12 Attention, Automaticity, and the Ability to Stop a Speeded Choice Response

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ABSTRACT

This chapter reports an investigation of people's ability to inhibit their responses in choice reaction-time tasks, when given a signal not to respond at various delays after the onset of the choice stimulus. Responses that could not be stopped were considered ballistic; responses that could be stopped were considered subject to attentional control. Two experiments were conducted. The first varied event and temporal predictability of the stop signal to examine strategies that subjects use to control the probability of inhibition, and the second varied discriminability and stimulus–response compatibility to localize the point in processing at which responses become ballistic. The findings suggest that people have some strategic control over whether or not they respond in choice reaction-time tasks, which they can exercise up to the point at which the physical response is initiated.

INTRODUCTION

The distinction between automatic and attentionally controlled modes of processing is generally considered to be important in understanding the mechanics of complex cognitive activity. Very generally, the distinction reflects a difference between processing that is controlled by the "stimuli" in the task environment and processing that is controlled centrally, by attentional mechanisms. This general view has several empirical interpretations, each focusing on a different implication of the same idea. For example, the dual-task method for distinguishing the two modes of processing exploits the idea that the capacity for attentional control is limited (Logan, 1979; Posner & Snyder, 1975). The unattended-channel method exploits the idea that automatic processes are stimulus driven. Stimuli or stimulus dimensions are presented outside the focus of attention and their effects on the attended task are measured (Posner & Snyder, 1975).

The present experiments explore a third empirical interpretation that reflects the distinction between stimulus control and attentional control more directly. They investigate subjects' ability to stop a speeded response after the eliciting stimulus has appeared. Subjects are engaged in a choice reaction-time task and, occasionally, a tone sounds which indicates that they should not respond on that trial. Whether or not subjects are able to inhibit their responses is the main variable of interest: Responses that can be stopped in response to the signal are clearly subject to attentional control, whereas responses that cannot be stopped are clearly beyond attentional control, hence automatic.

A similar distinction has proved useful in the study of rapid movements of the eyes and hands: Responses that can be modified to accommodate changes in the eliciting stimulus are considered *controlled,* whereas responses that cannot be modified to accommodate changes in the stimulus are considered *ballistic* (Lisberger, Fuchs, King, & Evinger, 1975; Megaw, 1974). These studies show that simple movements are neither purely ballistic nor purely controlled.

The present experiments investigated a similar distinction in choice reaction time using three types of parameters: The first, and most important, was the delay between the onset of the choice stimulus and the onset of the stop signal. Surely, all subjects would be able to inhibit their responses if the stop signal occurred well before the choice stimulus appears, and no subject could inhibit a response if the stop signal occurred after it. The points between these extremes describe an *inhibition function,* relating the probability of inhibiting a response to the delay between the onsets of the choice stimulus and the stop signal. Inhibition functions were obtained in each of the two experiments in the present investigation.

The second type of parameter affected subjects' ability to predict the occurrence of the stop signal and was used in the first experiment to investigate strategies that subjects may develop to exploit the predictability. Predictability was varied in two ways: The probability that a stop signal would occur on a given trial was varied (*event predictability,* $p = 0.1$ or 0.2), and the delay of the stop signal varied randomly within blocks or was fixed for a block of trials (*temporal predictability*). Stop signals with low probability or with delays that vary randomly would be unpredictable relative to stop signals with higher probability or with delay fixed for a block of trials. Increasing predictability generally improves performance with the predicted stimuli; thus, subjects should be better able to inhibit responses when the stop signal is more predictable.

Studies using the stop-signal methodology with simple reaction-time tasks suggest that subjects improve their ability to inhibit by sacrificing speed in the reaction time task: They appear to impose a delay between detecting the reaction-time stimulus and responding to it that is proportional to stop-signal delay, in order to increase the chances of detecting the stop signal (if it occurs) before responding (Lappin & Eriksen, 1966; Ollman, 1973). In choice reaction-time tasks, this sort of strategic adjustment should be apparent as a speed–accuracy tradeoff: In choice tasks, evidence for one response or the other is generally believed to accumulate over time, so if a delay were imposed before responding in order to improve the chances of inhibiting, any responses that resulted would be based on more evidence and hence would be more accurate. Moreover, if *latency operating characteristics* were calculated to reveal the fundamental relation between speed and accuracy, conditions that yield different mean reaction times, error rates, and probabilities of inhibition should yield equivalent latency operating characteristics. These possibilities were explored in Experiment 1.

The third type of parameter, varied in Experiment 2, affected the elementary processes recruited to perform the task (i.e., encoding and response-selection operations). They were included to provide information about structural limitations on the ability to inhibit. By observing the effects of these parameters on inhibition functions as well as on reaction time, it may be possible to estimate the point in processing at which responses become ballistic.

EXPERIMENT 1

Method

Subjects. Sixty-four undergraduate students from Erindale College participated in one 1-hr session to fulfill a course requirement.

