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ON THE ASSESSMENT OF PROCESSING DEMANDS IN COMPLEX TASK STRUCTURES

Jerry M. Owens and Steven D. Harris

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NAVAL AEROSPACE MEDICAL RESEARCH LABORATORY
PENSACOLA, FLORIDA

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SUMMARY PAGE

THE PROBLEM

Improved performance assessment methodologies are required for measuring and predicting human performance in complex and demanding task environments. Recent studies of human attention and information processing have successfully employed secondary probe task techniques to assess the differential demands placed upon man's "central processor" by various component task performances. Results from previous work have shown that the workload or demand associated with various tasks is dependent upon the type and extent of information processing required by different processing operations upon information. However, most of the research to date utilizing probe task techniques has examined combined task performance in situations involving very simplified primary and secondary task structures. The general applicability of secondary probe task techniques for assessing processing demands in more complex task situations remains to be established.

FINDINGS

A primary task involving successive processing operations upon information including 1) encoding, 2) rehearsal, 3) transformation, and 4) comparison-decision was performed simultaneously with secondary probe tasks requiring simple reaction time (RT) or choice reaction time (RT) responses. The two secondary tasks required different levels of capacity demands and provided a basis for evaluating the processing strategies used by subjects in the competing task demand situation. Probe stimuli occurred an equal number of times during each of the four primary task processing intervals.

Simple RT responses were performed significantly faster than choice RT responses in the secondary probe task. The increase in reaction time for choice RT responses as compared to simple RT responses was fairly constant across all processing intervals of the primary task and suggested that subjects used serial processing strategies to avoid capacity overload. Secondary task error rates increased during the comparison-decision interval of the primary task, and primary task reaction times increased when probes occurred during the transformation and comparison-decision intervals. The pattern of results indicated that demands were greater during primary task intervals requiring transformation and comparison-decision although reaction times to the secondary probe tasks did not provide a sensitive index of the increased demands. These findings suggest that procedural problems associated with controlling the allocation of processing resources to varying combined-task demands may depreciate the utility of secondary probe task techniques in complex task situations.

INTRODUCTION

The skilled tasks performed by human operators in complex man-machine systems often involve a series of processing operations from the point in time information is received until a response is executed. It is widely recognized that certain operations performed upon information require more of the limited human processing capacity than do others. Also, when competing demands for processing resources exist, a greater amount of interference can derive for the human operator if similar or more highly demanding operations are required (11). Practically, such findings imply that 1) less processing capacity will be available for the performance of additional tasks when an operator is engaged in more highly demanding processing operations, and 2) performance in a multiple task situation is highly susceptible to deterioration when interfering processing operations are simultaneously required. It is important for purposes of task design and integration to determine the extent to which various components of task performances can "load" the human information processing system. Furthermore, the direct study of processing in relatively complex task situations is necessary to extend the methods and findings of previous research utilizing simplified tasking paradigms.

Most recently, studies of attention and information processing have attempted to assess the relative demands placed upon man's "central processor" by various component operations upon information. Keele (5) indicated that operations which have been identified to require processing capacity include rehearsal, response selection and initiation, memory search and comparison, mental counting, and movement control. Mental transformations that require the "computation" of answers from stimulus material also impose processing demands (4, 14). The demands associated with transformations vary with the difficulty of the transform and are usually higher than pure rehearsal demands (6). Shwartz (16) demonstrated that perceptual (encoding) as well as post-perceptual (central processing) limitations on processing capacity can occur when perceptual processing capacity is overloaded by competing task demands in the same modality. The previous findings illustrate that the information processing demands of many skilled tasks are often transient within a task structure and vary as a function of the type and extent of processing required.

Most of the research to date on the topic of component task demands has been conducted with the use of simplified tasking paradigms. It is often noted, however, that the relatedness of this work to the complexity of actual task environments is questionable. Nonetheless, a number of provocative insights concerning the nature of man's limited processing capacity have been provided by studies employing secondary task techniques such as those used by Posner and Boies (13). These techniques essentially require subjects to perform various operations on stimulus materials in a primary task and to make simple responses, such as "same" or "different" in letter matching tasks. During the course of primary task performance, a simple reaction time (RT) response to an

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auditory or visual probe signal is also required at a number of temporal positions in the central task. The probes are usually single tones or light flashes and subjects are informed that this is a secondary task. If RTs in the central task remain relatively constant as a function of the temporal position at which the probe occurs, then variations in the probe RTs are hypothesized to reflect fluctuations in the amount of processing capacity required by the central task demands. The secondary probe task technique was used in the present study of complex task performance.

