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Timesharing in Relation to Broad Ability Domains

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The concept of a timesharing ability has been the subject of considerable interest in recent times. The present study set out to determine whether a timesharing factor can be identified when a number of competing tasks are presented in the midst of a range of single tests designed to sample a broad range of psychological dimensions. Evidence for the existence of such a factor would form an important addition to our knowledge of human cognitive functioning.

The framework for the study was provided by the theory of fluid and crystallized intelligence. A battery of single and competing tasks was presented to 126 subjects. The competing tasks represented a variety of within- and across-factor combinations from different levels of the (Gf/Gc) hierarchy. Modality of presentation was also varied in some combinations. On the basis of evidence presented in this study, it would be premature to seek to include a timesharing factor in the (Gf/Gc) model of intelligence.

INTRODUCTION

Existing Empirical Support for a Timesharing Factor

The ability to perform intellectual tasks of nontrivial difficulty simultaneously has traditionally been considered a sign of superior capacity. In the past, and in our modern world as well, this capacity must have had great survival value. People from all walks of life could justifiably claim that they encounter situations wherein the possession of such a capacity would benefit them enormously.

The concept of an ability to do two or more things at once has been accepted without question by some researchers (e.g., Levine, Romashko, & Fleishman, 1973). Tests requiring the simultaneous performance of two tasks have been in use for many years, apparently on the assumption that they tap an ability which is not tapped by the single tests. Despite its face validity, the evidence supporting this assumption is rather limited.

Research on the topic dates back to McQueen (1917) who concluded that a general ability to distribute attention did not exist. In more recent times the issue has been explored by a number of researchers who have reported conflicting findings. Sverko (1977) compared performance on single tasks with performance

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on those same tasks administered under competing task conditions. He found that the common variance of a component of a competing task is shared with the same task when it is given singly. On the basis of this finding, Sverko concluded that there is no timesharing ability and that performance under the competing task condition can best be predicted from the single tests. However, in a more recent paper, using slightly different tasks and with some improvements in procedure, Sverko reversed his original decision and reported that a factor which was associated mainly with competing tasks was measuring a separate timesharing ability (Sverko, Jerneic, & Kulenovic, 1980). There is the suggestion that this factor has the status of a primary ability in a Thurstonian sense.

Hawkins, Church, and de Lemos (1978) were critical of the notion of a general, trans-situational timesharing ability. They felt that competing-task situations were likely to make demands on a number of separate abilities and that the particular demands could vary from task to task. In a more analytical review, Ackerman, Schneider, and Wickens (1982) conclude that on the basis of existing evidence, the timesharing factor cannot be rejected. They also note, however, that the factor lacks firm empirical support. Continuing debate over this hypothetical timesharing ability points to one of the major problems confronting those interested in the practical application of these measures: for a variety of reasons, competing tasks do not appear to behave in a predictable fashion. This lack of predictability makes them a particularly difficult subject for research. Lansman, Poltrock, and Hunt (1983) go so far as to state that, with unpracticed subjects, ability to perform two tasks simultaneously is specific to the particular combination of tasks employed.

Defining the Nature of a Timesharing Factor

There are many problems surrounding the investigation of this factor. Both Hawkins et al. (1978) and Ackerman et al. (1982) are critical of the methodology employed in the one study (Jennings & Chiles, 1977) most often cited as providing evidence of a timesharing factor. Methodological criticisms extend to studies which have failed to report a timesharing factor. Ackerman et al. note that the few studies directed to the investigation of the timesharing issue have used exploratory factor analytic techniques. The inadequacy of this approach was revealed when Ackerman et al. showed that even a built-in factor was not always detected by exploratory techniques. This does not mean that a timesharing factor cannot be detected by exploratory techniques—the presence of such a factor in the Fogarty and Stankov (1982) study demonstrates that it can—but it does imply that confirmatory techniques are likely to provide a better test of its presence.

Perhaps, the major problem, apart from the methodological issues raised in these two sources, concerns the expectations of the researchers about the nature of this hypothetical factor. As Lansman et al. (1983) point out, there is a great deal of variability in the way different individuals approach the same competing task, and also in the way a given individual approaches different tasks. It is hardly possible for a timesharing factor to reflect a common approach to the problem. It is much more likely that the timesharing factor will reflect processes required to deal with the competing activities.

