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ASSESSING AUTOMATICITY *

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We propose two principles that should be followed in the study of automaticity for cognitive processes. Both follow from the general rule that experimental research should be guided by a model of the task in question, frequently a process model. The first is that the concept of automaticity is best applied to component processes of complex behaviors rather than to behaviors as a whole. The second is that the criteria chosen for the identification of automaticity should be motivated by the processes in question. Examples are discussed of research programs that are relevant to each principle.

During the past several years, there has been a good deal of concern about the automaticity of cognitive processes. This concern has been evident in two sorts of research programs. One is motivated by the goal of identifying cognitive processes that are automatic, and by describing the role that these processes play in cognition. The other has focused on the development of automaticity through training. Research programs concerned with either issue need to be preceded by a clear idea of the mental events for which the concept of automaticity is potentially appropriate, and a set of criteria that will be both necessary and sufficient to identify automaticity when it is encountered. The purpose

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of this paper is to articulate two principles that ought to be followed in meeting these needs. Both principles follow directly from the general heuristic that empirical research should be guided by a model of the experimental task in question. In the case of research concerned with automaticity, a process model is frequently the one of choice. Such a model typically provides both a clear statement of the processes involved in a task, and a motivation for choosing one criterion of automaticity over another. With such a model in hand, two principles can be prescribed for studying automaticity.

The first of these is that automaticity is a concept best applied to components of complex behaviors rather than to behaviors as a whole. One should always attempt to analyze a behavior of interest into its component processes, and separately study the automaticity of each of these processes rather than try to apply the concept to an ensemble of processes as a whole (see Newmann (1984) for a related point in the context of skill acquisition). In these days of reliance on an information processing treatment of cognition, this may seem like a somewhat obvious prescription, but it is a prescription that has not been filled often enough.

The second principle concerns the criteria that are used to assess automaticity. One should always have a model that specifies the features of component processes that are assumed to accompany the development of automaticity. These theoretical features can then serve as the basis for identifying criteria that can be used to discriminate automatic from nonautomatic processes. These criteria, in turn, typically lead quite directly to operational definitions of automaticity in the chosen task context. Once again, it may seem obvious that one should never proceed to experimentation without being informed by a model, but this has not prevented the study of automaticity as a descriptive rather than a theoretical concept.

Let us consider each of these principles in turn.

Principle 1: Component processes

Long before psychology became an experimental science, Descartes proposed a dualistic view of behavior. According to this view, there was one form of behavior, the *undulatio reflexa*, that was presumed to be elicited by external forces, not driven by an internal will. By contrast, there were other behaviors that had their motivation in internal will, guided by the soul.

There are many aspects of this dualistic theory, of course, that no longer have currency. However, it contains a view of behavior that has persisted in psychological theory: the dichotomy between automatic and voluntary processes. The original conception of this dichotomy, as illustrated by Descartes' theory, was that whole behaviors could be classified as either automatic or not. Psychologists who commented on automaticity in the late 1800's and early 1900's were sympathetic with this view. James (1890), for example, described the act of getting dressed as if the entire act were subject to automation. Likewise, Solomons and Stein (1896) discussed the act of writing as if the entire act could be treated as a whole, and be subject to the development of automaticity. That these early investigators of cognition considered acts as unanalyzable wholes is not particularly surprising, since the concept of elemental cognitive processes was still in its infancy. What is more surprising is that several current investigations of automaticity have persisted in the attempt to study automaticity for entire acts. Of course, it is entirely possible that certain complexes of processes *are* subject to the development of automaticity. But we suspect that this is the exception, not the rule.