The purpose of the present investigation was to assess the differential processing demands of a complex central task involving various functional requirements of the human operator. The task was not designed to represent any particular task derived from an actual system configuration, but rather was constructed to entail processing requirements which might be common to a number of tasking situations in various systems. Posner (12) pointed out the necessity and criticality of studies involving the abstraction of processing requirements of natural, complex task situations. Such studies represent one way in which improved extrapolations of results from studies of human performance to applied problems may be achieved.

The present research was also designed to evaluate the processing strategies employed by operators when tasks must be performed simultaneously. If a human limited capacity central mechanism operates serially upon incoming information, then the delay for a second task will depend only upon the time that a primary task processing operation requires the mechanism. If, however, the mechanism acts as a parallel system that attempts to process multiple signals simultaneously, then the delay for a second task might depend upon both the amount of time and the amount of space the primary processing operation requires in the mechanism. Kerr (6) indicated that it might be possible to distinguish between serial and parallel processing by using two secondary tasks that require different amounts of processing capacity combined with a primary task with stages known to produce different amounts of interference. If processing is accomplished in a serial fashion, then the interference with the more difficult secondary task will be longer than with the easier secondary task by a constant amount across all stages of the primary task. If parallel processing is employed, the primary task stages requiring more processing capacity would allow less parallel processing and cause greater interference with the more difficult secondary task than with the easier secondary task. Thus, an additive effect in secondary task RT scores would reflect a serial processing strategy, whereas an interactive effect would be indicative of a parallel processing strategy (6).

Two secondary tasks were used in the current study with the more difficult task postulated to require more processing capacity, not merely more execution time, than the easier task. The primary task required a series of processing operations on information including encoding, rehearsal, transformation, and comparison-decision. Based upon previous research, it was postulated that encoding and rehearsal demands would require significantly less processing

capacity than would demands for transformation and comparison-decision. Different amounts of interference between the various primary task processing operations and the processing operations required in the secondary task were therefore expected to occur. It was further assumed that the results derived from the use of secondary probe task techniques in conjunction with the specified tasking structures would not only provide the basis for assessing processing strategies in this combined-task situation, but also would allow an evaluation of the assessment technique for more general purpose applications.

PROCEDURE

SUBJECTS AND APPARATUS

Twenty-eight subjects participated in the experiment. The subjects were all male aviation officer candidates and naval flight officer candidates undergoing training at the Schools Command, Naval Air Station, Pensacola, Florida.

The experiment was fully automated. All stimulus sequences and subject responses were presented and recorded by means of a Data General Corporation NOVA 800 computer. The subjects served in a dimly but diffusely illuminated testing room which was isolated from extraneous noises or other distractions. Stimulus elements for the primary and secondary task displays were located behind one-way glass panels that allowed the stimulus elements to be seen only when illuminated. The stimulus displays for the primary task consisted of two rows of three, 2 cm x 2 cm IEE one-plane readouts mounted one above the other. For the secondary tasks one small white light bulb, 1 cm in diameter, was mounted at each of the four corners formed by the six one-plane readout displays. Red and green feedback lights also 1 cm in diameter, were associated with the central task and were mounted immediately beneath the one-plane readouts. The response keys for the tasks were mounted on a desk-type control console. Subjects were seated at the control console with a comfortable viewing distance to the glass panels of approximately 43 cm. Instructions were presented via a TEAC, Model A-7030, tape recorder.

TASKS

A primary task requiring various information processing operations was performed simultaneously with a secondary task requiring a simple reaction time (RT) response or with a secondary task requiring a choice reaction time (RT) response. The primary task was segmented into four intervals with different processing demands associated with each interval. The intervals were designated to basically require 1) encoding, 2) rehearsal, 3) transformation, and 4) comparison-decision operations.

