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PREPARATION COST AND DUAL-TASK PERFORMANCE: FURTHER EVIDENCE AGAINST A GENERAL TIME-SHARING FACTOR

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Preparation Cost and Dual-Task Performance: Further Evidence Against a General Time-Sharing Factor

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Abstract

The time-sharing performance of 12 pilot trainees and 12 subjects with no pilot training was evaluated on 8 dual-task and 4 single-task conditions. Three task characteristics--input modality (auditory or visual), output modality (vocal or manual), and task difficulty (easy or difficult)--were systematically manipulated across conditions in an effort to vary the nature of the specific time-sharing demands imposed. To assess their generality, time-sharing factors were correlated across task conditions. A factor was considered general if it correlated across conditions imposing dissimilar time-sharing demands. The results suggest that (a) neither an ability to time-share efficiently nor an ability to effectively prepare for multiple tasks is a general factor in dual-task performance, and (b) effective preparation for multiple tasks is a skill that increases with piloting experience.

Introduction

In a recent report (Hawkins, Rodriguez & Reicher, 1979) we presented evidence suggesting that a person who is good at time-sharing one set of tasks will not necessarily be good at time-sharing another set of tasks. Thus, we concluded that efficient time-sharing does not represent a general, transsituational ability.

This conclusion was based on data taken from a double-stimulation ("psychological refractory period") paradigm. On each trial, subject were required to respond to each of two independent stimuli, S_1 and S_2. Each trial began with the presentation of S_1. Subjects were told to treat this as the primary stimulus. S_2 could appear at the same time as S_1 or after S_1 at any one of five interstimulus intervals (ISI). The ISI could be as long as 1200 ms. Under these conditions, reaction time to S_1 (RT_1) tends to remain relatively stable as the ISI increases. Reaction time to S_2 (RT_2), however, is initially relatively long and systematically declines with increasing ISI. The elongation of RT_2 at the shorter intervals is called the psychological refractory period (PRP) effect.

Subjects were tested under 8 time-sharing conditions which were formed by the factorial combination of three binary task attributes: Task 1 stimulus modality (auditory or visual), Task 1 response modality (manual or vocal), and Task 2 difficulty (easy or difficult). Under all conditions, Task 2 combined visual stimuli with manual responses. Under these arrangements, each of the 8 time-shared task combinations contained two attribute values in common with 3 other combination, one attribute value in common with 3 others, and none in common with the remaining combination.

Time-sharing efficiency, defined as the amount of Task 2 processing (in ms) completed per ms of Task 1 processing, was found to correlate across task combinations exhibiting common attribute values (and therefore presumably exerting similar processing demands) but not across dissimilar combinations. On this basis, we concluded that time-sharing performance is largely determined by several poorly correlated, task-specific subcapacities rather than by a single general capacity or ability.

In our analysis of the data in the previous study, we assumed that, since RT_1 remained fairly stable across ISI, performance on Task 1 was not affected by Task 2. However, pilot data obtained prior to the present experiment suggests that this assumption is probably incorrect. Subjects responded to Task 1 under two separate conditions. In one, Task 1 was presented alone. In the other, Task 1 was presented along with Task 2 as in the previous study. Again, the instruction to treat Task 1 as primary in the dual-task condition yielded relatively stable RT_1 values across ISI. However, on the average. RT_1 was substantially longer under dual-task than under single-task conditions. Although the magnitude of this effect varied widely across pilot subjects, the effect does indicate that Task 1 performance can be affected by Task 2 processing requirements even when subjects are trying not to allow this to happen.