There are two errors that may occur if one is not analytic about the processes that may be subject to automaticity and its development. The first, of course, is that one may conclude that a particular behavior is not automatic when, in fact, some important components of it may be. There is a more insidious error that is possible as well: One may conclude that some entire task is automatic, when a careful analysis of the components of this task would reveal that some are not automatic at all. How could this occur? Our research on frequency judgments, presented below, suggests a possibility. In brief, the problem is that without a process analysis, one could design experimentation that permits task processes to proceed in a manner that is not strained, and not influenced by variables that might affect them if they are not automatic (see the discussion of the effect of presentation time on frequency judgments below). Or one might choose variables that are more sensitive to automatic components than to nonautomatic ones. In short, one could construct insensitive tests of automaticity without an explicit model of the processes involved. (See, e.g., Flexser and Bower (1975) and Zacks et al. (1982) for small effects of intention and practice respectively that might have been accentuated given the proper conditions, thus calling into question the automaticity of frequency estimation.) Let us examine how this may have occurred in the study of frequency estimation. Following this, we shall describe cases in which the first potential error may have been omitted: Automaticity may have been missed for some component processes in letter and word identification.

Frequency judgments

By now, many experiments have shown that subjects, both human and infrahuman, are exquisitely sensitive to the frequency of occurrence of events in their environments. Evidence from several lines of experimental work has been used to support the argument that this sensitivity to frequency is a function of an automatic coding and retrieval skill that creates memories of the events in question, memories that in turn can be used to support judgments of frequency that may be required of subjects. The major criteria that have been marshalled in support of the automaticity of frequency processing are insensitivity to competing demands (Zacks et al. 1982), insensitivity to intentional strategy (Flexser and Bower 1975; Howell 1973a, b; Zacks et al. 1982), insensitivity to individual differences (Hasher and Zacks 1979; Zacks et al. 1982), insensitivity to practice (Hasher and Chromiak 1977; Zacks et al. 1982), and insensitivity to development (Attig and Hasher 1980; Hasher and Chromiak 1977; Hasher and Zacks 1979; Kausler and Puckett 1980).

Is the sheer weight of these criteria sufficient to be convincing about the automaticity of frequency processing? Let us first consider the task whose automaticity is in question. Subjects in a typical experiment are shown a series of slides on each of which there is some item, say a word. The number of slides in such a series is typically quite large, perhaps 150. After presentation of the series, subjects are given a list of the items that were included in the slides, and asked to judge the frequency with which each of them occurred.

This is obviously quite a complex task. First of all, there are several options that subjects can use to encode frequency information during the time of stimulus presentation. These might include some form of counting, whether overt or covert. Or it might be the creation of a network in memory which links each presentation of a word with a list marker that can later serve as the retrieval mechanism (cf., Anderson and Bower 1972). Whatever the coding strategy, it is clear that there are options that may be exercised differentially depending on the conditions of the experiment (e.g., length of list, encoding time).

Consider the retrieval task as well. Subjects might try to use their feelings of the subjective strength of a memory trace as the basis on which to produce a frequency judgment. Or, they may have available a multiplicity of created codes as an index of how often an item occurred. Yet still, there may be an actual numerical code that may have been stored as the basis of judgment. Whatever the strategy, there are options. And various studies in the literature have suggested the viability of one or another of these options in different experimental contexts (see, e.g., Hintzman (1976) and Howell (1973a, b) for reviews). In addition to these coding and retrieval strategies, there may be some variety in retention strategies as well. With all these options potentially available to subjects, is it possible that the entire task of coding, storing, and retrieving frequency is automatic? Unlikely. From Bryan and Harter (1897) to Shiffrin and Schneider (1977), one principle about the development of automaticity has been clear: There needs to be little variability in the conditions of execution of an act in order for automaticity to develop and maintain itself. With this in mind, there seems little chance that a skill as potentially complex as judging frequency could be automatic, when viewed as a whole.

The case against the automaticity of frequency processing is strengthened by reexamination of the criteria that have been amassed in its support. One source of data relevant to this reexamination is a series of experiments by Naveh-Benjamin and Jonides (1985).