Apparatus and Stimuli. The stimuli for the choice task were the letters A and B (uppercase), presented singly in the center of a cathode-ray tube (Tektronix Model 604 equipped with P31 phosphor) under the control of a PDP-11/03 laboratory computer. The letters were formed by illuminating approximately 20 points in a 5×7 dot matrix. One point was illuminated every 78 μsec. Viewed at a distance of 60 cm, each letter subtended $0.43 \times 0.57°$ of visual angle (constant viewing distance was maintained by using a headrest). The letters were exposed for 500 msec following a 500-msec foreperiod during which a fixation point was illuminated in the center of the screen. The interval between trials (i.e., from the termination of a letter to the beginning of the next foreperiod) was held constant at 2.5 sec.

The stop signal was a 500-msec, 1000-Hz tone presented through a speaker behind the cathode-ray tube. It occurred on 10% or 20% of the trials (see following) either 100, 200, 300, or 400 msec after the onset of the letter.

Subjects responded by pressing one of two telegraph keys mounted on the table in front of them. The computer measured reaction time and recorded which key had been pressed.

Procedure. This experiment manipulated stop-signal delay (100, 200, 300, and 400 msec), the probability that a stop signal would occur (event predictability; $p = 0.1$ or 0.2) and the temporal predictability of the stop signal (blocked or randomized delays). Stop-signal delay was varied within subjects, whereas event and temporal predictability were varied between subjects, forming four groups of 16 subjects.

Each subject completed four blocks of 160 trials. The letter A appeared on half of the trials, and the letter B occurred on the other half. At each delay, half of the stop signals occurred when A was presented and half occurred when B was presented. Half of the subjects in each group pressed the right key for A and the left key for B, and the other half did the opposite.

The order of delays was balanced for the two groups for whom the stop-signal delay was blocked. They received one block of 160 trials at each of the four delays, in an order determined by a balanced Latin square. Within each group, four subjects received each order, and the order of delays was orthogonal to the assignment of stimuli to responses. For the two groups for whom the stop-signal delay was random, the four delays occurred equally often within each block of 160 trials. Note that in the random conditions there is a danger that the delays "age"; that is, the stop signal becomes more probable as time passes. However, the aging effect is slight: In the 20% random condition, the probability that a signal will occur at any one delay is .05. Thus, the probability that the signal will occur if it has not already is .050, .053, .056, and .059, for the 100- to 400-msec delays, respectively. In the 10% random condition, the aging effect is half as large.

Whether the delay was blocked or random, every subject received the choice stimuli and the stop signals in a different random order. Subjects were not told of the temporal or event predictability of the stop signal. The instructions emphasized the reaction-time task over the inhibiting task.

Results and Discussion

Probability of Inhibition. The mean probabilities of inhibiting responses when the stop signal occurred are displayed for each group as a function of stop-signal delay in Fig. 12.1A. The figure shows that subjects could inhibit their reaction-time responses if the stop signal occurred early enough, but their ability to do so declined roughly linearly as stop-signal delay increased. The probability of inhibition was affected by both event and time predictability: Increasing the probability that a stop signal would occur from .1 to .2 increased the "intercepts" of the inhibition functions by about .1 but had no effect on the "slopes." Increasing the temporal predictability of the stop signal also increased the probability of inhibition, having a stronger effect at the longer delays (i.e., temporal

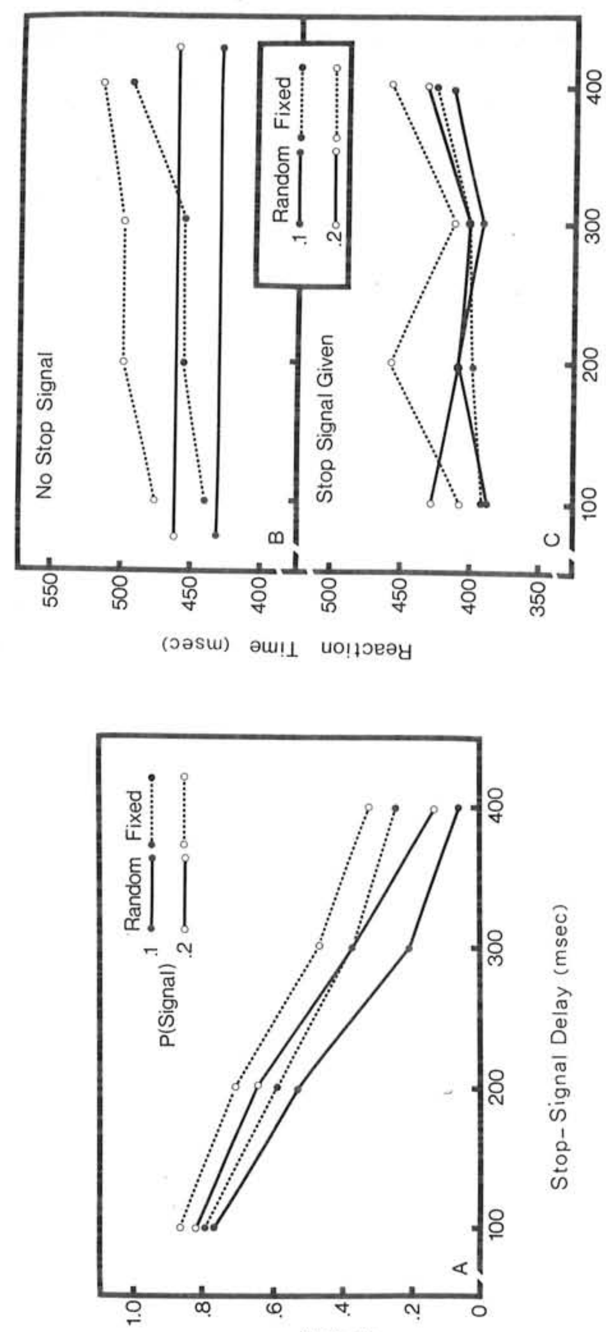

FIG. 12.1. (A) Probability of inhibiting a response as a function of stop-signal delay in Experiment 1. (B) Reaction time in the choice task as a function of stop-signal delay for responses from trials in which no stop signal was presented. (C) Reaction time in the choice task as a function of stop-signal delay for responses from trials in which the stop signal was presented but subjects responded anyway.

predictability affected the slopes but not the intercepts of the inhibition functions).