For the primary task white lights appeared for 0.5 sec in the displays of a row of three IEE one-plane readouts. The lights served to cue the beginning of each trial in the primary task. Immediately following the offset of the white lights three digits from the set of one to eight appeared for 1 sec in the same displays. Subjects were instructed to observe the digits and to remember them. A 2.5-sec rehearsal interval then followed in which the displays were darkened. After the rehearsal interval three arithmetic operators, which were either plus or minus symbols, were presented in a set of displays directly beneath the displays in which the digits occurred. Subjects were told to add or subtract the number one from each of the original numbers which were directly associated with each of the operators. The operators remained present in the displays for a period of 5 sec to allow subjects sufficient time to perform the arithmetic transformations. Three new digits from the set of zero to nine were then presented in the upper row of displays. Subjects were instructed to compare the three new numbers with the results of their calculations and to determine how many of the new numbers were incorrect. If zero or two numbers were incorrect, the subject was to respond by pressing an illuminated response key on the console labeled "even." If one or all three numbers were incorrect, the subject was to press a key labeled "odd." The three digits were present in the display until the subject made a response. A green light, indicating that the response was correct, or a red light, indicating an incorrect response, appeared for 1.5 sec immediately following the key press. A new trial began with the termination of the feedback light; a total of 96 trials were presented in the experimental test sessions.

In the secondary visual probe tasks the subjects were to make a single key press when they detected the brief occurrence of two simultaneously presented white lights. The two lights appeared for 0.3 sec at the upper left and lower right or at the upper right and lower left corners of the primary task displays. In the simple RT condition of the experiment the subjects were instructed to press an illuminated response key on the console labeled "signal" when either of the diagonal light patterns occurred. For the choice RT condition a signal event was defined as the occurrence of the two lights at the upper left and lower right corners, whereas a nonsignal event was defined as the occurrence of the two lights at the upper right and lower left corners. Accordingly, the subject was to press one of two response keys labeled "signal" or "nonsignal" when these events occurred.

The stimulus sequences for the secondary probe tasks were identical in both the simple RT and choice RT conditions of the experiment. Only one probe stimulus could occur during a given trial of the primary task. Probes were presented randomly on one-half, or 48, of the primary task trials with the restriction that 12 probes occurred within each of the four processing intervals of the primary task. A further restriction in the choice RT condition was that 6 signal and 6 nonsignal stimuli occurred during each of the four processing intervals of the primary task. On probe trials equal numbers of "even" and "odd" responses were required at each probe position, and the order of "even" and "odd" responses was randomly arranged. Probes were presented either 1 sec, 2 sec, 5.75 sec, or 9.5 sec following the onset of the white cue lights in the primary

task. Therefore, the probe stimulus presentations occurred 1) 0.5 sec after the beginning of the encoding interval, 2) 0.5 sec after the beginning of the designated rehearsal interval, 3) 1.75 sec after the start of the transformation interval, and 4) 0.5 sec after the test digits were presented in the comparison-decision interval.

METHOD

The twenty-eight subjects were randomly assigned in equal proportions to either the simple RT or choice RT conditions of the experiment. In both groups, subjects first received taped instructions regarding the requirements of the primary task and were presented 24 practice trials on the task. The secondary probe task was then described, and the subjects were allowed 15 practice trials on either the simple RT or the choice RT task, depending upon the group to which they were assigned. After the single task practice sessions the subjects received 24 practice trials on the primary task in combination with either the simple RT or choice RT secondary tasks. As in the experimental test session which followed, secondary probe stimuli were presented on one-half of the primary task trials, and an equal number of probes occurred within each of the four processing intervals of the primary task. The test session was then begun and consisted of 96 trials on the primary task performed simultaneously with either the simple RT or choice RT secondary tasks.

Subjects were instructed to perform as accurately as possible in the primary task and to take as much time as they required to make a response. It was also pointed out that the subjects should not miss making a response when a stimulus occurred in the secondary task. The duration of the combined practice and test sessions was approximately 50 min and the average time of the 96 trial test sessions was 22.5 min.

The data were analyzed by means of a split-plot factorial 2.4 analysis of variance (7). The between subject variable was type of response in the secondary task, simple or choice RT. Probe position during intervals involving 1) encoding, 2) rehearsal, 3) transformation, and 4) comparison-decision was the within-subject variable. Dependent measures included the correctness and latency of responses in both the primary and secondary tasks.

RESULTS

For each subject a median RT for correct responses was determined for secondary task probe and primary task odd-even RTs at each of the four probe positions. Odd-even RTs represent the time to respond "odd" vs. "even" in the primary task as a function of the temporal position of the secondary task probe stimulus. Figure 1 illustrates the mean probe RTs, averaged across individual subject medians, for both simple and choice RT conditions and probe position. The corresponding data for odd-even RTs in the primary task are shown in Figure 2.