An interpretation of the effect is suggested by recent work by Gottsdanker (1979). In Gottsdanker's view much, perhaps all, of the performance decrements observed under dual-task conditions are a result of inadequate preparation. In this sense, preparation refers to a variety of preparatory activities a subject can carry out prior to task onset which function to optimize performance once the task actually begins. These activities might include orienting to the appropriate input channel, rehearsing or orienting to task relevant material in memory (e.g., S-R contingencies), assembling the sequence of processing operations needed to complete the task, and the like. On the assumption that such preparatory action cannot be carried out as thoroughly or efficiently for two simultaneous tasks as for one, subjects should be less well prepared for either task under dual-task conditions. Consequently, performance on each task should suffer under dual-task relative to single-task conditions.

On these grounds, we sought in the present experiment to determine whether the effect of diminished Task 1 preparation under dual-task conditions represents a general attribute of performance. That is, does an individual who exhibits a relatively low reaction time cost in association with diminished Task 1 preparation under one set of time-shared conditions show similar results with another, dissimilar set of time-shared conditions?

As we noted previously, time-sharing skills are generally assumed to be important in piloting and in other tasks requiring high rates of information exchange between the operator and his/her environment. Indeed, the results of several studies over the past 30 years have revealed a small but reliable correlation between measured time-sharing and rated piloting performance (Melton, 1947; Trankell, 1959; Gopher and North, 1976: Damos, 1978). Given these results, it is reasonable to suppose that pilots as a group might show more efficient time-sharing performance than non-pilots and that the more experienced a pilot, the more efficient his/her time-sharing performance will be. To investigate these possibilities, we included 12 pilot trainees along with 12 non-pilots as subjects in the present experiment. The trainees reported 30-180 training hours, and 3-1000 flight hours.

Method

Subjects. The subjects consisted of 8 men and 4 women drawn from the University of Oregon paid subject pool, 8 men and 2 woman pilot trainees enrolled in Lane Community College's Flight Technology Program and two student pilots enrolled at the University of Oregon. All 24 subjects had previously participated as paid volunteers at the Oregon Cognitive Laboratory for 2-4 hours. None had previously participated in a dual-task experiment, and none reported auditory or visual deficits. Subjects drawn from the paid subject pool were paid $3.00 per hour and the pilot trainees were paid $3.50 per hour with a $25.00 bonus awarded to all who completed a set of 4 experiments which included the present one.

Procedure. Subjects were tested for about 2 hours on each of two consecutive days. Practice was given on all experimental conditions at the beginning of Day 1. Following practice on Day 1 and beginning at the outset of Day 2, subjects were tested for 84 trials under each of 8 dual task conditions and for 24 trials under each of 4 single task conditions. The order of conditions was counterbalanced across subjects and reversed across days within subjects.

Visual stimuli were displayed on a computer-controlled cathode ray tube (CRT) situated in a small darkened subject cubicle. The subject was seated about 65 cm in front of the CRT display with the middle and index fingers of either the right hand or both hands (depending upon the condition) resting on piano-type response keys. Each trial began with the exposure of a fixation cross which remained in view in the center of the CRT screen for 500 msec. Under conditions in which two visual stimuli were presented, stimulus 1 appeared simultaneously with the offset of the fixation cross and .5 degrees to its left. Under conditions in which stimulus 1 was auditory, a pure 80 db(B) tone appeared binaurally over headphones, onsetting with offset of the fixation cross. Whether visual or auditory, stimulus 1 remained on for 500 msec. Following a stimulus onset asynchrony (SOA) of either 0, 100, 200, 600, 900, or 1200 msec, stimulus 2 appeared on the CRT screen .5 degrees to the right of the position that had been occupied by the fixation cross. When two visual stimuli were present, they subtended a visual angle of 1.6 degrees.

Under all conditions, instructions were to respond quickly and accurately and to treat Task 1 as primary. To facilitate the latter objective, feedback concerning the pattern of Task 1 latencies was given following each trial block.