These conclusions received some support in an analysis of variance on the inhibition data: The main effect of delay and the interaction between delay and temporal predictability were significant, F's $(3,180) = 215.0$ and 3.51, respectively, p's $< .02$, MSe $= .022$. However, the main effects of event and temporal predictability only approached conventional levels of significance, F's $(1, 60) = 2.83$ and 3.23, respectively, $p < .10$, MSe $= .210$. No other effects were significant in the analysis.

Reaction Times. Mean reaction times from trials on which no stop signal occurred are displayed for each group as a function of stop-signal delay in Fig. 12.1B. Note that for the random-delay groups reaction times cannot be associated with particular delays, so the points are "stretched" horizontally across the figure to facilitate comparison.

In general, the figure shows that subjects seemed able to adjust the probability of inhibition by trading speed in the reaction-time task for an improvement in the ability to inhibit; reaction times increased in conditions in which the probability of inhibition increased (relative to controls). In particular, reaction times were longer when the stop signal occurred on 20% of the trials than when it occurred on 10%; in the groups for whom delay was blocked, reaction time increased with stop-signal delay.

These conclusions received rather weak support in analyses of variance performed on the reaction-time data: In an analysis of the fixed-delay conditions by themselves, the main effect of stop-signal delay was significant, $F(3, 90) = 8.16$, $p < .01$, MSe $= 1513.44$. In an analysis comparing the random-delay conditions with the averages over delay from the fixed-delay conditions, the F-ratios for temporal and event predictability were greater than unity but not significantly so, F's $(1, 60) = 2.44$ and 2.34, respectively, MSe $= 7904.03$. These findings replicate those of Lappin and Eriksen (1966) and Ollman (1973) and extend them to choice reaction-time tasks.

Mean reaction times from those trials on which a stop signal was presented but subjects responded anyway (i.e., failed to inhibit) are displayed in Fig. 12.1C for each group as a function of stop-signal delay. Although in general there were too few responses for any stable pattern to emerge (especially at the longer delays), these reaction times were slightly faster than reaction times from no-stop-signal trials. However, the stop-signal-given reaction times were within the range of no-stop-signal reaction times.

Latency Operating Characteristics. In order to evaluate the possibility that the covariation between reaction time and the probability of inhibition was primarily a strategic phenomenon, latency operating characteristics were calculated. For each subject, reaction times in each condition were rank ordered, and the mean reaction time and probability of error in each successive 10% of the distribution were calculated (Lappin & Disch, 1973). The mean functions across subjects in each condition are displayed in Fig. 12.2.

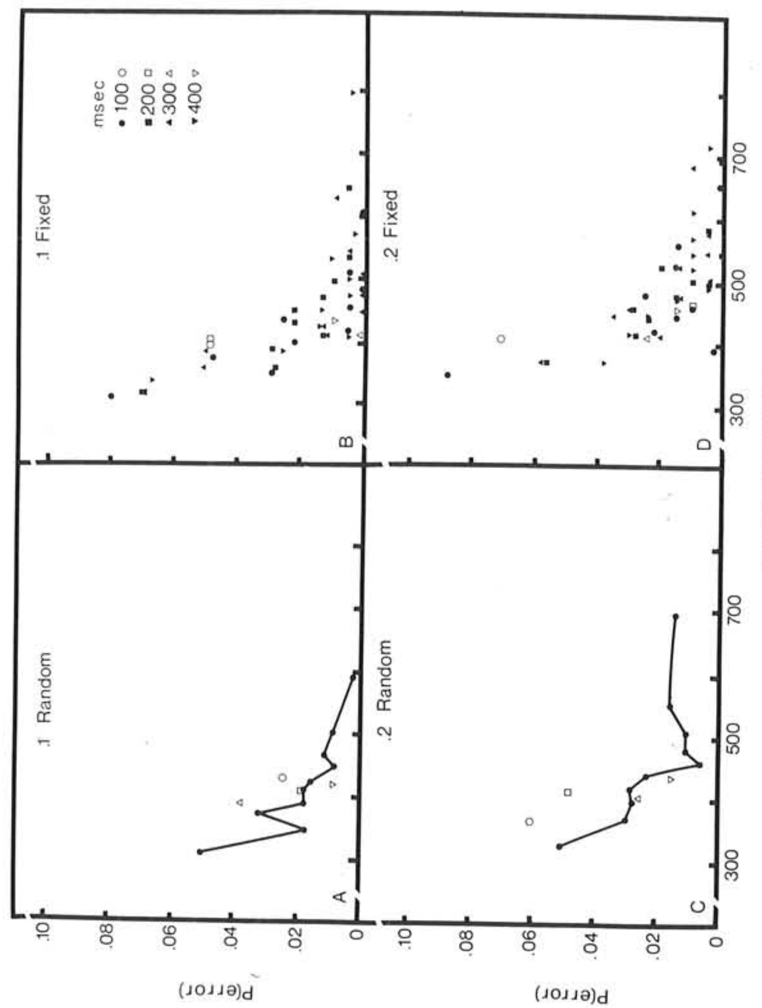

FIG. 12.2. Latency operating characteristics from each condition of Experiment 1.