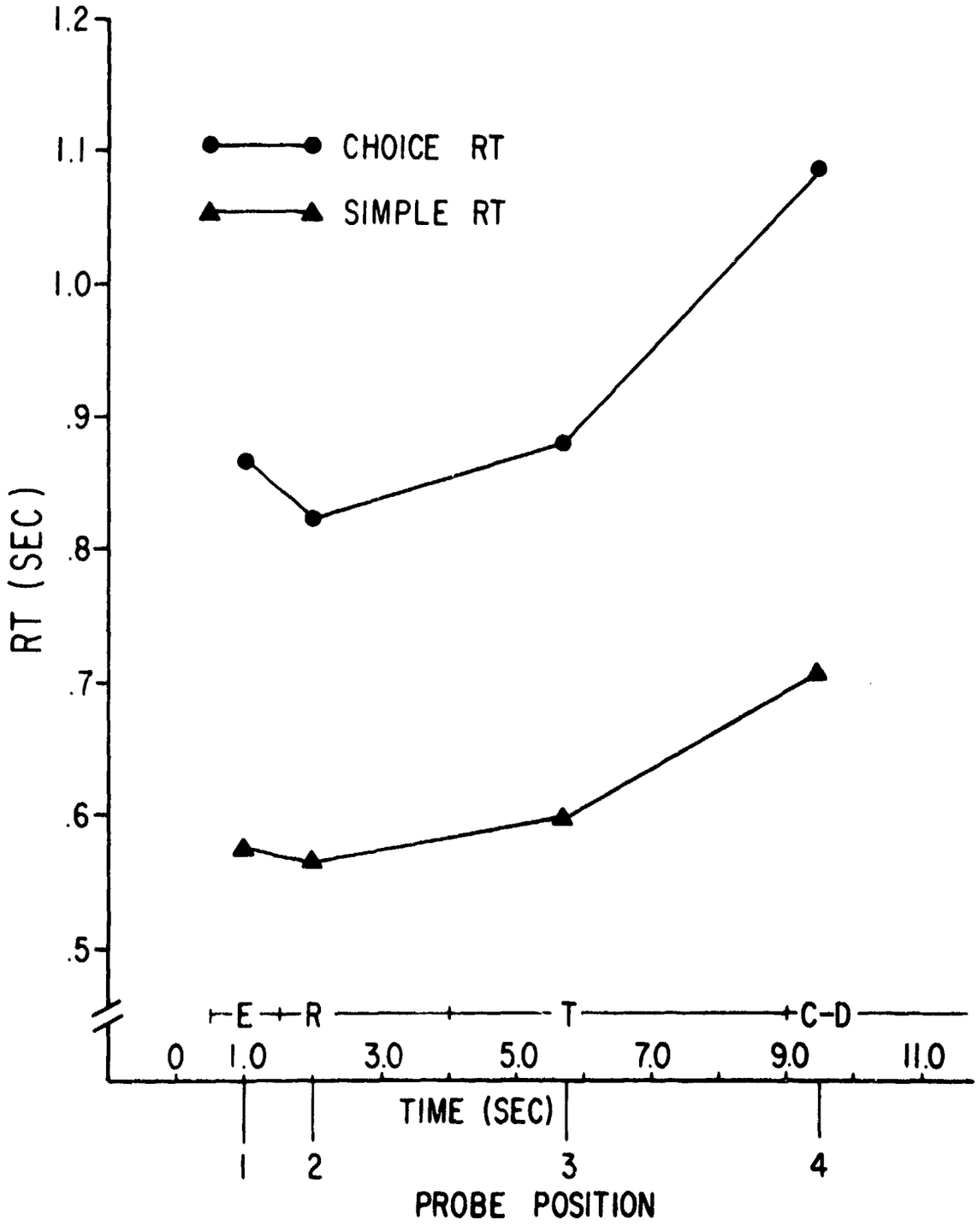

Figure 1. Probe task RTs as a function of probe position during processing intervals involving (E) encoding, (R) rehearsal, (T) transformation and (C–D) comparison--decision. Simple and choice RT conditions.