In one experiment, Naveh-Benjamin and Jonides (1985) examined whether frequency judgments were, in fact, unaffected by competing task demands. The case that Zacks et al. (1982) had made for this claim rested on the fact that subjects who were told to expect both a frequency test and a free recall test gave frequency judgments that were indistinguishable from those from subjects who were led to expect just a frequency test. The rationale was that uncertainty about which test would be upcoming would produce competing task demands. This is a weak manipulation, however, since there is no direct way of calibrating the task demands of these expectations. Instead, Naveh-Benjamin and Jonides (1985) opted for the more traditional approach of a dual task methodology, in which a secondary task varied systematically in its required processing demands. In this experiment, subjects had to engage in a counting task that varied in difficulty during presentation of words whose frequency had to be judged later on. The results of the experiment were unequivocal: Increased processing demand of the secondary task led to a decline in the discriminability and accuracy of the frequency judgments, and to an increase in their variability.

In another experiment in this same series, Naveh-Benjamin and Jonides examined the claim that frequency judgments are unaffected by intention to code frequency. The literature is somewhat mixed on the effect of this variable. There have been reports of a difference between incidental and intentional instructions with respect to frequency coding (Fisk and Schneider 1984; Greene 1984). However, some investigators have found no effect of this manipulation (Flexser and Bower 1975; Howell 1973a, b). One problem with failures to find an effect of intention, discussed by Greene (1984), is that incidental instructions have not fully separated incidental memorization of the material from incidental coding of frequency. A second reason for the controversy is that strategy effects may show themselves only in the earliest stages of the encoding process (Fisk and Schneider 1984). The experiment that addressed these hypotheses included variation in whether subjects intended to code frequency of occurrence for words in a list as well as variation in the presentation time for each of the words. At a presentation time of four seconds, there was no effect of intention to code frequency. However, at presentation times shorter than this, intention resulted in judgments that discriminated better among the actual frequencies, that were less extreme in their underestimation of the actual frequencies, and that were less variable than judgments made under incidental learning instructions.

So it seems that the criteria of insensitivity to capacity demand and insensitivity to intentional coding strategy do not hold up under closer scrutiny. Likewise, Greene (1984) has commented critically on the other criteria that have been used to assess the automaticity of frequency coding as well. The principal reason for the discrepancy between these recent experiments and the previous examinations of automaticity concerns the domain in which the criteria have been applied. Previous studies used fairly coarse applications of criteria to assess automaticity, coarse in the sense that the criteria were applied to the whole task of judging frequency, rather than to its individual components. In combination with some insensitivity in the criteria, such an application of the criteria to whole task performances may have left this enterprise vulnerable to inappropriate acceptance of the null hypothesis: automatic processing. The recent reports of Fisk and Schneider (1984), Greene (1984), and Naveh-Benjamin and Jonides (1985) apply criteria to assess automaticity in a way that isolates individual processes somewhat more finely. This is, of course, consistent with the prescription that individual processes are the proper referent for the concept of automaticity.

In the Naveh-Benjamin and Jonides (1985) experiments, isolation of processes was achieved by manipulating variables that have their effect directly at the time of stimulus presentation. During this time, subjects are encoding each word and updating the information that will be the basis for later frequency judgments. The load and presentation time variables were manipulated such that they could have an immediate impact on the process of encoding each word and updating the frequency dependent code. Our results suggest that this updating may not be automatic, by standard criteria.

Take note that we are not arguing that frequency coding as a whole is not automatic. This argument is inappropriate since frequency coding is too complex a process to assess as a whole. There may be components of it that are automatic, and components of it that are not. Or there may be some strategies of frequency coding that have embedded in them sub-processes that are subject to automaticity. In fact, there could be sub-processes involved in frequency coding that have an automatic character. This may be suggested by the fact that even in the most demanding capacity and presentation conditions in the experiments by Naveh-Benjamin and Jonides (1985), frequency judgments still had some fidelity. All of this suggests that there may indeed be automatic processes implicated. These should be isolated and subjected to further test.