If subjects delayed reaction time to improve their ability to inhibit (either by increasing the amount of time or evidence required to reach a decision), the error rates should decline proportionately, and conditions that yield different mean reaction times, error rates, and probabilities of inhibition should yield equivalent latency operating characteristics.

Both of these predictions were confirmed in the fixed-delay conditions: Mean error rate declined as delay and reaction time increased (the means were .021, .020, .020, and .016, respectively), and the operating characteristics from the different delays were indistinguishable (see Fig. 12.2B and D). However, the change in the probability that a signal would occur from .1 to .2 actually increased mean error rate (from .019 to .020), though the operating characteristics seemed similar (compare Fig. 12.2A and B with C and D).

Reaction times and error rates from trials on which the stop signal was presented but subjects responded anyway are displayed in Fig. 12.2 as the open symbols. The figure suggests that much of the difference in reaction time can be accounted for by differences in error rate; stop-signal reaction times appear to come from the fast, inaccurate end of the no-stop-signal reaction-time distributions.

EXPERIMENT 2

This experiment was conducted to determine the point in processing at which responses become ballistic. The idea was to manipulate parameters of the experimental situation that were associated with different stages of processing and to observe their effects on the inhibition functions. In general, parameters that affect stages prior to the point at which responses become ballistic should affect the inhibition functions, increasing the probability of inhibition as they increase the duration of the stage. Parameters that affect stages subsequent to the point at which responses become ballistic should have no effect on the inhibition functions, because at that point responses would be beyond attentional control.

The experiment required that subjects indicate the position of an X on the cathode-ray tube by pressing the appropriate telegraph key. The positions were easy or difficult to discriminate, and the responses were compatible (e.g., "press the key under the X") or incompatible (e.g., "press the key opposite the X") with the judged position. Previous research has shown that both these variables affect reaction time, but their joint effects are additive (Egeth, 1977). Following Sternberg's (1969) additive-factors logic, this means that they affect different stages, discriminability affecting an encoding or comparison stage and compatibility affecting a response selection stage.

If responses become ballistic after the first few milliseconds of stimulation (as Lappin & Eriksen, 1966, suggested was true of simple reaction-time responses), neither discriminability nor compatibility should affect the probability of inhibition. If responses become ballistic after the encoding or comparison stage, discriminability should affect the probability of inhibition but compatibility should not. If responses become ballistic after the response selection stage, both discriminability and compatibility should affect the probability of inhibition.

Method

Subjects. Sixteen undergraduate students from Erindale College were paid to participate in four 1-hr sessions.

Apparatus and Stimuli. The stimuli for the choice task were capital X's, displayed singly to the left or right of fixation. The separation between the X's on the left and right varied between blocks. In the wide-spacing conditions, the separation was about 3.01° of visual angle center to center; in the narrow spacing condition, the separation was about .60° of visual angle. Again, the viewing distance, maintained by a headrest, was 60 cm, and each X subtended .43 × .57° of visual angle.

Each X was exposed for 50 msec, preceded by a 500-msec foreperiod and followed by a 2950-msec intertrial interval. A central fixation point was illuminated for the first 250 msec of the foreperiod and extinguished for the last 250 msec.

In all other respects, the apparatus and stimuli were the same as in Experiment 1.

Procedure. Each subject completed four sessions of 640 trials. Each session was divided into four blocks of 160 trials, representing the factorial combination of the two discriminability conditions and the two compatibility conditions (i.e., these variables were manipulated within subjects). In each block, the stop signal occurred on a random 20% of the trials. Stop-signal delay varied randomly within blocks (i.e., low temporal predictability). Four delays were used (i.e., 75, 150, 225, and 300 msec), and half of the stop signals at each delay occurred with X on the right and half with X on the left.

The order of conditions varied between subjects each session and within subjects over sessions according to a balanced Latin square. The instructions emphasized the reaction-time task over the inhibiting task.

Results and Discussion

Probability of Inhibition. The mean probabilities of inhibiting responses when the stop signal occurred are displayed as a function of delay and experimental conditions in Fig. 12.3A. The data in the figure are collapsed over subjects and sessions.