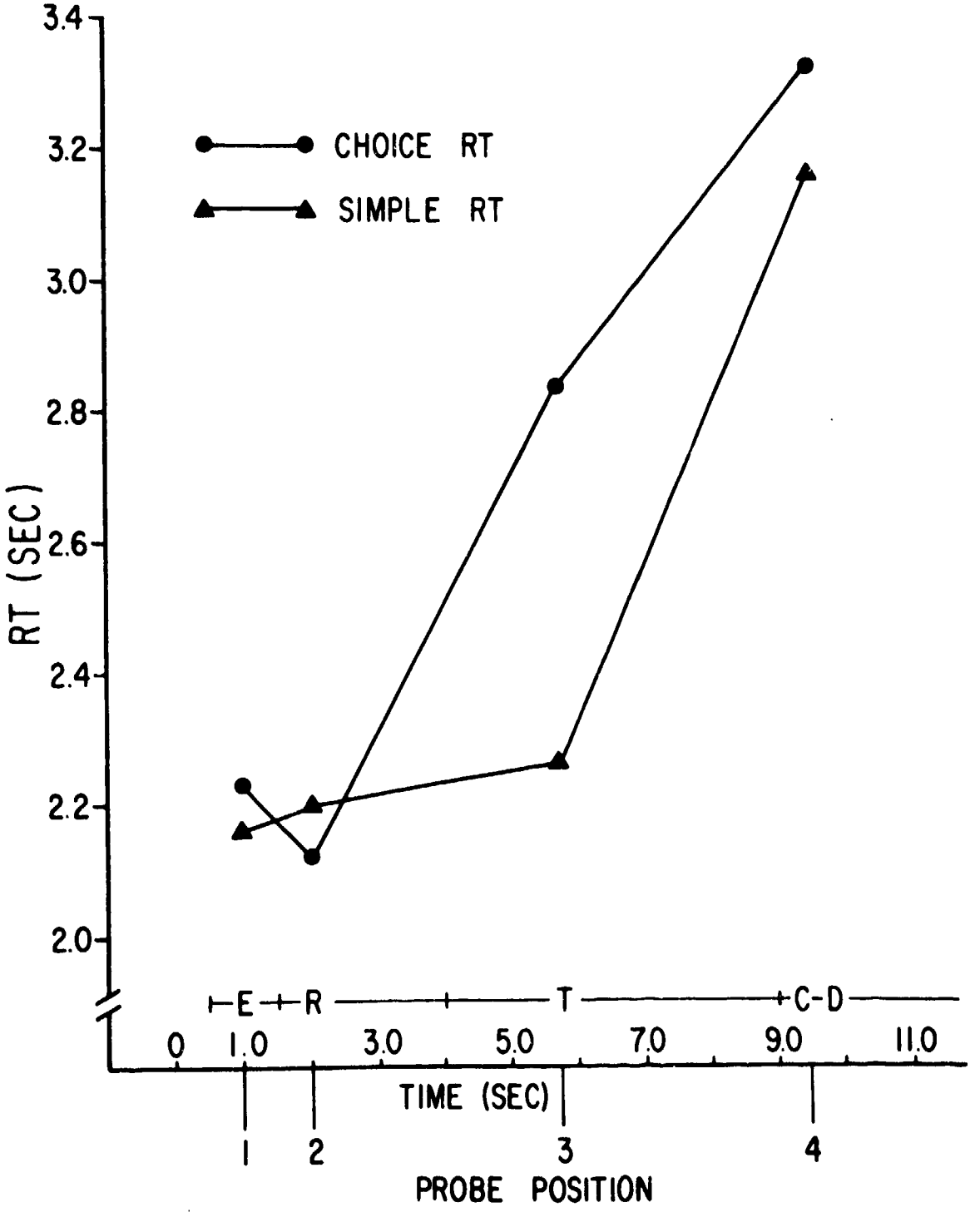

Figure 2. Primary task odd–even RTs as a function of probe position during processing intervals involving (E) encoding, (R) rehearsal, (T) transformation, and (C–D) comparison–decision. Simple and choice RT conditions.

PROBE TASK

The results of an analysis of variance on the median RT data from the probe task are presented in Table I. Simple RT responses were performed significantly faster than choice RT responses ($F = 20.593$, df 1/26, $p < .001$) at all probe positions. The main effect of probe position also proved to be statistically significant ($F = 16.474$, df 3/78, $p < .001$). A post hoc analysis, using the Tukey HSD statistic, revealed that RT at position 4 (comparison-decision) was slower than at positions 1, 2 or 3 for choice RT responses ($p < .01$) There were no differences in simple RT as a function of probe position, however.

