism tends to converge clearly on values between 150 ms (Efron, 1970, 1973) and 550 ms (Kristofferson, 1976), with a neat 250 ms as the modal value (Averbach & Coriell, 1961; Cavanagh, 1972; Kahneman, 1973; Massaro, 1974 Posner, 1975; and others).

For the purpose of our present discussion there are *two* event types that are of direct concern: the perceived duration of an event, and the perceived relation between two successive events, especially their *coherence* and their order.

Psychophysical studies of the perception of duration have thoroughly established that indeed the most sensitive perception is of intervals between roughly 200 and 800 ms, with an optimum around 400 ms (Eisler, 1975; Fraisse, 1967; Michon, 1964, 1967b). Whereas for synchronization behavior ranging between 200 and 800 ms precisions usually are reported on the order of 4—5 percent (Michon, 1967a, b), recent studies by Kristofferson (1976) and by Vorberg and Hambuch (1978), have shown that with (indeed very long) practice an extremely high precision can be achieved. Kristofferson found that after 2 months of daily practice a subject was capable of producing intervals in a synchronization task with variance that was constant at less than 2% between 400 and 1200 ms, increasing very slowly beyond. His conclusion is that synchronizing behavior is brought about by two independent part processes, one being the basic minimal S—R delay distribution (under certain experimental conditions this will be the approximate distribution for simple reaction times) plus a completely deterministic (zero variance!) delay process. Very fine timing is, of course, also known in complex motor skills, while — as we shall see later - the perception of temporal patterns in speech also points to a high quality processing of temporal information. A recent outburst of new experiments in this realm in psychoacoustics offers further support (cf. Plomp, 1975).[**95**]

The perceptual coherence between sequentially independent events increases when the events are more than 150 ms apart. When presented at higher rates they split up in two or more independent sequences, or else they are grouped subjectively. The optimum coherence in rhythmic patterns is reached between 350 and 700 ms (Fraisse, 1956; van Noorden, 1975; Vos, 1973). Huggins (1974) studied click sequences presented alternatively to both ears and found that for low rates the subject “shadowing” the clicks will follow the switching pattern, but at five clicks or more per second, he will match his shadowing performance to one ear only, thus halving the apparent tempo. This again points to the transition of the within-span to the independent-event mode of precategorical storage.

Finally, it has been documented by several authors that the order of successive events is perceived correctly only if they do not interfere in precategorical storage. Ladefoged and Broadbent (1959), and more recently Thomas, Hill, Carroll, and Garcia (1970), Warren and his collaborators (Warren & Obusek, 1972; Warren, Obusek, Farmer & Warren, 1969), and van Noorden (1975) have shown that order perception in complex sequential patterns depends on event independence, requiring a separation of at least 200—300 ms. Warren et al. (1969) have shown the importance of the availability of cognitive labels (counting, etc.) for naming the patterns. When sequential or temporal events fall within the range of precategorical storage, grouping is inescapable. Vos (1973) pointed out that only when a verbal (or at least a symbolic) label can be assigned to such a group, it can be represented internally as a stable, independent event. The rate of producing such labels is restricted by the same mechanism, as it requires the pronunciation of at least one covert syllable (see also Perkins, 1974).

3. Primary memory or short-term memory

The next question, to be dealt with very briefly, is whether we can equate the total width of the specious present with short-term memory. Equating the upper limit of 7 ± 2 s of the present with the 20 to 30 s range commonly found for STM seems somewhat farfetched. Moreover, the paradigms are essentially different: the 20—30 s estimates are obtained with a limited *static* load on memory, whereas the loads on the present are dynamic and more comparable with running memory tasks as studied by Sanders and Van Borselen (1966), or with the primary memory paradigm developed by Waugh and Norman (1965), or even with Crowder's suffix effect (Crowder 1972, Crowder, & Chao-Ming Cheng, 1973).

The principal question here is: to what extent can temporal patterns be concatenated in such a way that at the end the relations can still be comprehended and the earlier parts modified in the light of the later ones? In primary memory we indeed have information available at the surface level required for such processing. What is to be understood as surface structures is a matter of some doubt, [**96**] but it should be a rather primitive level. In speech it would have to be at the phonological level at most. The question "Anymore tea dear?" may escape the husband who is watching the Cup Final on TV for several seconds, but he can retrieve the message up to the intonation and syntactic patterns. An experimental test of this phenomenon is currently being carried out by Franchik (Broadbent, personal communication, 1976): this study seems to offer support for a rather long availability interval.