A review of previous studies of the timesharing factor does not shed much light on the possible nature of any specialized processes that might be called upon in this situation. As a starting point, it can at least be assumed that a large part of the variance in competing task performance can be attributed to the processes responsible for performing the single tests. Sverko (1977) noted this in his study, as did Hawkins et al. (1978). Ackerman et al. (1982) took it to be an a priori assumption when discussing models of competing task performance.

This fact does not rule out the possibility that there may be a factor common to all competing tasks which also accounts for a significant portion of the variance. The factor-pattern matrix reported in the Fogarty and Stankov (1982) paper displays such a structure. Components of competing tasks loaded on the same factors as the corresponding single tests. In addition, however, almost all competing task measures loaded on an extra factor. There were no single test loadings on this factor.

Having ruled out the possibility that the processes required by a hypothetical timesharing factor are the same as those required by single tests, the search is narrowed to the consideration of the types of processes which might be called for when the tasks are performed simultaneously. In so doing, one must rule out those situations in which a timesharing factor reflects peculiarities of presentation, response mode, and so forth (Ackerman et al., 1982; Hawkins et al., 1978). These are characteristics that would not necessarily transfer to other tasks and so should not be regarded as indicative of a timesharing factor. The point is that all other possible interpretations should be ruled out before one accepts that a factor associated exclusively with competing tasks in a particular study is, in fact, a timesharing factor.

There is another feature of the timesharing factor which deserves mention here. Up to this point, it has been assumed that all competing tasks are more or less alike in the demands that they impose on the organism. This is not true, of course. Competition can arise in a variety of ways. It is present when a task intrudes between the presentation and recall stages of a memory task (concurrent task). It is also present when two tasks are presented simultaneously through the same sensory modality. Would both situations tap the same timesharing processes? Hawkins et al. (1978) argue that they may not. These authors also draw attention to the role that practice may play in lessening the demand for timesharing processes. People undoubtedly acquire skill in performing competing tasks (Spelke, Hirst, & Neisser, 1976). Do these skills transfer to new tasks? In what way does practice affect the need for timesharing processes?

When all of these factors are taken into consideration, the scales seem set against the existence of a general timesharing factor. Nevertheless, the issue is worthy of further investigation. From a practical viewpoint alone, given the increasing complexity of many job situations, it is important that we try to understand the nature of the abilities involved in competing task performance. Furthermore, on the basis of existing evidence it would be unwise to dismiss the possibility that there is an important psychological domain which is untapped by current testing procedures.

Aims of Study

Most previous studies involving competing performance have included a limited sample of cognitive tasks. A characteristic of experimental work to date has been the use of relatively simple and highly automated competing tasks or a combination of a simple task and a more complex task. Some of the psychometric work, on the other hand, has involved rather complex tests similar to those found in intelligence test batteries (Fogarty & Stankov, 1982; Horn & Stankov, 1982; Hunt, 1980; Stankov, 1983a). In both cases, the tasks have been chosen in an almost nonsystematic manner from the cognitive domain, perhaps on the assumption that one competing task will serve as well as another.

The present study seeks to reverse this tendency by including a selection of tasks representing a variety of within- and across-factor combinations from different levels of an established model of intelligence. Modality of presentation, an important moderator of performance, is also varied in some combinations. If there is a separate, identifiable ability that comes to the fore in these situations, then its importance has to be assessed in relation to other broad-ability domains. The broad framework, in this case, was provided by the widely accepted theory of fluid (Gf) and crystallized (Gc) intelligence (Cattell, 1971; Horn, 1980).

The main aim is to examine changes in the pattern of interrelationships that are brought about by presenting two tasks simultaneously. As yet, no studies have reported a timesharing factor in the midst of an array of known psychological dimensions. The inclusion of a broad range of competing tasks representing a variety of within- and across- factor combinations provides an appropriate setting for the further investigation of the timesharing factor.

Data collected in this study may help to indicate whether such a factor can be identified and, if so, whether it makes a substantial contribution to the explanation of performance in the presence of these other factors. Since little is known about the characteristics of this hypothetical timesharing factor, its relationship with the other broad factors identified in Gf/Gc theory is yet to be established.