Encoding letters and words

Let us now turn to examination of a second kind of error that is possible in assessing automaticity. The error here is that investigation of a task as a whole may lead one to conclude that the task is not performed automatically, when one or more of the component processes used in completing the task may, in fact, be automatic by acceptable criteria. This issue arises most prominently in several recent demonstrations that purport to disconfirm the automaticity of perceptual processes occurring early in word and letter perception (Francolini and Egeth 1980; Hoffman et al. 1980; Johnston and Dark 1982; Kahneman and Henik 1977; Regan 1981) [1]. All of these demonstrations share a feature in common, a feature that is best illustrated by examining two of the phenomena in question.

The first example is a phenomenon documented in a series of experiments by Kahneman and Henik (1977). In one condition of their experiment 2, subjects had to report the ink color of a word that appeared in a circle located unpredictably to the left or right of fixation. On the other side of fixation there appeared another word that was surrounded by a square. Either of the two words could be neutral with respect to the color response that was required (e.g., shoe), compatible with the response (e.g., red, if the color of the word in the circle was red), or incompatible (e.g., red, if the ink color of the word in the circle was green). Subjects were instructed to remain fixated in the center of the display between the two words at all times.

The main result of the experiment is adequately described by considering three conditions. When both words were neutral with respect to the ink color to be named, mean RT was 906 msec. When the word whose ink color was to be named was itself an incompatible ink name, mean RT was 1108 msec when the other word in the display was neutral. This, of course, is the classical effect described by Stroop (1935). When the word whose ink was to be named was itself neutral but the other word was an ink color which conflicted with the required response, response time was 956 msec. So there was interference caused by the word whose ink color was not in question, although the interference was less than in the condition in which the conflicting word was itself the word whose ink was to be named. Kahneman and Henik (1977) reasoned that this asymmetry in the amount of Stroop interference compromises the conclusion that word encoding is automatic. If it were, then there should have been automatic encoding of both words, and equal interference caused by both.

Before discussing the implications of this experiment, let us consider

[1] Paap and Ogden (1981) also report evidence that seemingly disconfirms the automaticity of early encoding processes for letters, however the procedure used in their experiments is subject to the methodological criticisms outlined by Jonides and Mack (1984).

a second set of experiments by Francolini and Egeth (1980) that purports to disconfirm the hypothesis that early encoding processes are automatic. Francolini and Egeth (1980) had subjects count the number of red letters that appeared in a display. Also present in each display were a number of black characters, either letters or digits. The issue addressed by this experiment was whether the black items would interfere with the subjects' task of reporting the number of red letters that were presented. To assess such interference, Francolini and Egeth (1980) had the black items sometimes be digits that did not correspond to the correct answer about the number of letters. For example, if there were three red letters present in a display, there may have been two instances of the digit '2' in black ink as well. Compared to the presentation of black *letters* among red letters, this arrangement creates a situation somewhat analogous to Stroop's (1935). However, Francolini and Egeth (1980) found that there was no significant interference from the black digits. They reasoned that if the encoding of digits is automatic, there should have been interference from the black digits, analogous to the standard Stroop task. Since they found no such interference, they concluded that the encoding of digits must not be automatic.

How do we interpret these effects and the other reports of failures to detect automaticity in encoding (Hoffman et al. 1980; Johnston and Dark 1982; Regan 1981)? The feature that all these lines of research share in common is that subjects either have uncertainty about the location of the focal stimulus, or their attention is intentionally diverted from the stimulus whose automaticity of processing is being assessed (Johnston and Dark 1982). In the Kahneman and Henik (1977) experiment, for example, the words were shown off the fovea, and subjects had to shift attention to the requisite word. In the Francolini and Egeth (1980) case, the red letters were in unpredictable locations. In all of the cited cases, in fact, it seems plausible to suppose that an attention-switching component was required in addition to the encoding component whose automaticity is in question. Suppose, for example, that subjects did process words and letters automatically. Once processed, however, there could be a late selection of categorized items for purposes of preparing a response (see Van Der Heijden (1984) for support of this model). This second process may be quite effortful and subject to voluntary control. Nevertheless, the first, encoding, may still be automatic. Such a model seems a plausible account of many of the phenomena reported in the literature cited above, including those of Kahneman and Henik (1977) and Francolini and Egeth (1980) [2].