4. Orientation

A final distinction concerns the backward or forward orientation of attention with respect to the immediate past or the immediate future. In terms of processing, these two temporal orientations will be adopted by the subject when he is engaged in a rehearsal task and an anticipation task, respectively. I wish only to mention this aspect for the sake of completeness. There is a vast body of literature on both rehearsal and anticipation, but the role of this dual orientation on the dynamics of the specious present has not been systematically studied. (Anticipation is known to slow down the subjective flow of time though.)

B. Availability and Segmentation

One important aspect of the present is that information in it remains in a state of availability until it can be processed at a higher and more abstract level. This availability will persist until some structural boundary (a syntactic boundary or a pause, for instance) is reached. This will free the information channels for higher order analysis, upon which a new present may start. Until such a boundary is reached, the information remains available at the level of the surface structure for further (re-) interpretation, comparison, etc., but thereafter the surface in-formation will be irretrievably lost. In Husserl's phenomenological analysis, it will be recalled, this is the point at which an experience is "cut loose" and be-comes a memory.

The segmentation that occurs at structural boundaries divides the stream of consciousness into internally representable units, thus relieving the higher coding and storage processes. And because of it we always remember structurally “healthy” patterns: there is never a memory straddling two successive structural units. This observation also reduces the plausibility of explaining the present in terms of either some internal clock “ticking away” successive presents, or a new present starting whenever the preceding one is “filled.” In the absence of structural boundaries in the input the subject may, however, sometimes succeed in avoiding confusion by using accidental features as boundary markers, or he may try to impose a purely subjective segmentation pattern on the input. The latter strategy will succeed only when the prosodic features of the input are minimal, as, for instance, in isochronic sequences (see Section IV.B).[**96**]

Thus, we have two organizational principles of the present: availability and segmentation. Both are open to empirical study, and both occur in the auditory and visual modalities.

Boundaries of events can be indicated by pauses and other “prosodic” features, such as intonation, or by such higher order features as syntactic and semantic aspects of the stimulus. The relative roles of pauses and prosody and of the higher order boundaries have been studied quite extensively in the past few years (Bower & Springston, 1970: Carroll & Bever, 1975; Dooling, 1974; Martin, 1972; van Katwijk, 1973; and others).

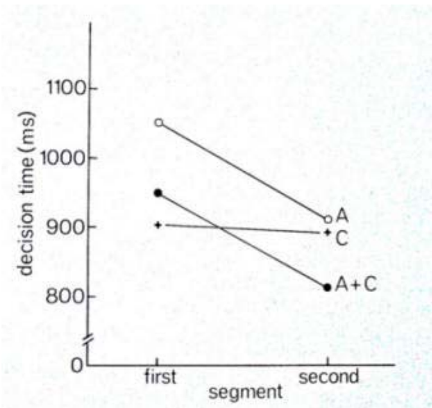

FIG. 1. Time to decide whether a 6-frame movie fragment was *old, new,* or *paraphrase,* for fragments before or after a change in scene (A), a cut (C), or the combination of the two (A + C). (After Carroll & Bever, 1975.)

The general conclusion is that the temporal structure by itself is not a sufficient condition for segmentation. However, if a pause or a stress coincides with a higher order structural feature, then segmentation is facilitated. That is, the probability of segmentation is greater in that case than when the higher order structural boundary is presented in isolation. Thus, it seems that it is primarily the higher structural boundaries (syntactic or semantic) that determine the potential points of segmentation, but that the temporal structure will very strongly stimulate the actual process.

A good illustration of these processes is offered by a recent experiment of Carroll and Bever (1975). They used a paradigm conceived by Jarvella (1970) and further developed by Caplan (1972) to study the availability of surface [**98**] information in event sequences. Using this paradigm, Carroll and Bever (1975) showed short movie sequences, each consisting of two consecutive fragments. The fragments were separated by either a “cut” or a change of action, or by a combination of the two.