Time-sharing conditions. Eight dual-task conditions were generated from the factorial combination of three binary variables. The three variables were stimulus 1 modality (auditory or visual), response 1 modality (vocal or manual), and Task 2 difficulty (easy or difficult). The conditions are given in Table 1. Under all conditions, Task 1 contained two stimulus alternatives, each requiring a unique response. Task 1 visual stimuli consisted of the upper-case letters H and N. The auditory Task 1 stimuli were a 600 and a 1400 Hz tone. Under conditions in which Task 1 entailed a manual response, one stimulus required a response by the middle finger of the subject's left hand, and the other stimulus required a left-hand index finger response. Under vocal conditions, subjects responded with the word "RED" to one stimulus and with "GREEN" to the other. Response latencies under vocal conditions were measured by means of a voice-activated switching circuit.

Under all dual-task conditions, stimulus 2 was visual and response 2 was manual. In the easy form of Task 2, stimuli were the digits 2 and 3. Subjects were instructed to respond with the index finger of the right hand when 2 appeared and with the middle finger of the same hand when 3 appeared. The difficult form of Task 2 consisted of two 4:1 S-R mappings: the digits 2, 5, 6 and 9 required a response by the index finger of the right hand and the digits 3, 4, 7 or 8 required a response by the middle finger of that hand.

Table 1

Relations among the eight time-sharing conditions.

	Stimulus 1 - Visual, Stimulus 2 - Visual		Stimulus 1 - Auditory, Stimulus 2 - Visual	
	Easy Task 2 (1:1 S-R mappings)	Difficult Task 2 (4:1 S-R mappings)	Easy Task 2 (1:1 S-R mappings)	Difficult Task 2 (4:1 S-R mappings)
Response 1 - Vocal, Response 2 - Manual	VEV	VDV	AEV	ADV
Response 1 - Manual, Response 2 - Manual	VEM	VDM	AEM	ADM

Single task conditions consisted of the 4 forms of Task 1 generated by the factorial combination of two binary variables--input modality and output modality. These conditions are denoted VV, VM, AV and AM.

Results and Discussion

Mean reaction time (RT) and proportion incorrect responses were calculated for each subject at each of the 6 ISI's for Task 1 and task 2 under the 8 dual-task conditions and for Task 1 under each of the 4 single task conditions. The results, averaged across subject type and days are given in Tables 2a-c. Two aspects of these data deserve comment. First, under dual task conditions, Task 1 RT remained fairly stable across ISI, increasing only slightly at the shortest intervals, while Task 2 RT showed a marked increase between the 1200 and the 0 ms ISI (the PRP effect). This result indicates that subjects were generally able to follow our instruction to treat Task 1 as primary during each trial. Second, Task 1 RT was substantially higher under dual-task than under single-task conditions, suggesting the possibility that preparation state played an important role in the present result. We will return to this point below.

Considered in greater detail, the results of this experiment address several more specific theoretical issues regarding the determination of time-sharing performance. We will now treat these in turn.

Is time-sharing a general ability?

In the earlier report (Hawkins, et. al., 1979(, two alternative measures of time-sharing effectiveness were examined. One of these, the PRP effect, was rejected as a valid index of time-sharing effectiveness because it is confounded by the overall speed of the subject. It appeared that the longer

Table 2[a]. Mean reaction time and proportion incorrect responses on Task 1 under each of the 8 dual-task conditions as a function of interstimulus interval

Task 1

Interstimulus Interval

Conditions	0	100	250	600	900	1200
AEM						
RT	646	612	569	604	598	606
Proportion Error	(.035)	(.027)	(.017)	(.015)	(.013)	(.001)
ADM						
RT	662	648	626	614	614	610
Proportion Error	(.035)	(.018)	(.018)	(.012)	(.009)	(.005)
VEM						
RT	628	610	592	559	567	567
Proportion Error	(.021)	(.023)	(.023)	(.023)	(.011)	(.015)
VDM	670					
RT	670	635	611	575	555	577
Proportion Error	(.018)	(.021)	(.019)	(.027)	(.019)	(.018)
AEV						
RT[a]	675	677	657	654	670	653
ADV						
RT[a]	704	691	671	669	675	676
VEV						
RT[a]	649	648	637	625	630	633
VDV						
RT[a]	657	658	621	622	615	622

[a] Vocal trials were spot monitored for errors during practice. Error rate was found to be negligible or non-existent for all subjects at this time.