METHOD

Subjects

A total of 126 subjects were involved in the study. Roughly one-third of these were Psychology I students who participated to gain extra grade credit in their course. The remainder of the subjects were drawn from the adult population around Sydney. Subjects who reported vision or hearing defects were excluded.

Throughout the duration of the study every effort was made to ensure that the subject pool was quite varied with respect to age and education level. The average age of the subject pool was 26 years with a standard deviation of 9.9 years. The average education level was just below university standard; that is, roughly 12 years of formal education. There were 66 females and 60 males.

Description of Test Battery

The battery of tests used in this study consisted of 20 single and 14 competing tasks. The 20 single tests included 16 which were used as components of competing tasks plus four additional markers for the broad factors: general fluid intelligence (Gf), general crystallized intelligence (Gc), general visual function (Gv), and general auditory function (Ga). The construction of these various markers posed considerable problems since the tests had to be suitable for simultaneous presentation with another test. This problem was overcome by selecting tests from those described in the literature on individual differences and then modifying them to suit the requirements of this experiment.

Single Tests

Unless stated otherwise, the following conditions apply to these single tests: a) the letter A attached to the abbreviation of a test name indicates that it was presented in auditory form; the suffix V indicates visual presentation; b) the test consisted of 15 items; c) the test was administered by computer; d) there were no time limits; the computer did not proceed to the next item until the subject responded to the current item; e) the stimuli for the various items were presented at the rate of one per second (sequential presentation).

A brief description of each test follows.

1. Number Series (NSA). Subjects are presented with a series of six numbers. Their task is to work out the rule governing the formation of the series and to type in the next number in the series. Source: this study; original version: Thurstone (1938).

   Example: 1 2 4 8 16 32 ? (Answer = 64)

2. Number Series (NSV). Parallel form of the above test presented visually.
3. Letter Reordering (LR). The letters R,S,T are presented to the subject. They may appear in any order. The subject has to note the order in which they appear. The letters are then repeated, but usually in a different order, for example, S,T,R. The subject has to give the order on the second presentation using the first presentation as a basis for comparison. The answer in this example would be 2,3,1. Source: this study; original version: Stankov and Horn (1980).
4. Tonal Counting (TC). Sequences of five, six, or seven notes are pre-

sented. Each sequence is formed from repetitions of three clearly identifiable notes: a low note, a medium note, and a high note. The subject has to report how many times each low note occurs, followed by the number of medium notes, and, finally, the number of high notes. Source: this study; original version: Stankov (1983b).

5. Sets (STA). Two sets of three letters are presented, for example, D,R,O; A,R,O. Two of the letters are the same in each set. Subjects must name both the letter that is missing and the letter that replaces it. In this example, the answer is DA. Source: this study; original version: Crawford and Stankov (1983).
6. Sets (STV). Parallel form of the above test presented visually.
7. Matrices (MATR). The subject has to choose from among five options the design which completes a matrix. Presented in paper and pencil form. Source: Cattell's Culture Fair Test of Intelligence–Scale A, Level 3.
8. Spelling (SPA). Five-, six-, or seven-letter words are spelled out; the subject must indicate whether the word is spelled correctly by typing Y or N. They are not given the word so they must decide what the word is and whether or not it is spelled correctly. The words were selected from various spelling texts and, in many cases, involved violations of certain rules. Some irregular words were also included. Care was taken to avoid particularly obscure words. Source: this study.

Example: L I L I E S (Answer = Y)

9. Spelling (SPV). Parallel form of the above test presented visually.
10. Similarities (SMA). Subjects have to choose from among four words two that have similar meanings. Source: this study; original version: Ekstrom, French, Harman, and Derman (1976).

Example: TRY GET ATTEMPT PLAY (Answer = 1,3)

11. Similarities (SMV). Parallel form presented visually.
12. Scrambled Words (SW). Subjects have to rearrange four letters to form a word. An attempt was made to vary the difficulty level of the items by choosing words from different sections of a word frequency list (Kucera & Francis, 1967). Source: this study; original: Ekstrom et al. (1976).

Example: E T R E (Answer = TREE)

13. Hidden Words (HWA). A string of letters is presented. The string is either six letters (first 10 items) or eight letters (last 5 items) in length. Each string contains one four-letter word which the subject must identify and

report. The word itself is never scrambled although it can appear in any part of the string. Source: this study; original: Ekstrom et al. (1976).