Subjects were then shown 6-frame sequences that were to be classified as *old, new* (not seen before), or *paraphrase* (similar but not identical to old). The *old* 6-frame sequences were either the last 6 frames before, or the first 6 after, the transition. The authors measured the response latencies for these different target sequences. Their results show clearly that both the cut (C) and the change of action (A) boundaries are effective, but C is only effective *together with A.* The differences between the A and A + C scores on the first versus the second segment indicates the greater difficulty of retrieval for the in-formation contained in the first sequence (see Fig. 1). Apparently, we may draw the conclusion that structural boundaries serve as signals for segmentation of the ongoing present, while other, more strictly temporal, features are aiding this process. If presented exclusively by themselves they prove no sufficient cause for segmentation. Apparently, the subject must have a thorough knowledge of the structural properties of the stimulus sequences in order to make an appropriate use of the temporal information that is available in them.

C. The Role of Pauses

Given the phenomenon of segmentation as discussed in the previous section, the role of pauses deserves some separate attention. It has been argued that apart from being an organization principle inducing proximity in the events between the pauses (Bower & Winzenz, 1969; Fraisse, 1956: Garner, 1974; Vos, 1973), the pause also fulfills the role of an information bucket, in which information is collected that cannot be dealt with immediately upon presentation because it cannot be integrated into the main pattern of events. The shift phenomenon, discussed by Fodor, Bever, and Garrett (1974) is an example of this “bucket” function. Apparently, the present tends to perceptual closure achieved at the cost of shifting nonintegrated information to a pause.

Furthermore, Bower and Springston (1970), Martin (1972), and others have pointed out that extra time becomes available in a pause for extra or higher order abstraction processing. This is only the case when the pause coincides with a structural boundary, or when the segments are so long that sub-segments are necessary to cope with the information. Pauses and hesitations are then introduced subjectively (but audibly) in speech *production* (Boomer, 1965; Goldman-Eisler, 1968; Martin & Strange, 1968a, b).

The particular role of the pause is illuminated by the fact that it frequently is a nonentity; that is, it goes unnoticed even though it is physically present. The phenomenon, known as the dead interval (Fraisse, 1956, 1967; McDougall, 1903) has been found to depend on the temporal structure of the task pattern, but in no case to exceed 300 -400 ms (Michon, 1968, 1977). This suggests [**99**] that, after processing the contents of one present, one empty “cycle” of the pre-categorical storage process is made before a new present is started. This result seems to be in line with the earlier discussion of the temporal parameters of the present. Also, it may point to relations with the course of preparation (Kahneman, 1973; Killeen, 1975; Posner, 1975), or with the psychological refractory period (see Kahneman’s discussion, 1973). A discussion of this relation can be found in Michon (1977).

IV. WHY WE PERCEIVE PATTERN: TUNING

The perception of temporal pattern enables the organism to *tune in* on the flow of information, thus making it possible to optimalize its processing activity. If the internal representation of the time course of information matches the external events, the subject may make optimal use of the peaks and pauses in the incoming information. The role of peaks and pauses in the perception of temporal structure is perhaps the most direct aspect that deals with the discovery of pattern. As in visual perception, the places at which information is at a maximum (contours) achieve a dominant perceptual quality, whereas elements that are (relatively) void of information spontaneously assume the status of "background." In this context one should consider in particular the various Gestalt grouping principles of elements that are similar in a certain way. The latter factors, studied in the well-known Gestalt laws, are discussed by Bregman (1978).

Not only will overload of the processing channels be avoided, but temporal pattern also may help considerably in reducing the class of possible stimuli that the subject may expect, thus reducing the amount of search necessary for event recognition. Thus, we may expect the temporal structure of sequential patterns to be a powerful organizing principle.

A. Pattern Description Systems

Recent years have seen the emergence of a number of procedures or grammatical systems for describing sequential patterns in formal terms (for reference see in particular Greeno & Simon, 1974; Jones, 1974, 1976: Leeuwenberg, 1969; Martin, 1972; Restle, 1970; Simon, 1972; Vitz & Todd, 1969). In principle these are purely formal descriptive systems, although they all claim some psychological relevance. However, when psychological meaningfulness is tested by comparing the complexity of the description with the psychological complexity as measured by scaling or processing time, ambiguous results are frequently obtained. This indicates that other factors help determine perceived complexity. It is necessary for a pattern description system to take into account such factors as the load on memory and the amount of attention allocated to the various parts of the sequence. We may further expect an important influence of the speed of [**100**] presentation that will constrain the possibility to apply the various rules of the pattern description. In most cases this does lead to additional assumptions, which are not a part of the descriptive system as such. Simon (1972) and Greeno and Simon (1974) have shown, however, that it is feasible to construct models which incorporate such restrictions in the system, for instance by introducing certain upper limits on the memory for part sequences.