Table 2b. Mean reaction time and proportion incorrect responses on Task 2 under each of the 8 dual-task conditions as a function of interstimulus interval

Task 2

Conditions	Interstimulus Interval					
	0	100	250	600	900	1200
AEM RT	999	865	740	538	485	462
Proportion Error	(.027)	(.015)	(.020)	(.020)	(.009)	(.011)
ADM RT	1115	1117	891	661	629	622
Proportion Error	(.025)	(.048)	(.047)	(.047)	(.047)	(.031)
VEM RT	931	843	747	493	465	464
Proportion Error	(.031)	(.024)	(.019)	(.018)	(.015)	(.012)
VDM RT	1089	965	866	667	638	624
Proportion Error	(.055)	(.073)	(.061)	(.048)	(.045)	(.037)
AEV RT	939	846	763	549	499	468
Proportion Error	(.015)	(.033)	(.025)	(.015)	(.018)	(.019)
ADV RT	1025	939	838	696	648	616
Proportion Error	(.035)	(.030)	(.045)	(.069)	(.035)	(.033)
VEV RT	928	833	726	525	473	453
Proportion Error	(.061)	(.023)	(.039)	(.036)	(.030)	(.015)
VDV RT	1055	971	857	670	613	617
Proportion Error	(.064	(.061)	(.047)	(.053)	(.069)	(.059)

Table 2c. Mean reaction time and proportion incorrect responses on Task 1 under single task conditions.

Condition	RT	Porportion Error
AM	452	(.022)
VM	464	(.038)
AV	551[a]	
VV	523[a]	

[a] Vocal trials were spot monitored for errors during practice. Error rate was found to be negligible or non-existent for all subjects at this time.

a person's RT to Task 1, the longer it is before full attention can be turned to the processing of stimulus 2, and hence the greater the delay in responding to that stimulus. In other words, the delay in processing stimulus 2 that constitutes the PRP effect appeared to be determined in large measure by how slow a subject is on Task 1.

To avoid this problem, we devised a measure of time-sharing efficiency, e_{ts}, based on the amount of Task 2 processing, in ms per ms of Task 1 processing. That is,

$$e_{ts} = \frac{RT_{2_{1200}} - (RT_{2_0} - RT_{1_0})}{RT_{1_0}}$$

where RT_{1_0} is the response latency to Task 1 at the 0 ISI, $RT_{2_{1200}}$ is the latency to Task 2 at the longest (1200 ms) ISI, and RT_{2_0} is the latency to Task 2 at the 0 ISI. If no PRP effect were present--that is should RT_2 not elevate at the shortest ISI--the value of e_{ts} would equal 1.00. If the PRP effect were equal to RT_{1_0}, as though no Task 2 processing took place prior to response 1, the value of e_{ts} would be .00. The measure will show a negative value should the PRP effect exceed Task 1 latency.

If time-sharing is a general ability, then time-sharing efficiency, measured by e_{ts}, should be correlated across dual-task conditions. In the previous work (Hawkins, et. al., 1979), we found that time-sharing efficiency was correlated only across conditions exerting similar time-sharing demands on the subject. This finding implies that time-sharing is not a general factor, but, rather, that it is quite specific to the particular processing demands imposed by a task combination, Table 3 shows the results of a correlational analysis of e_{ts} carried out in the present data.

Table 3

Correlation in time-sharing efficiency, e_{ts}, as a function of the number of characteristics shared by two dual-task conditions. Condition codes and split-half reliabilities are given in the top portion of the table. A correlation coefficient of .344 is significant at the .05 level (one-tailed) n=24.