Again, the probability of inhibition declined roughly linearly as stop-signal delay increased. It was clear that the probability of inhibition was affected by discriminability and compatibility; reducing discriminability and reducing compatibility both increased the "intercepts" of the inhibition functions, and neither

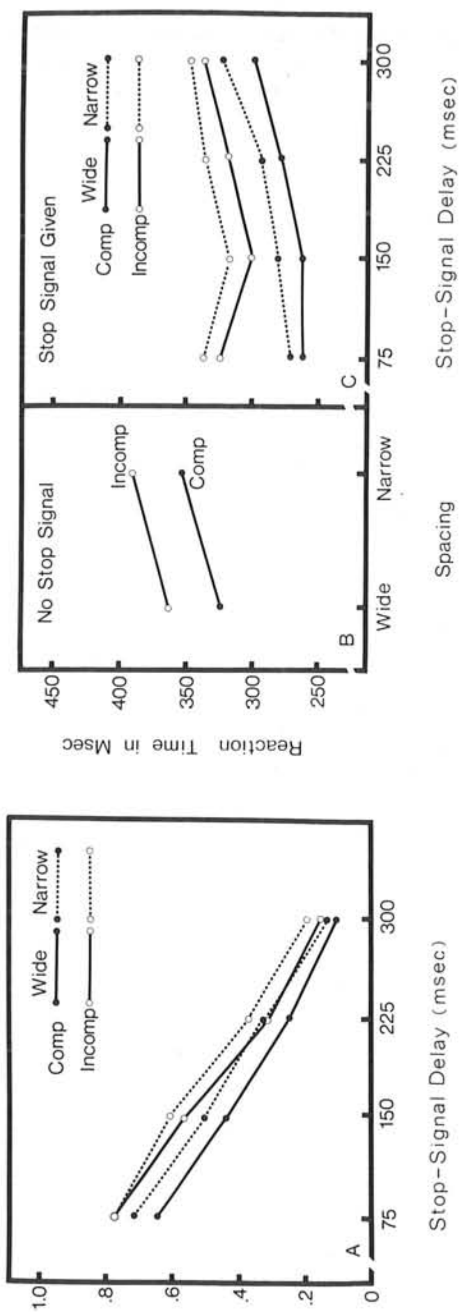

FIG. 12.3. (A) Probability of inhibiting a response as a function of stop-signal delay in Experiment 2. (B) Reaction time from no-stop-signal trials as a function of spacing and compatibility. (C) Reaction time from stop-signal trials as a function of stop-signal delay.

affected the "slopes." These conclusions were supported by an analysis of variance on the inhibition data in which the only significant effects were the main effects of the stop-signal delay, $F(3, 45) = 100.79$, $p < .01$, MSe = .163, discriminability, $F(1, 15) = 16.28$, $p < .01$, MSe = .033, and compatibility, $F(1, 15) = 26.41$, $p < .01$, MSe = .052.

These data suggest a locus for the point at which responses become ballistic: Parameters that affect stages prior to the point should influence the probability of inhibition, whereas parameters that affect the ballistic processes should not. Since both discriminability and S–R compatibility affected the probability of inhibition, it follows that responses become ballistic after the response selection stage.

Reaction Times. Mean reaction times from trials on which no stop signal was given are displayed as a function of discriminability and compatibility in Fig. 12.3B. Note that delay is not a factor because delay varied randomly within each block.

The results replicate previous findings: Reaction time increased as discriminability was reduced and increased as compatibility was reduced; moreover, these effects were additive (Egeth, 1977). These conclusions were supported by an analysis of variance on the reaction-time data, in which the main effects of discriminability, $F(1, 15) = 67.36$, $p < .01$, MSe = 756.16, and compatibility, $F(1, 15) = 28.72$, $p < .01$, MSe = 3065.20, were significant, but the interaction between them was not, $F(1, 15) = 1.91$, MSe = 300.42. The main effect of sessions, $F(3, 45) = 3.06$, $p < .05$, MSe = 3944.33, and the interaction between sessions and compatibility, $F(3, 45) = 7.03$, $p < .01$, MSe = 720.62, were also significant, reflecting improvements in performance with practice.

The mean reaction times from those trials on which a stop signal was presented but subjects responded anyway (i.e., failed to inhibit) are displayed as a function of stop-signal delay and experimental conditions in Fig. 12.3C. Again, there were too few responses for statistical analysis to be reliable, but these reaction times resemble the no-stop-signal reaction times in Fig. 12.3B (i.e., both discriminability and compatibility effects are apparent and seem to be additive). Again, reaction times from responses that escaped inhibition were faster than reaction times from no-stop-signal trials but remained within the same range (see following).

Latency Operating Characteristics. Latency operating characteristics were calculated for each of 14 subjects (2 subjects' data were lost due to disk damage) by pooling reaction times from the same conditions over days, rank ordering them, and calculating mean reaction time and probability of error in each successive 10% of the reaction-time distributions. The average functions across subjects appear in Fig. 12.4.

From the figure, it is clear that latency operating characteristics varied dramatically between conditions; the differences in reaction time and error rate were not simply due to an adjustment of a temporal or evidential criterion. Moreover, the