B. Isochronic Stimulus Sequences

In the limiting case, subjects have to process sequences of strictly identical events occurring at strictly regular instants. These sequences arc called isochronic. It is well known that such series, which in fact have no intrinsic patterning and consequently offer no cues for segmentation, are nevertheless perceived as being temporally structured. This phenomenon — known as subjective grouping — is also observable in the visual perception of regular tile patterns. Usually, a subject will consciously pay attention to an isochronic sequence, either because he is instructed to count events in one way or another, anticipates the arrival of the stimulus (in synchronizing task), or is continuing a particular series. This suggests that subjective grouping is employed as a strategy because it is an efficient and load reducing way of processing sequential information. Grouping enables the subject to assign a cognitive label to each group, viz., by counting or stressed tapping. Depending on the speed of the presentation, the subject will choose a labeling tempo that is close to an optimum in the perception of temporal structure, that is, at intervals close to 500 ms (Fraisse, 1956; Perkins, 1975; Vos, 1973).

C. Garner's Experiments

When we deal with event sequences that *do* have a temporal structure, such as the binary sequences studied by Garner and his associates (Garner. 1974), the question, which organization principles do account for the way in which the structure of these sequences is perceived, is raised. One thesis is that pattern perception in this case is based on some very simple rules, so simple that we may say that the organism is "preattuned" to them, and only just picking up the information contained in the sequences. Given a structuring according to figure and ground, the pattern cannot help but be noticed.

The experiments of Garner and his associates (summarized in Garner, 1974) are the single most coherent set of experiments dealing with the discovery of temporal pattern.In these experiments subjects were presented with binary sequences of buzzes (high and low) or flashes. The sequences consisted in most cases of eight or nine events, and were repeated indefinitely until the subject was able to reproduce or describe the correct order of events in the sequence. The sequences were [**101**] constructed in such a way that they contained no subgroups, and (what amounts to the same) would be different, irrespective of the starting point of the sequence chosen by the subject.

Thus, [x o o o x x o o] is such a sequence, whereas [x o o x x o o x] apparently is not. As a result, each of the cyclical orders of the elements may be perceived as an independent pattern without any a priori preference, except for the fact that certain organizations of the events will be perceptually more stable than others. For the observer it will be easier to tune in on such a stable organization.

This implies that stable patterns will be perceived more quickly, that is, with fewer repetitions and by more observers, as the preferred organization. Looking at the structural similarities of strong patterns as opposed to others whose organization remains ambiguous may help to uncover the rules underlying the organization of such binary patterns.