Or turn things around. Suppose attention has its effect quite early, in selecting which aspects of a display will be the focus of further processing. This may be a nonautomatic process, but, once chosen, the attended stimuli may nevertheless be processed completely automatically. This model may also account for some of the phenomena in question (e.g., Francolini and Egeth 1980). Under this scenario, we wouldn't want to conclude that encoding is not automatic. By analogy, consider the effect of giving a visually farsighted observer corrective glasses with which to view a Stroop display (a nonautomatic intervention). This would surely increase the effectiveness of the Stroop effect, but we wouldn't want to conclude from this that the Stroop effect is not automatic.

Let us be clear that we are not advocating one of these models over another for any particular one of these phenomena. What we *are* advocating is that investigators be more process-oriented in their analysis of tasks; this could lead to greater sensitivity to alternative interpretations of the sort sketched above.

The danger in all of the cases we have considered is to conceive of tasks as consisting of a single unitary encoding process. Considered as such, the authors are right: The entire tasks are not automatic. But if we partition each task into an attention directing process and an encoding process, then we may ask separately about the automaticity of each. When partitioned this way, we may not need to abandon the idea that early letter and word processes are automatic.

Reviewing the research on frequency judgments and early encoding processes highlights the importance of the first principle described above: The concept of automaticity is most productively applied to component processes, not to entire complex behaviors. How does one apply this principle, however? Of course, the first requirement is that a process model be developed for any given task that can serve as a guide to the components that may be of interest with respect to the issue of automaticity. For many of the tasks that have been the focus of automaticity research, models already exist that have substantial sup-

[2] It is also a potentially appealing account of the dilution effect reported by Kahneman and Chajczyk (1983).

port on which to rest. So an analysis of component processes is quite feasible already.

The second requirement is that experimental methods must be devised by which to test for the automaticity of any given component. This can be quite a difficult undertaking, depending upon the extent to which the process of interest can be isolated from others that may participate in task performance.

The third requirement is that one must choose the criteria that are to be applied to assess automaticity, and choose the particular way in which these criteria will be operationalized in any given task context. This third requirement is the focus of the second principle that we advocate in the study of automaticity.

Principle 2: Criteria

What are the necessary and sufficient conditions for identifying an automatic process? The literature that dates back to James (1890) lists several possible candidates, all of which, in one context or another, coincide with our intuitions about the nature of automaticity and with formal theories that have been proposed about automaticity and its development (Schneider and Shiffrin 1977). Of the candidates that have been proposed, perhaps the ones most frequently cited are that automatic processes should be free from demands on processing capacity and inflexible – in the sense that voluntary control does not markedly alters them. But these are not the only criteria that have been cited, as illustrated by the list used in the study of frequency coding. How do we choose among these various candidates?

One possibility is to declare that the issue is a definitional one. Several investigators seemed to have adopted this stance. In fact, many investigators cite other investigators as the reference sources for the criteria that they have chosen to use, much as a dictionary uses words to define other words. One problem with this strategy is that since definitional issues are not subject to empirical scrutiny, different investigators could define different sets of criteria as crucial. In fact, this is largely what has happened, although tacitly so. The choice of criteria seems to have become subject to principles of democracy, with individual investigators voting for their favorite candidates. This does not, however, seem to be an appropriate domain for the democratic process to prevail.

Rather, there is an alternative principle to guide the choice of criteria for automaticity. This is that the choice of criteria should depend on the examination of a processing model of the task in question, and the presumed change in processes that attends the development of automaticity. A well-articulated model will specify the component processes involved in a task. This will itself suggest criteria that can be used to assess whether processes have been altered during the presumed development of automaticity, or possibly it will suggest the features of performance that ought to be exhibited by an automatic process in the model. These criteria can then be instantiated in operational definitions specific to the task context. This approach is exemplified in various lines of research, beginning with the work of Schneider and Shiffrin (1977). A case in point is a series of experiments by Naveh-Benjamin and Jonides (1984) concerned with maintenance rehearsal. Let us briefly examine this research since it provides an illustration of how a process model can provide a compelling reason to favor certain criteria over others.