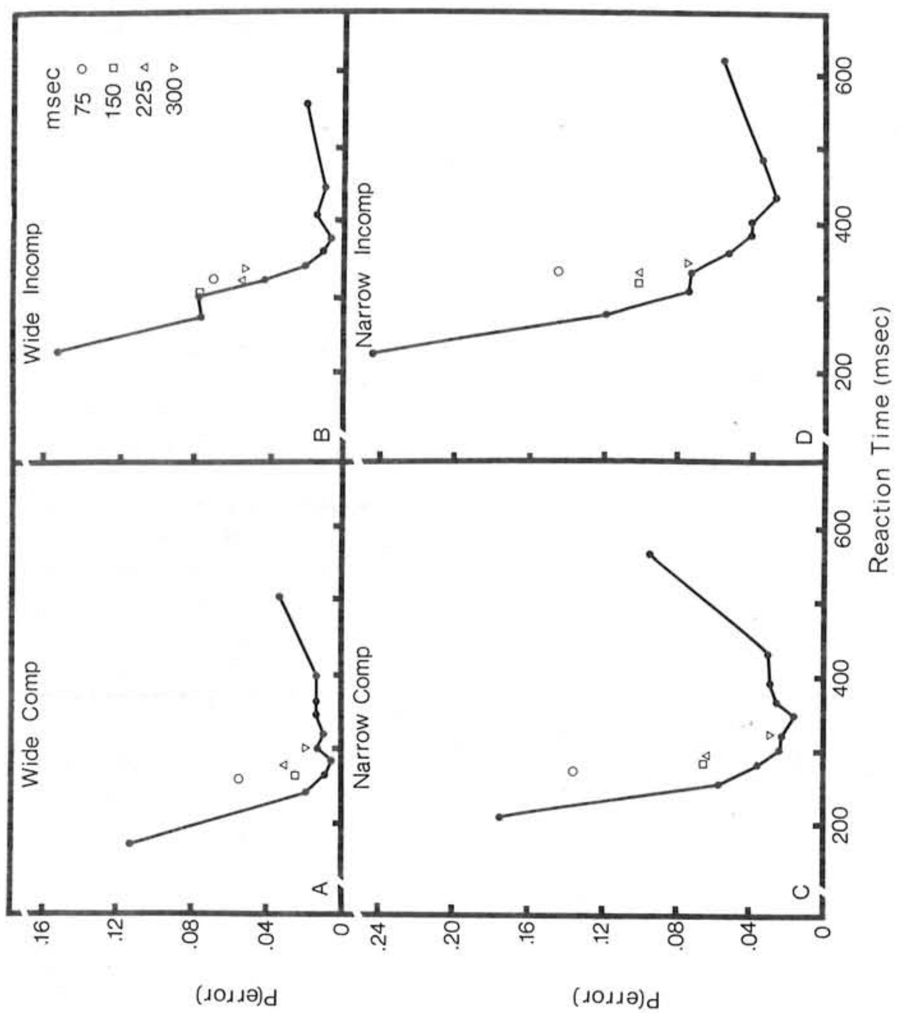

FIG. 12.4. Latency operating characteristics from each condition of Experiment 2.

different manipulations appeared to affect the functions in different ways: Changing the separation between alternative positions from wide to narrow tended to increase the proportion of slow erroneous responses (compare the rightmost points in Fig. 12.4A and B with C and D), while increasing mean error rate from .032 to .060. By contrast, reducing the compatibility of S–R mapping tended to increase the proportion of fast erroneous responses (compare the leftmost points of Fig. 12.4A and C with B and D), while increasing mean error rate from .036 to .056.

Reaction times and error rates from stop-signal trials are plotted in Fig. 12.4 as well (open symbols). Again, they were relatively close to the functions, but in some cases the error rates appeared too high for the reaction times (e.g., the 75-msec delay in the narrow-compatible condition).

Reaction-Time Distributions. The conclusion that responses become ballistic after the response selection stage entails two predictions about the relation between the probability of inhibition and the distribution of choice reaction times: The stop-signal task may be modeled as a "horse race" between the processes responding to the stop signal and the processes responding to the choice stimulus, in which the probability of inhibition represents the probability that the processes responding to the stop signal will finish before the processes responding to the choice stimulus. This probability will depend on both the distribution(s) of finishing times for the stop-signal processes (which will depend on stop-signal delay) and the distribution(s) of finishing times for the choice processes (which will depend on the subject's strategy and the difficulty of the choice task). This means that the probability of inhibition may be increased by presenting the stop signal at an earlier delay or by delaying the choice response, either strategically or by making the choice task more difficult. Thus, the time between the presentation of the stop signal and the response to the choice task should be a better predictor of inhibition than stop-signal delay by itself.

The logic behind this prediction can be seen by comparing the different situations depicted in Fig. 12.5. In Fig. 12.5A, the choice reaction-time distribution is delayed relative to Fig. 12.5B, but the probability of inhibition remains the same because the stop-signal delay has been increased by the same amount. In Fig. 12.5C, the choice distribution is delayed relative to Fig. 12.5B, but the probability of inhibition is different because there was no compensating change in stop-signal delay.

To test this prediction, the inhibition data from both experiments were plotted against the difference between mean reaction time and stop-signal delay in Fig. 12.6A and B. This is equivalent to shifting the points in Fig. 12.1A and 12.3A to the left by an amount corresponding to the differences in reaction time between conditions. Note that the interactions apparent in Experiment 1 disappear in this plot; differences in reaction time provide a nearly perfect account of differences in probability of inhibition. The correlation between the means is .991 in Fig. 12.6A and .992 in Fig. 12.6B.