Garner's analysis revealed a number of very simple Gestalt-like principles that described the actual tuning behavior of the subjects to a large extent. The first principle discovered was that subjects select one of the two event types as representing a background, the other being chosen as figure. Thus, they would assign these roles to either of the following two part sequences.

```
sequence           . . . x o o x x x o o . . . .
part sequence (a)  . . . x     x x x     . . . .
part sequence (b)  . . .   o o       o o . . . .
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This assignment is arbitrarily made and can be easily reversed. After having established a figure-ground relation, the perception of stable pattern is based on two structural rules: the *gap rule,* which states that the preferred end of a cycle is the longest run of ground-elements. The second rule is *runs-rule,* which states that the longest run of figure elements is preferably put at the beginning of the perceived pattern. (It will be clear that these two rules implicitly use the Gestalt laws of similarity and proximity.) These two rules may conflict, in which case the gap-rule tends to overrule the runs-rule; or there may be a conflict in a sequence, for example, if there are two gaps of length 2, as in the example just given. In these and other cases, the result will be an ambiguous pattern: some subjects choosing different organizations, or the same subjects choosing different organizations on different trials. It will also result in a large increase in the number of repetitions of the pattern needed for making a decision.

One main feature of these experiments is the high degree of spontaneity involved. The lack of preset instructions and of preliminary knowledge of the "system" insures that the patterns in this situation speak for themselves. We may indeed call this tuning; not only does the subject pick up the preferred organization of the pattern, he also discovers without difficulty the period of the cycle.[**102**] Accordingly, the rules established by Garner may be considered as fundamental principles of organization, which are supported by the results of other studies of sequential and temporal pattern (Fraisse, 1956; Restle, 1970; Vos, 1973).

D. Complex Patterns

The active imposition of a structure on the way sequences are perceived is more likely to arise when we are dealing with the more complex sequential patterns that have been studied among others by Simon and Kotovsky (1963), Vitz and Todd (1969), and Restle (1970). Restle, for instance, pointed out the importance of *runs* and trills as principles of organization in the structure of sequential pat-terns. In a sequence made up of events chosen from a set of ordered elements, [1, 2, . . 6] a run would be represented by a sequence like [2345] , a trill by a sequence like [5454]. Restle and Brown (1970) trained subjects on a pattern learning task, either in *a runs only* condition, for example, [654354324321], or a *trills only* condition [565343323121] . They were then tested on an ambiguous series such as [2123434565] , which can either be coded in terms of trills *or* of runs. It is not entirely surprising that the authors found this pattern being structured in accordance with the learned regularity.

In an analogous way, Dooling (1975) trained subjects to listen to sentences in noise that conformed to a particular prosodic pattern. After a number of sentences that had an identical rhythmic structure, he would suddenly present a sentence with an equal number of syllables but with a different rhythmic structure. Thus, after 10 sentences of the type

They are háppy̆ péoplĕ

a sentence would follow like

They are prĕcíse ăccoúnts.

Comprehension in such cases dropped dramatically, and it was also found that the effect was strong enough to transgress word boundaries.

The most explicit attempt to relate a formal description of pattern to the perceived temporal structure of sequences of events is Martin's study (Martin 1972), which described the essence of the tuning process in terms of two principles, *relative timing* and *relative stress.* Both principles indicate that it is very unlikely (as was already argued by Lashley in 1951) that temporal patterning consists of serial concatenation.

Relative timing is the ability to compress or dilate a temporal pattern in time in such a way that the relative temporal relations between successive events are either retained or, at most, changed in a systematic way. The first occurs when we repeat a sentence at a different speed; the second will happen, for instance, in speech, when a particular vowel is followed by phoneme strings of different lengths. Subjects are found to *tune in* on changes in tempo quite easily, although [**103**] it may take some "cycles" in a pattern (e.g., a few words or sentences or bars of music) before subjects "catch up" with the new rate (Huggins, 1972; Michon, 1967b).

The second aspect, discussed in Martin's paper, is relative accent, which refers to the fact that under a wide range of conditions the pattern of placements of accent (stress) is invariant. With a highly parsimonious description derived from these principles, Martin was able to describe many of the prosodic features of the English language. Thus he succeeded, among other things, in explaining the prosodic relations between stress and relative timing pattern of sentences that allow different stress patterns (viz., I *told you to go,* vs. I *told you to go* or *I told you to go).*

It has been thoroughly established by now that the perception of stress in language is based on very subtle and inconspicuous cues in the physical sound pattern. By studying the location of perceived stress in artificially inflected syllable sequences and sentences, van Katwijk (1973) has shown that it is precisely the pattern of intonation (inflection) that is a necessary (though not sufficient) condition for accent to occur. Manipulation of other speech dimensions as cues for stress require a massive effort on the part of the speaker: increments on the order of 20% in intensity or duration are required before they lead to the perception of stress.