Example: S C R I S E (Answer = RISE)

14. Hidden Words (HMV). Parallel form of the above test presented visually.
15. Esoteric Word Analogies (ANAL). Subjects are asked to select from among six options the term that completes a verbal analogy. There are 30 items in this test. Subjects are asked to do as many as possible in a five-minute period. Presented in paper and pencil form.

Example: Fire is to Hot as Ice is to
(1) Pole (2) White (3) Cold (4) Cream (5) Born (6) NA
(Answer = 3)

16. Memory Span (MS). The task is to reproduce digit strings which increase in length until the subject makes two successive errors. The score is the length of the longest correctly reproduced string. (Taken from the Wechsler Adult Intelligence Scale and administered in the usual fashion).
17. Hidden Figures (HF). Two figures are presented, the first at the top left and the second at the top right of the screen. A larger, more complex figure appears in the lower half of the screen. The display lasts for five seconds after which time the subjects make one of the following responses: 0 – neither figure present in the larger pattern; 1 – figure 1 present; 2 – figure 2 present; or 1,2 – both figures present. Source: this study; original version: Ekstrom et al. (1976).
18. Card Rotations (CR). Subjects must compare a form with a model and decide whether the form can be rotated so that it matches the model. Subjects are asked to solve as many as possible in a three-minute period. Paper and pencil test. Source: Ekstrom et al. (1976).
19. Tonal Memory (TM). A sequence consisting of three, four, or five tones is presented. The sequence is then repeated with one of the tones changed. The subject must identify the position of the tone that changed. Source: this study; original version: Seashore, Lewis, and Saetveit (1960).
20. Chord Decomposition (CD). A three-note chord is followed by three individual notes. The subject has to decide whether the notes are the same as those played in the chord (S), or whether one has moved up (U) or down (D). Source: this study; original version: Wing (1962).

The hypothesized factorial structure of the single tests is as set out in Table 1. Note that the structure presented here is "idealized" in the sense that no overlap is postulated, and also in the sense that a four-factor solution is likely to be overly

TABLE 1
Broad Factorial Structure of Single Tests

Variable		Gf	Gc	Gv	Ga
1. Number Series	(A)	x			
2. Number Series	(V)	x			
3. Letter Reordering		x			
4. Tonal Counting		x			
5. Sets	(A)	x			
6. Sets	(V)	x			
7. Matrices		x			
8. Memory Span		x			
9. Spelling	(A)		x		
10. Spelling	(V)		x		
11. Similarities	(A)		x		
12. Similarities	(V)		x		
13. Scrambled Words			x		
14. Hidden Words	(A)		x		
15. Hidden Words	(V)		x		
16. Analogies			x		
17. Hidden Figures				x	
18. Card Rotations				x	
19. Tonal Memory					x
20. Chord Decomposition					x

(A) indicates auditory presentation
(V) indicates visual presentation

restrictive. In reality, using typical exploratory-factor analytic techniques, this structure could not be expected to emerge.

Competing Tasks

There are a number of techniques of presentation that will lead to competition between tasks. In many experiments, some effort is made to present the elements which make up the two tasks simultaneously so that the subject is faced with the additional task of coping with competition at an input as well as at a processing level. This form of presentation was used wherever possible in this study. That is, the competing tasks involved not just the simultaneous presentation of two items but, wherever possible, the simultaneous presentation of the elements comprising the items.

Apart from these construction details, there are some other important features that should be noted here. The most obvious way to study the effect of competing task performance is to take the single tests and combine them in various ways. Direct comparisons could then be made between the two conditions. Unfortunately, this is not really possible in an individual differences study where it is important to achieve a reasonable spread of scores in both single and competing task conditions. If it were possible to construct single tests that exhibited the desired spread of scores, it is almost certain that these tests would prove to be much too difficult when combined with one another.

In an attempt to overcome this problem, some easier items were added to the competing tasks to encourage the subjects to keep trying. As a general rule, each component of a competing task was a replica of the single version of the test with an extra five items randomly interspersed. This modification increased the length of the test from 15 to 20 items. It was hoped that the extra length would compensate for the generally lower reliabilities that have been observed with competing tasks in the past (Fogarty & Stankov, 1982). This particular solution to the difficulty problem has the added advantage that it still enables direct comparisons to be made should the need become evident. This can be done by ignoring the five additional items selected for the competing tasks.