Table I

Analysis of Variance Source Table for Probe Task RT

SOURCE	df	MS	F	P
Between Subjects	27			
A - Response Type	1	2.597	20.593	< .001
Subj. w. groups	26	.126		
Within Subjects	84			
B - Probe Position	3	.239	16.474	< .001
A x B	3	.020	1.404	.247
B x Subj. w. groups	78	.014		

The types of possible errors in the probe task were different between the simple and choice RT conditions of the experiment. In the simple RT response situation only errors of omission could occur, whereas errors of omission and choice could occur in the choice RT condition. The errors committed in the probe task are shown in Table II as a function of response type (simple vs. choice RT) and probe position.

Table II

Summary of Error Data in Probe Task

RESPONSE TYPE	ERROR TYPE	PROBE POSITION 1	2	3	4	Total	Rate
SIMPLE RT	Errors of Omission	0	2	1	1	4	0.6%
CHOICE RT	Errors of Omission	0	0	5	8	13	1.9%
	Errors of Choice	4	4	1	14	23	3.5%
	Total:	4	4	6	22	36	5.4%

Each of the 14 subjects in the simple and choice RT conditions of the experiment was presented 48 probe stimuli during the test session. Of the 672 responses required per group, only 4 errors were made in the simple RT condition as compared to 36 errors in the choice RT condition. It is also of interest to note that 61 percent of the errors in the choice RT condition occurred during the comparison-decision processing interval (probe position 4).

PRIMARY TASK

The analysis of variance on the odd-even RT data from the primary task (Table III) indicated that only probe position had a significant effect (F=26.810,

Table III

Analysis of Variance Source Table for Primary Task RT

SOURCE	df	MS	F	P
Between Subjects	27			
A-Response Type	1	.930	.966	.664
Subj w. groups	26	.964		
Within Subjects	84			
B-Probe Position	3	7.122	26.810	< .001
A x B	3	.542	2.041	.114
B x Subj. w. groups	78	.266		

df 3/78, $p < .001$). Post hoc analyses showed primary task odd-even responses were slower if probes occurred at position 4 as opposed to positions 1, 2, or 3 ($p < .01$) when the primary task was performed in combination with the simple RT probe task. When the probe task required choice RT responses, primary task odd-even responses were slower if probes occurred at position 4 as opposed to positions 1 and 2. ($p < .01$). Also, primary task responses were slower when probes occurred during the transformation interval (position 3) as opposed to positions 1 and 2 ($p < .05$).

An analysis of variance on the error data from the primary task failed to reveal any reliable effects of type of response or probe position. A split-plot factorial 2.2 analysis of variance was also performed on the primary task error data with type of response in the secondary task (simple or choice RT) as the between-subject variable and probe vs. nonprobe trials as the within-subject variable. Significantly more errors were made in the primary task on probe trials as opposed to nonprobe trials ($F = 17.161$, df 1/26, $p < .05$). The total number of errors in the simple RT condition was 76 on probe trials and 53 on nonprobe trials. In the choice RT condition, 62 errors were made on probe trials as compared to 54 errors on nonprobe trials. The total error rate on the primary task averaged 19.2 percent for subjects in the simple RT condition and 17.3 percent for subjects in the choice RT condition.

DISCUSSION

Keele (5) indicated that human information processing is limited due to limitations of space and limitations of time. Shwartz (16) proposed that the function of consciousness may be to maximize the efficiency of utilization of the space and time available to the information processing system. When the capacity of a system is overloaded due to limitations of space, a safeguarding attempt will be made to serialize, attenuate, or reject irrelevant signals in order to reduce the overload. On the other hand, if limitations of time do not permit the complete processing of a signal, then an active attempt will try to regulate the speed of processing, often at the expense of efficiency (15).

The two secondary probe tasks used in the present study were proposed to require differing amounts of processing capacity, and subjects were not under a significant amount of time pressure in either the secondary or primary tasks. The RT data from both the secondary and primary tasks suggested that subjects adopted a serial processing strategy when capacity overload was threatened in the choice RT condition. There was no difference between primary task RTs as a function of the type of response to the secondary task, but in the probe task data a significant and fairly constant increase in RT was noted for choice RT responses as compared to simple RT responses. An additive effect in secondary task RTs was predicted if a serial processing strategy was employed.