To study the importance of tuning in speech perception, it is sufficient to disturb the temporal pattern of the message. There are several techniques to degrade either the temporal, the prosodic, the phonological, or even the syntactic structure. (For further discussion, see Huggins, 1978.)

E. The Anticipatory Role of Tuning

Thus far we have not discussed very explicitly the attentive function of the tuning process. However, tuning does not serve only to passively facilitate efficient processing. Its role is much more active, as it also helps to anticipate important events such as peaks in the flow of information. The effect of warning signals, either in a regular sequence or by repeated presentation of a single pair of signals may be considered in this light. The precision of synchronization also belongs here, but these topics fall beyond the immediate scope of the present study.

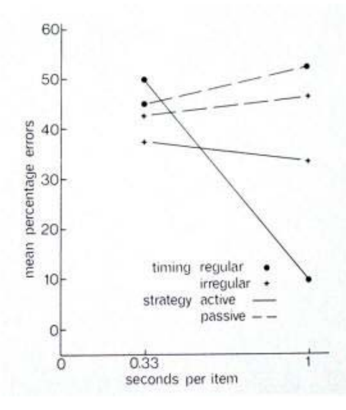

FIG. 2. The effect of timing regularity and attentional strategy on errors in recall, for low and fast presentation rates (1 and 3 items per second). (After Hamilton and Hockey, 1974.)

The precision of anticipation of temporally structured events has been studied extensively, and it has been established that practiced subjects are very quick to pick up a pattern: 2 or 3 cycles suffice when the rate of events is within the confines of rhythm perception, that is, if the inter-event intervals are between 250 and 900 ms (Best & Bartlett, 1972; Fraisse, 1956; Michon, 1967b). With prolonged training a very high degree of precision can be obtained, as was shown by Kristofferson (1976), and as we know from musical ensemble playing.

Recently Hamilton and Hockey (1974) undertook an attempt to investigate the ability to anticipate and extract critical information from certain (but not [**104**] other) elements a sequence of events. In this study, the subject's task was to select for recall certain target words, letters, or numbers at the expense of others. The main question they asked was whether it is possible to induce a patterned fluctuating state of preparation to handle a sensory input. Otherwise subjects would have to use an event counting method in anticipating the next critical event (tagging), or even to accept all input words, rejecting the irrelevant ones only at the end (exhaustive storage). For this purpose they presented their subjects with sequences of 9 letters, words, or numbers in which the critical items were numbers, either in positions 2, 4, 6, and 8, or in random positions.

The results favored an interpretation in terms of the first of the three strategies. This became clear when the critical items were randomized, thus making anticipation impossible, and also when the subjects were presented with regular sequences but instructed to follow either a "passive" or an "active" strategy. However, the results differed considerably as a function of the inter-item interval. In fact, when this interval was 0.375 s there was no difference between the anticipatory and the passive receptive strategy, but whereas the passive strategy gave a constant percentage of missed critical items, irrespective of the speed of presentation (0.375, 0300 or 0.750 s), the active strategy improved performance consider-ably. Similarly, the irregular timing (random order) of the critical items did not affect the results of the passive strategy but had a dramatic effect on the active strategy, albeit only if the presentation was rather slow.

As Hamilton and Hockey have argued, the results require some explanation of the tuning process that is involved here in terms of an attentive mechanism [**105**] that can be triggered in a temporally patterned fashion. The same assumption has been made with respect to the perception of speech pattern, but apparently in the present case *we* ar*e* dealing with a comparatively slow, cognitive process that requires a considerable amount of time. This is suggested by the absence of an effect at the 375 ms interval. The process of "controlled activation," hypothesized by Hamilton and Hockey(1974), should possibly be equated to phasic arousal processes as described by Posner (1975) and Posner and Boies (1971), but in a cyclical version.

An extremely interesting and thoughtful treatment of the temporal organization of arousal and selective attention has been given by Killeen (1975). Killeen dealt with these mechanisms in a framework of temporal conditioning, a field that has undergone a rapid development in recent years. He took the amount and *type* of observed behavior between two successive instants at which food is delivered as indicative of the operation of two attention-related mechanisms. Briefly, after the first of these instants there is an increasing tendency to show generalized activity, indicative of the state of arousal of the organism. The rate of increase is dependent on the organism's expectancies about when the next food-delivering will occur. At the same time, however, there is also an increasing tendency for selective behavior to interfere with and inhibit general activity; this tendency is observable as a progressive reduction of generalized behavior and a display of "freezing" or other orienting behavior. This pattern of behavior shows great generality across experimental situations as well as species. Killeen demonstrated that the process is highly adaptive to the temporal structure of the feeding cycle, within a range of at least 2 min. Within this range the pattern of generalized activity is not time-locked to the feeding instant, but is posited at approximately 0.3 or 0.4 of the inter-feeding interval. At the next feeding instant orienting behavior, and thus response preparation, is maximal.