Code	Condition	Reliability	Code	Condition	Reliability
1	AEM	.830	5	VEM	.709
2	ADM	.618	6	VDM	.630
3	AEV	.872	7	VEV	.726
4	ADV	.868	8	VDV	.654

No Common Characteristic

r_{1-8} = .032

r_{2-7} = .118

r_{3-6} = .020

r_{4-5} = .055

Mean r^a = .046

One Common Characteristic

	Input	Output	Difficulty
	r_{1-4} = .121	r_{1-6} = .236	r_{1-7} = .135
	r_{2-3} = $.579^b$	r_{2-5} = $.420^b$	r_{2-8} = .023
	r_{5-8} = .269	r_{3-8} = .330	r_{3-5} = .332
	r_{6-7} = $.404^b$	r_{4-7} = $.390^b$	r_{4-7} = .016
Mean r^a	= .356	.346	.131

Two Common Characteristics

	Input-Output	Input-Difficulty	Output-Difficulty
	r_{1-2} = $.664^b$	r_{1-3} = $.581^b$	r_{1-5} = $.590^b$
	r_{3-4} = $.526^b$	r_{2-4} = .304	r_{2-6} = .323
	r_{5-6} = $.604^b$	r_{5-7} = .219	r_{3-7} = $.404^b$
	r_{7-8} = $.645^b$	r_{6-8} = $.480^b$	r_{4-8} = .330
Mean r^a	.569	.405	.419

[a] Mean r obtained by transforming r to z, calculating mean z, then transforming back to r.

b significant at .05 level

The results closely replicate those of our previous work, which indicates, once again, that the time-sharing demands imposed under the double-stimulation paradigm do not tap a general time-sharing ability.

Is preparation-cost a general ability?

Earlier in this report, we described preliminary data indicating that RT to Task 1 is considerably faster under single-task than under dual-task conditions. Preparation-cost was tentatively interpreted as due to a reduction in the degree of Task 1 preparation under dual-task conditions. We wished to determine 1) whether and to what extent this effect appeared in the present data, 2) whether its magnitude was greater when Task 1 was paired with the difficult rather than the easy Task 2, 3) whether the effect declined with practice, and 4) whether the magnitude of the effect manifested by subjects was correlated across time-sharing conditions.

One problem that developed in evaluating these questions was the small but persistent RT increase appearing at the shortest ISIs in Task 1 under dual-task conditions (see Table 2). This RT pattern, which did not appear in our prior work (Hawkins, et. al., 1979), reflects a failure on the part of some subjects to adequately follow our instructions to treat Task 1 as primary. Consequently, the latency difference between Task 1 under single- and dual-task conditions manifests "on line" time-sharing costs as well as preparation costs. For this reason, we defined Task 1 preparation cost as the difference between mean latency for a given single-task condition (e.g., VM) and Task 1 latency under the corresponding dual-task condition (e.g., VEM) at the 1200 ms ISI. The choice of the 1200 ms ISI latency data was based on the plausible assumption that on-line time-sharing cost would be essentially non-existant at this interval. Table 4 presents data relevant to the first three questions asked at the beginning of this section. The table shows Task 1 RT under three separate sets of conditions (single task, easy dual-task, and difficult dual-task) for each of the two days of training. Each entry represents the mean latency of the 24 subjects averaged across 4 conditions. The single task entry, for instance, is the average RT_1 across conditions AV, AM, VV, and VM, and the easy dual-task entry is the average of AEV, AEM, VEV, and VEM at the 1200 ms ISI. These data were subjected to an analysis of variance with both condition and level of training (day 1 versus day 2) treated as within subject factors. Conditions, $F(2,46) = 110.0$; p .01; level of practice $F(1,23) = 40.13$; p .01; and the interaction of the two factors, $F(2,46) = 11.02$; p .01, were all significant sources of variance. A Fisher's Least Significant Difference (LSD) test revealed that Task 1 RT under both dual-task conditions was significantly slower than under single task conditions ($LSD = 24$ ms; $p = .05$). Thus, Task 1 processing apparently suffered from reduced preparation (Gottsdanker, 1979) under the conditions of the present experiment; but, not significantly more in the difficult relative to the easier form of task 2. Further, the extent of preparation cost declined with practice, which indicates that as performance automates, the importance of specific pre-trial preparation diminishes.