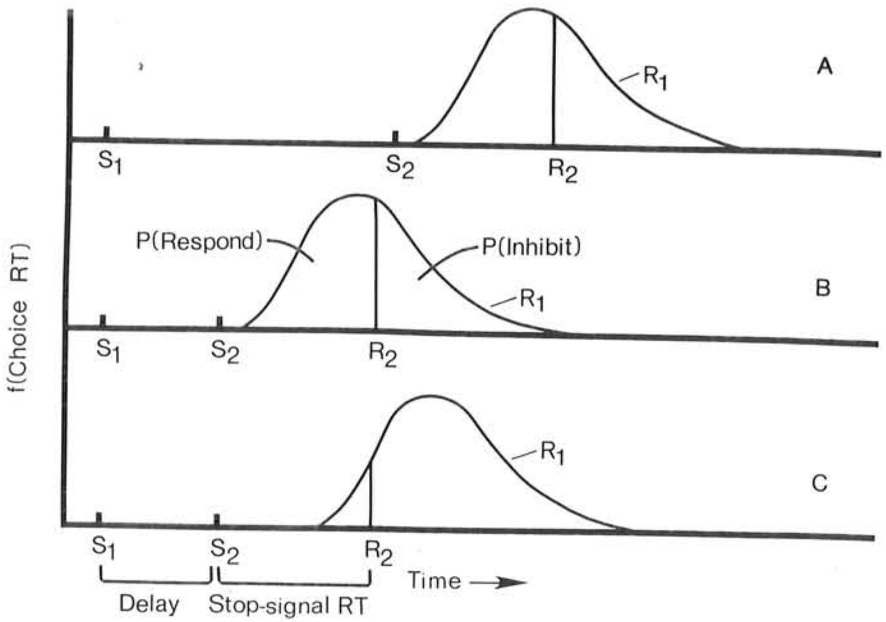

FIG. 12.5. Possible relations among choice reaction-time distributions, stop-signal delay, and "reaction time" to the stop signal (S_1 = choice stimulus; R_1 = distribution of responses to choice stimulus; S_2 = stop signal; R_2 = internal response to stop signal).

The assumption that choice responses can be inhibited up to the point at which the physical response is initiated suggests that it should be possible to predict reaction time to the stop signal, given the probability of inhibition, stop-signal delay, and the distribution of choice reaction times. The logic can also be seen in the situations depicted in Fig. 12.5. To a first approximation, probability of inhibition reflects the proportion of the reaction-time distribution that is slower than the average response to the tone. In the distributions in Fig. 12.5, this represents the area to the right of R_2, the response to the tone. Thus, it should be possible to estimate the time at which a response occurs to the tone by integrating the reaction-time distribution (from zero to infinity) and by finding the point at which the integral equals (one minus) the probability of inhibition. In Fig. 12.5, this amounts to drawing a vertical line through the distribution such that the area to the right of the line equals the probability of inhibition and using the point at which the line intersects the time axis as an estimate of the time at which the stop signal was responded to.

These estimates were calculated for all subjects in Experiment 1 and for 14 of the subjects in Experiment 2. The means across subjects appear in Fig. 12.6C and D for Experiments 1 and 2, respectively. The sloping lines in the two figures