Although this research refers to a somewhat specific area of behavior, it underlines the importance of tuning for the optimal organization of behavior. It is also suggestive of the sort of mechanism which is at work in the processing of sequential events.

V. SUMMARY AND CONCLUSIONS

The attentional mechanisms and the precategorical and primary memories seem to offer a parsimonious — albeit oversimplified — description of the properties of the specious present. How the present behaves depends on the organization of the event sequences and on the higher order rules available to the subject. It also seems likely that at a low level subjects adhere to principles of organization (Gestalt rules) that may be considered as referring to primary or precognitive processing.

The conscious present emerges whenever the subject is engaged in the more complex or ambiguous cases of detecting or constructing pattern. With respect [**106**] to the tuning or adaptation of the organism to the temporal structure of the input, it is held that variations in the present, as it is perceived, reflect the tuning process.

This implies that we must accept the idea that there is a temporal dimension to attention. Not only is it necessary to distinguish between a spatial and a non-spatial (or categorical) component of attention (Janssen, 1976; Wertheim, 1977), a temporal component is also needed.

When the subject is paying attention to temporal relations, effort is allocated that cannot be allocated elsewhere (Hicks, Miller, & Kinsbourne, 1976; Michon, 1972; Thomas & Weaver, 1975). This runs partly counter to the position of Keele, who held that the tuning process might not require effort at all (Keele, 1975; Keele & Boles, 1973). Michon's (1966) technique of measuring mental load by a secondary interval production task seems to support this; no detrimental effect of the secondary task on the main task was found. However, Keele's conclusion may well be attributed to a difference in the degree of training of the subjects with respect to the temporal versus spatial components of the task, or to a difference in the complexity of these components — the temporal structure of many laboratory tasks does not put a heavy tax on the capacity of the system. Additionally, training in finding spatial positions (keyboard musicians, Go players) may result in an effortless processing of spatial patterns.

If we acknowledge the three-dimensional character of the attentional field, the effects of task performance on the subjective experience of the present and of the subjective flow of time — will become accessible to more precise predictions.

A. The Time Estimation Paradigm

The foregoing analysis of the relation between the conscious present, especially its duration, and the processing of information suggests an experimental paradigm to supplement the RT paradigm commonly used in performance studies. The rationale follows directly from our principal thesis that the subjective present is a mode of information processing which reflects the processing of temporal information. Given the limited capacity of the subjects they will, when asked to estimate time, either pay attention to the *temporal* information of the situation or to their main task. When absorbed by the task, no spare capacity is available to notice the passage of time, and consequently time seems to pass quickly; when the task is simple, much attention can be spent on time passing and estimates will be long. The relation between time experience and information processing in general determines the most dramatic confrontation with time that we know: the variability of the subjective speed of time. This phenomenon has been studied in some detail (see Fraisse, 1967; Hicks, Miller, & Kinsbourne, 1976; Michon, 1972; Pöppel, 1978; Vroon, 1973a, b, for useful reviews). Only recently has a more systematic approach been adopted in which not only the [**107**] are considered (e.g., Mo, 1975, 1976; Thomas & Cantor, 1975). Thus, Time Estimation (TE) has become a within-task instead of a between-tasks paradigm, and should he especially useful in such tasks where there is a certain temporal structure in the processing of information. For instance, if there is a pause in the input or in effect of a particular task on experienced duration is observed, but also the specific properties of the stimuli the processing, no "time" is added to experience, and consequently our estimate of duration would tend to decrease (Michon, 1977). One interesting application of the TE paradigm is that of Noizet and Do (1972/73), who looked at the TE for French sentences of various types and de-rived some distinctions between, for example, embedded versus right branching clauses, or noun phrases differing only in the use of *qui* versus *que* as a connective.

There are several candidate models that may give the TE-paradigm a good quantitative basis. Some of the more recent ones were proposed by Michon (1967b), Wing (1973), Thomas *et al.*(1974; 1978) and most recently Vorberg and Hambuch (1978)). Of these, only Thomas (and to some extent Michon, 1967b, Ch. 5) thus far dealt explicitly with the trade-off between temporal and nontemporal information.

A consistently applicable experimental paradigm for the adoption of TE remains to be found but given such a standard procedure, it may be expected that TE will become a very useful tool, in which we will find that the large trial-to-trial variability in time estimation data, originally taken as a headache of time psychologists, does in fact reveal what we are after as performance theorists: the effects of attention and performance on the making of the present.

ACKNOWLEDGMENTS

This study was written while the author was at the Netherlands Institute for Advanced Study N.I.A.S., Wassenaar, The Netherlands.

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