Developments in memory theory since the proposal of a levels of processing framework by Craik and Lockhart (1972) have led to the view that there are two separately identifiable sorts of rehearsal. One has been called elaborative rehearsal, the process by which information in a short-term store is recoded so as to produce a longer-term trace. The other type of rehearsal has been called maintenance rehearsal, referring to rote repetition. Elaborative rehearsal has been characterized as an effortful process that frequently involves quite conscious strategies, while maintenance rehearsal is seen to be more automatic in character.

Based on prior experimental work, Naveh-Benjamin and Jonides (1984) hypothesized that maintenance rehearsal comprises two sub-processes, consistent with Baddeley and Hitch's (1974) view of short-term memory as a central processor and an articulatory loop. As applied to maintenance rehearsal, the central processor is responsible for retrieval of an articulatory code of the verbal material that is to be rehearsed. The second sub-process, which includes the use of an articulatory loop, involves the repetitive execution of this code, which results in the recycling that is characteristic of this type of rehearsal. The first sub-process, the retrieval of the code, was hypothesized to be a process that is less automatic than the loop since it involves potentially effortful search through memory. The recycling of the retrieved material, by contrast, was hypothesized to be quite automatic in character. This view led to the test of three plausible differences between the two presumed sub-processes of maintenance rehearsal: The second sub-process should be less demanding of resources than the first. Second, once initiated, it should be less susceptible to interruption by competing activity that interfered with the act of articulation. And third, as maintenance rehearsal progressed, the articulations themselves should become more and more stereotyped, since they are presumed to resemble a taperecorder loop. These three criteria, demand on capacity, susceptibility to interruption, and stereotypy, served as tests of the automaticity of the second sub-process relative to the first, and relative to elaborative rehearsal. The experiments that implemented these criteria showed a nice convergence among them: The later portions of maintenance rehearsal were more automatic in character than the first, and than any portion of elaborative rehearsal. Of concern to us here is the choice of criteria that were used in this research. The ones chosen were motivated by the particular theoretical view of maintenance rehearsal that was hypothesized. Note that one of the criteria by this choice, stereotypy, is somewhat atypical of those that appear in the automaticity literature. Yet it was motivated by virtue of the model that was adopted.

We should note that there is one potentially troubling aspect of this second principle for assessing automaticity. The idea at the core of this principle is that models of processing ought to inform us about the characteristics of automaticity in any particular context. Does this imply that there is really no unified concept of automaticity that cuts across the particular tasks and paradigms that appear in the literature? It is too early to tell. It is intriguing, however, that similar criteria recur quite frequently in many studies of automaticity. The central ones that recur most often are light demand on capacity, and insensitivity to voluntary control. It could be that these features recur only because they are the most frequent ones that are tested. Rather, though, their recurrence may be a function of the frequently implicit intuitions of investigators about the most appropriate characteristics in their particular tasks. To investigate whether these characteristics do have some transsituationality, though, there has to be more systematicity in the choice of criteria, and in the motivation for these criteria.

Application of the two principles that have been discussed will promote an assessment of whether the concept of automaticity has value beyond any task context. Analysis of performance into component processes will allow us to apply our knowledge about the automaticity of these processes to various different task performances in which these processes participate. Coupled with a better motivated choice of criteria to assess automaticity, this research strategy should allow us to better generalize the study of automaticity across tasks.

In his 1890 *Principles*, James remarked that 'If an act became no easier after being done several times, if the careful direction of consciousness were necessary to its accomplishment on each occasion, it is evident that the whole activity of a lifetime might be confined to one or two deeds – that no progress could take place in development'. James was talking about automaticity in this passage. Let us hope that he was also *not* talking about the *study* of automaticity.

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