The increase in primary task odd-even RTs at probe position 3 in the choice RT condition also supports the conclusion that subjects processed information from the two tasks in a serial fashion. The average median response latency for odd-even responses in the primary task on nonprobe trials was 2.394 in the simple RT condition as compared to 2.344 in the choice RT condition. From Figure 2 it can be seen that interference deriving from the secondary choice RT task became apparent when the choice RT probes occurred during the transformation interval of the primary task. The requirements for simultaneous information transformation and choice responding apparently induced subjects to discontinue processing in the primary task, switch to the secondary task to perform a response, and then return to primary task processing. The time available during the transformation interval was sufficient to allow such a serial strategy and the completion of the required calculations before the test digits were presented. In order to protect the adequacy of the stored representation of results deriving from the calculation, however, rehearsal time was probably borrowed from the following processing interval of the primary task. A comparison of the stored results to the test digits and subsequent decision-making could then proceed, but the final odd-even RTs would be commensurately increased. The absence of any systematic effect of probe position on error rates in the primary task indicated that the adequacy of the stored representation of results from the transformation process and, thereby, accuracy in the primary task were preserved in this instance.

It appears, therefore, that subjects adopted processing strategies which allowed them to safeguard accuracy in the primary task when capacity was exceeded due to competing task demands. These findings illustrate that subjects were following experimental instructions to devote more attention to the primary task and to maintain a high degree of accuracy. There were other indications that subjects were attending mainly to the primary task: 1) odd-even RTs in the primary task as a function of probe position did not differ for simple and choice RT response conditions; 2) the error rate in the primary task did not differ between simple and choice RT response conditions, and no systematic effects were evident across probe position; 3) the overall error rate in the probe task increased as the demands increased from simple to choice responding (0.6% vs. 5.4%, respectively); and 4) more errors (61%) occurred in the choice RT probe task during the last and more demanding processing interval of the primary task. The significant increase in primary task errors under probe as compared to nonprobe conditions suggests that the probe tasks were sufficiently demanding to create substantial interference between processing operations, but would not necessarily imply that the primary task was of less priority when probes occurred.

Performance was clearly most susceptible to disruption in the last processing interval involving comparison, decision, and, subsequently, response selection and execution in the primary task. Probes occurred one-half second after the test digits were presented, and subjects were instructed to make the simple or choice RT responses before responding in the primary task. It is interesting to

note that primary task RTs under both simple and choice RT conditions were delayed by a significant and almost equal amount in the fourth interval, although simple RT responses to probe stimuli were performed much faster than choice RT responses. These data indicate that very minimal secondary task requirements such as simple RT responses can be highly interfering to a complex and very demanding primary task processing operation. This interference is especially apparent when closely adjacent discrete responses are required or when a fairly continuous response output is required in addition to discrete responding. For instance, Damos and Wickens (2) found that tracking information cannot be processed while central processing involving stimulus identification and responding to digit alternatives is proceeding. Error on the tracking task increased linearly with increased processing load (number of alternatives) on the choice RT task. The findings of Damos and Wickens (2) as well as the present results appear to support the notion that a single-channel, central processing bottleneck limits processing in a high-demand task structure when such processing as stimulus identification, response selection, and response execution are required in a secondary task.

Although probe task RTs in the present study reflected the overall increase in central processing time required for simple decision-making as opposed to simple detection, they did not prove as sensitive to variations in primary task processing demands as might be expected from previous research. The lack of positional effects on probe task RTs across the first three processing intervals of the primary task can seemingly be attributed to the temporal structure and response requirements of the primary task. With sufficient time available during each processing interval of the primary task and responses required only at the end of the last processing interval, subjects could effectively alternate attention between the two tasks without affecting accuracy in the primary task. During the first three processing intervals and also the last interval in the simple RT condition, the serial processing strategy ensured efficient responding to the probe task, irrespective of primary task processing demands. The significant increases in choice RTs and errors during the last processing interval revealed that interference between the tasks was too high for efficiency to be maintained in the secondary probe task as well as in the primary task, even though the serial processing strategy could be employed. It seems reasonable to postulate that if less time were available to subjects during the various processing intervals of the primary task, then RTs and/or error rates in the primary and secondary probe tasks would likely be systematically affected as a function of probe position.

The results of the present study lend further perspective on the use of secondary probe task techniques for the assessment of information processing demands of other combined tasks. Although researchers have successfully employed probe task techniques to evaluate the differential processing demands associated with various component operations upon information, the methodology most often involves the use of simplified primary task structures with information very briefly presented by means of tachistoscopes. In the current investigation which used a more complex, multistage processing primary task, the

probe RT data alone did not provide a straightforward index of the processing demands assumed to be associated with the primary task. However, further analyses of primary task RT data and error rates in the secondary probe task suggested that processing demands were greater during the transformation and comparison-decision intervals of the primary task. These results are consistent with other findings from research employing traditional secondary task techniques in more complex task situations (e.g., 1, 17) which show that the addition of a secondary task often reduces performance efficiency in a primary task. The usefulness of a secondary task measure to reflect differential amounts of workload or processing demand in a primary task is depreciated, however, when performance varies in both tasks.