To assess whether preparation cost reflects a general characteristic of time-sharing performance the magnitude of the increase in Task 1 RT between single- and dual-task conditions was correlated across the 8 time-sharing conditions. The results of this analysis appear in Table 5. The condition label AEM appearing in the table identifies the latency difference between Task 1 under the dual-task condition AEM (at the 1200 ms ISI) and the single task condition, AM.

Table 4. Task 1 RT on days 1 and 2 under three conditions: single task, dual task-easier Task 2 and dual task-more difficult task 2.

	Level of Practice	
Condition	Day 1	Day 2
Single Task	522	471
Easy Task 2	675	573
More Difficult Task 2	690	580

The correlation pattern shown in the table is compatible with the idea that Task 1 preparation cost, like e_{ts}, is not a general time-sharing ability. That is, an individual who shows a relatively high measure of preparation cost under one time sharing condition will not necessarily show a high preparation cost under another condition, unless the two conditions contain similar features (e.g., as in the case of AEM and ADM).

We have focused on the effects of preparation cost on Task 1 performance. However, given the instruction to treat Task 1 as primary in the present experiment, it seems probable that Task 2 manifested at least as much preparation cost as did Task 1. However, because Task 2 performance at the shortest ISIs was determined by an unknown mix of on-line time sharing cost and preparation cost, we are unable to estimate the contribution of either factor in determining the value of the PRP effect or e_{ts}.

Preparation cost and the acquisition of time-sharing skill

As shown in Table 4, Task 1 preparation cost declined with practice in the present experiment. However, time-sharing efficiency, e_{ts}, which had an average value of .294 on day 1 and .296 on day 2, seemed uninfluenced by level of practice. Given our assumption that preparation cost should occur in Task 2, and given the fact that the expression defining time-sharing efficiency (eq. 1) includes an index of the PRP effect, the failure of e_{ts} to show changes with practice may seem surprising. That is, if preparation cost diminishes with practice and if preparation cost figures in e_{ts}, why does e_{ts} not show changes with practice? The reason appears to be that preparation cost figures into both the numerator and the denominator of the e_{ts} ratio thus producing a cancellation of effects.

Table 5

Correlation in the magnitude of preparation cost as a function of the number of characteristics shared by two conditions. Condition codes and split-half reliabilities are given in the top portion of the table. A correlation coefficient of .344 is significant at the .05 level, one-tailed (n=24).

Code	Condition	Reliability	Code	Condition	Reliability
1	AEM	.738	5	VEM	.901
2	ADM	.801	6	VDM	.825
3	AEV	.791	7	VEV	.722
4	ADV	.711	8	VDV	.893

No Common Characteristic

$r_{1-8} = .112$

$r_{2-7} = .186$

$r_{3-6} = .206$

$r_{4-5} = \underline{.048}$

Mean $r^a = .138$

One Common Characteristic

Input	Output	Difficulty
$r_{1-4} = .659^b$	$r_{1-6} = .328$	$r_{1-7} = .314$
$r_{2-3} = .328$	$r_{2-5} = .423^b$	$r_{2-8} = .170$
$r_{5-8} = .213$	$r_{3-8} = .239$	$r_{3-5} = .079$
$r_{6-7} = \underline{.420}$	$r_{4-7} = \underline{.209}$	$r_{4-7} = \underline{.317}$
Mean $r^a = .422$	.304	.222