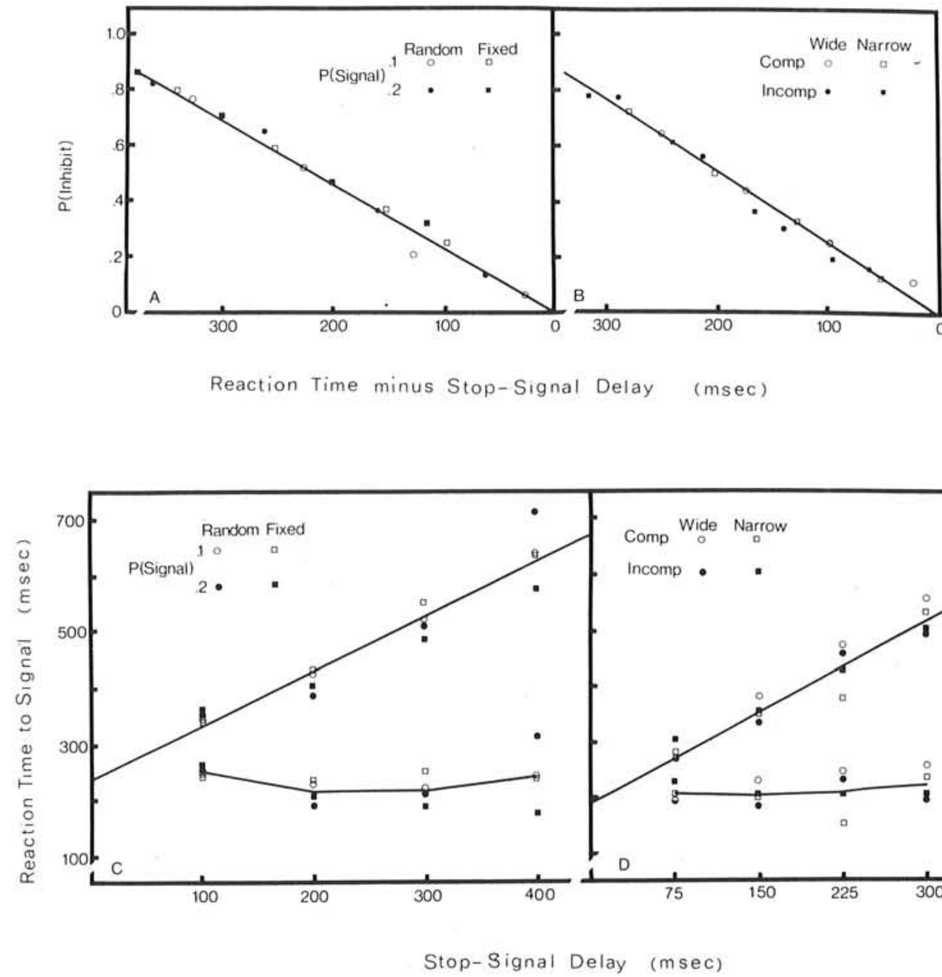

FIG. 12.6. (A) Probability of inhibition as a function of the time between the onset of the stop signal and the onset of the choice repsonse in Experiment 1. (B) Probability of inhibition as a function of the time between the onset of the stop signal and the onset of the choice response in Experiment 2. (C) Predicted reaction times to the stop signal, relative to the onset of the choice stimulus (upper sloping line) and relative to the onset of the stop signal (lower flatter line) in Experiment 1. (D) Predicted reaction times to the stop signal relative to the onset of the choice stimulus (upper sloping line) and relative to the onset of the stop signal (lower flatter line) in Experiment 2.

are drawn through estimates of the time at which the stop-signal response occurred relative to the onset of the choice stimulus and so include stop-signal delay. The zero intercepts of these best-fitting functions are estimates of reaction time to the stop signal, 239 msec for Experiment 1 and 195 msec for Experiment 2. The correlations between the means providing these estimates were .968 and .964, for Experiments 1 and 2, respectively.

The lower, flatter lines in Fig. 12.6C and D are drawn through estimates of reaction time to the stop signal, calculated by subtracting stop-signal delay from estimates of the time at which the response to the stop signal occurred relative to the onset of the choice stimulus. The average of these estimated reaction times was 231 msec for Experiment 1 and 212 msec for Experiment 2. Calculated either way, these estimates are close to what would be expected for simple reaction time to a tone, and the agreement between experiments is encouraging. It is interesting that the estimated reaction times were so fast and were not affected by tone delay. This suggests that the response to the stop signal and the response to the choice task developed in parallel with no interference. This finding stands in marked contrast with typical results when the tone requires a separate, manual response; in those situations, tone reaction time is elevated substantially and strongly affected by tone delay (e.g., Posner & Klein, 1973).

GENERAL DISCUSSION

The experiments have shown that people have some strategic control over whether or not they respond to a stimulus in a choice reaction-time task, and that they can exercise this control up to the point at which the motor system initiates a physical response. Of course, these conclusions may be limited somewhat by the details of the experiments. For example, the experiments involved relatively little practice, and it is possible that, with extended practice, reaction-time responses would become automatic enough to be difficult to inhibit at premotor stages. Further, the experiments provide little evidence on the extent to which having to respond to the tone affected the reaction-time task. Despite these limitations, the experiments have some interesting implications.

First and foremost, the stop-signal method is a measure of automaticity, and the conclusions drawn from the experiments may be compared with conclusions drawn from experiments using other measures of automaticity. Though the stop-signal method addresses the question of attentional control versus stimulus control more directly than do dual-task and unattended-channel methods, it is not a more appropriate measure that should be explored at the expense of the others. Rather, conclusions drawn from the different methods should converge to provide a more accurate picture of the nature of attentional control.

At first glance, the conclusions drawn from the different methods appear to be at variance: Dual-task and unattended-channel measures suggest that reaction-time tasks are largely automatic (e.g., Logan, 1978; Posner & Snyder, 1975), whereas stop-signal measures suggest that reaction-time tasks are largely controlled. However, it is important to recognize that the conclusion, drawn from Experiment 2 and the analysis of distributions from both experiments, that subjects can control reaction-time tasks up to the point at which the motor response is initiated does not mean that the processes prior to motor initiation are necessarily controlled. The experiments merely identify a point of control; it remains possible that processes prior to this point are automatic. For example, the stages underlying performance may each function automatically, and attention may have its controlling influence at the interface(s) between stages. Viewed this way, the present results are relatively easy to reconcile with results from other methods: By and large, dual-task and unattended-channel methods measure the automaticity of component processes, whereas the stop-signal method measures the automaticity of the whole task. Possibly, the components are automatic, but their organization as a set to perform a task requires attentional control (Logan, 1978; 1979).

Possibly, the most important aspect of the present investigation is the relatively direct focus on the function of attention (i.e., to control the execution of mental processes) rather than on derived properties like capacity and selectivity. There are surprisingly few experiments and theories on control processes in the literature, despite a general belief that attention is primarily a control process. Perhaps experiments using the stop-signal methodology, or derivatives of it, can remedy this situation.

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13 Characteristics of Automatism

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ABSTRACT

In this chapter we propose a definition of and some tests for *automatism* and describe certain characteristics of automatism. The development of automatism is explored by assessing the role of consistency of training and by considering the effects of searching for versus finding targets. What can and cannot be automatized is examined by search for conjunctions of features. What is learned during automatism is assessed by transfer and generalization tests.

INTRODUCTION

It is our aim in this chapter to offer a definition and some tests of automatism and to review certain characteristics of automatism, including the conditions under which it develops and the nature of the automatic state.