Due to the procedural difficulties frequently associated with maintaining the primacy of an intended primary task and controlling individual processing strategies, a limited utility may often be realized in the application of traditional secondary tasking techniques to a larger class of more complex tasking situations. Recent studies (3, 8-10) have emphasized the need for improved performance assessment methodologies in order to derive better controlled estimates of combined-task processing demands, human attention capacity, and voluntary attention control. Norman and Bobrow (9, 10) outlined a number of assumptions and requirements which should be considered in the development of future multitask measurement techniques. It appears especially critical that experimental methods must incorporate means for more precisely controlling the allocation of processing resources to various task demands in order to better specify the relationship between performance and the processing resources available under a given set of task requirements. The necessity for such procedural controls and the inadequacies of traditional secondary task measurement techniques become even more pronounced as the number and complexity of simultaneously performed tasks are increased. Systematic examinations of the role of task demands, task structures, priority manipulations and feedback techniques are clearly required to improve methods for measuring and predicting human performance in highly demanding, multitask environments.

CONCLUSIONS

1. A significant and fairly constant increase in reaction time for secondary task choice RT responses as compared to simple RT responses across all processing intervals of the primary task indicated that subjects adopted serial processing strategies when capacity overload was threatened due to competing task demands.

2. Error rates were greater in the secondary probe task when choice RT responses were required as opposed to simple RT responses; more errors occurred in the secondary task during the comparison-decision interval of the primary task.

3. The serial processing strategies enabled subjects to maintain accuracy in the primary task as no systematic differences in error rates were found in the primary task as a function of probe position or type of response required (simple or choice RT) in the secondary task.

4. Primary task RTs did not differ as a function of secondary task response requirements but were affected by probe position; RTs increased during the transformation and comparison-decision processing intervals in the choice RT condition and during the comparison-decision interval in the simple RT condition.

5. Secondary probe task RTs did not provide a straightforward index of primary task processing demands due in part to the structure of the primary task and to the lack of control of processing resources allocated to combined-task demands.

6. Due to procedural problems associated with maintaining the primacy of an intended primary task and controlling subjects' processing strategies, the utility of secondary probe task techniques may be depreciated in more complex task situations such as the one employed in the present investigation.

7. Multitask performance assessment methodologies should incorporate means to control the allocation of processing resources to varying combined-task demands.

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Recent studies of human attention and information processing have successfully employed secondary probe task techniques to assess the differential demands placed upon man's "central processor" by various component task performances. Results from previous work have shown that the workload or demand associated with various tasks is dependent upon the type and extent of information processing operations upon information. However, most of the research to date utilizing probe task techniques has examined combined task performance in situations involving very simplified primary and secondary task structures. The general applicability of secondary probe task techniques for assessing processing demands in more complex task situations remains to be established.

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20. A primary task involving successive processing operations upon information including (1) encoding, (2) rehearsal, (3) transformation, and (4) comparison-decision was performed simultaneously with a secondary probe task requiring a simple reaction time (RT) response or with a secondary probe task requiring a choice reaction time (RT) response. The two secondary tasks required different levels of capacity demands and provided a basis for evaluating the processing strategies used by subjects in the competing task demand situation. Probe stimuli occurred an equal number of times during each of the four primary task processing intervals.

Simple RT responses were performed significantly faster than choice RT responses in the secondary probe task. The increase in reaction time for choice RT responses as compared to simple RT responses was fairly constant across all processing intervals of the primary task and suggested that subjects used serial processing strategies to avoid capacity overload. Secondary task error rates increased during the comparison-decision interval of the primary task and primary task reaction times increased when probes occurred during the transformation and comparison-decision intervals. The pattern of results indicated that demands were greater during primary task intervals requiring transformation and comparison-decision although reaction times to the secondary probe tasks did not provide a sensitive index of the increased demands. These findings suggest that procedural problems associated with controlling the allocation of processing resources to varying combined-task demands may depreciate the utility of secondary probe task techniques in complex task situations.