Two Common Characteristics

Input-Output=	Input-Difficulty	Output-Difficulty
$r_{1-2} = .725^b$	$r_{1-3} = .466^b$	$r_{1-5} = .320$
$r_{3-4} = .744^b$	$r_{2-4} = .553^b$	$r_{2-6} = .305$
$r_{5-6} = .762^b$	$r_{5-7} = .164$	$r_{3-7} = .001$
$r_{7-8} = \underline{.771}^b$	$r_{6-8} = \underline{.213}$	$r_{4-8} = \underline{.399}^b$
Mean $r^a = .751$	.360	.262

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[a] Mean r obtained by transforming r to z^1, calculating mean z^1, then transforming back to r.

[b] Significant at the .05 level.

The finding that preparation cost declines with practice relates to the recent finding by Damos (1977) that time-sharing performance on two continuous tasks shows systematic improvement over two days of practice. The present results raise the possibility that these improvements are due to declining preparation costs rather than to improvements in parallel processing or attention-switching efficiency.

Pilots versus non-pilots

Pilots were compared with non pilots on e_{ts}, PRP, Task 1 RT under single-task conditions, and preparation cost. The differences between groups failed to approach significance in all cases. This failure could reflect either, or both, of two factors. First, pilot trainees, even those training to become instructors, may not be a particularly select group in terms of their information-processing capabilities. Second, it is likely that the pilots were less motivated than the non-pilot controls. The non-pilots consisted of individuals who were put in contact with the Cognitive Laboratory through the Student Employment Service at the University of Oregon. Their participation reflected a need to earn money. The pilots, however, were approached during a training session by members of the Cognitive Laboratory staff and were asked to participate for pay in a study that would "advance our understanding of piloting performance". Several of the pilots expressed reluctance to continue the experiment into the second day and some remarked that the pay seemed inadequate given the effort required. On this basis, the failure to observe differences between the groups should be viewed with some caution.

Performance as a function of piloting experience

Damos (1978) found that the correlations between time-sharing and rated piloting performance increases with piloting experience. This suggests that experience provides pilots with transferable time-sharing skills that might show up in the time-sharing measures used in the present study.

Two separate measures of piloting experience were recorded for each pilot: 1) the total number of flight hours (averaging 146), and 2) total training hours (averaging 67). Training hours consisted of non-cockpit instruction. Correlations were calculated between both these measures and e_{ts}, PRP and preparation cost. The results appear in Table 6. The finding that experience correlates marginally with PRP and preparation cost but not with e_{ts} suggests that it is preparation cost that is benefited by experience. It was not initiallyobvious, however, why our measures correlated with training hours but not with flight hours. Information processing skills relevant to piloting should be acquired through experience in the cockpit rather than through experience in the classroom. The reason flight hours did not correlate with our performance measures is traceable to a subject with 1000 flight hours -- by far the greatest number recorded for our pilot subjects -- who showed substantial PRP and preparation cost effects. When the data of this subject are excluded from analysis, flight hours correlate with e_{ts} at .243, with PRP at -.601., and preparation cost at -.591. [c] However, since we had no apriori reason for discarding the data of this subject, these correlations must be regarded with suspicion.

Table 6

Correlations between measures of piloting experience and time-sharing variables

	Flight hours	Training hours
e_{ts}	.191	.207
PRP	-.139	-.561[b]
Preparation Cost	-.289	-.476

[b] A correlation of .506 is significant at the .05 level (one-tailed).

In summary, the major conclusions emerging from this study are that: 1) as found previously (Hawkins, et al., 1979), the parallel processing and attention-switching components of time-sharing do not reflect general abilities; 2) likewise, the preparation cost component of time-sharing performance does not reflect a general ability; 3) none of the performance measures taken in this study differentiated pilots and non-pilots; and 4) a possible relationship appears in the present study between piloting experience and two closely related performance variables--PRP and preparation cost--investigated in the present study.

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[c] A combination of .521 is significant at the .05 level with n=11.

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