Unless otherwise stated, the following conditions apply to these competing tasks: a) in the auditory/auditory combinations, one voice is male and the other female; b) all tests consisted of 20 items; c) all tests were presented by computer.

1. Number Series/Letter Reordering (NS/LR). Both tasks presented auditorily with the Number Series going to the left ear and Letter Reordering to the right.

Example:	NS:	2	4	6	8	10	12	(14)
	LR:	R	S	T	T	S	R	(3,2,1)

2. Number Series/Letter Reordering (NS/LR). Number Series presented visually; Letter Reordering presented auditorily.
3. Spelling/Tonal Counting (SP/TC). Both tasks presented auditorily with Spelling going to the right ear and Tonal Counting to the left. The Tonal Counting task consisted mostly of sequences of five or six tones, although some sequences contained seven tones. The words to be spelled always matched the length of the tonal task.
4. Spelling/Tonal Counting (SP/TC). Spelling presented visually; Tonal Counting presented auditorily.
5. Similarities/Scrambled Words (SM/SW). Both tasks presented auditorily with Similarities to the left ear and Scrambled Words to the right.

Example:	SM:	HIGH	LOFTY	STILL	FLYING	(1,2)
	SW:	H	T	A	E	(HATE)

6. Similarities/Scrambled Words (S/SWA). Similarities presented visually; Scrambled Words auditorily.
7. Hidden Figures/Sets (HF/STA). Hidden Figures presented visually; Sets

presented auditorily. The Hidden Figures display was timed to appear for the exact duration of the auditory task.

8. Tonal Memory/Sets (TM/STA). Both tasks presented auditorily with Tonal Memory to the left ear and Sets to the right. The Tonal Memory task was limited to three notes per sequence in order to align it with the Sets task.
9. Tonal Memory/Sets (TM/STA). Tonal Memory presented auditorily; Sets presented visually.
10. Hidden Figures/Hidden Words (HF/HW). Hidden Figures presented visually; Hidden Words presented auditorily. Once again, the display for the Hidden Figures task was timed to coincide with the auditory task.
11. Chord Decomposition/Hidden Words (CD/HW). Both tasks presented auditorily with Chord Decomposition to the left ear and Hidden Words to the right. A strict matching of the elements comprising the items was not possible, but the individual items began and ended simultaneously.
12. Chord Decomposition/Hidden Words (CD/HW). Chord Decomposition presented auditorily; Hidden Words presented visually.
13. Tonal Memory/Hidden Figures (TM/HF). Tonal Memory presented auditorily, Hidden Figures presented visually. The items were aligned so that they began and ended simultaneously.
14. Tonal Memory/Chord Decomposition (TM/CD). Both tasks presented auditorily with Tonal Memory to the left ear and Chord Decomposition to the right.

Comment on Design

One of the major purposes of the present study was to collect performance data on a wide range of competing tasks. Table 2 shows how each of the 14 competing tasks fits into the overall design of the study.

In most respects, this design satisfies the main aims of the study. It covers a total of nine different factorial combinations from various levels of the Gf/Gc hierarchy, and it includes a mix of within- and across- modality presentations. On the negative side, however, there are some weak points which should be explained.

To begin with, the design illustrated in Table 2 is incomplete: there are no visual/visual splits. There are two reasons for this: (1) it is technically very difficult to present two visual tasks simultaneously; and (2) to complete the design set out in Table 2 would have required the expansion of a test battery that was already very large. Time considerations rendered this impossible. Because the total battery had to be pruned, it was convenient to omit the problematic visual/visual combinations.

Order of Presentation of Tests

The order of presentation was systematically changed during the study. Five different orders were used, and the positions of the tests were shuffled after every

TABLE 2
Tests Used to Form Various Combinations

Factor	(Gf)	(Gc)	(Gv)	(Ga)
(Gf) (both auditory)	*N* Series with Letter Reorganization	Tonal Counting with Spelling		Sets with Tonal Memory
(auditory /visual)	*N* Series (V) with Letter Reor.	Tonal Counting with Spelling(V)	Sets(V) with Hidden Figures	Sets(V) with Tonal Memory
(Gc) (A/A)		Similarities with Scrambled Words		Hidden Words with Chord Decomposition
(A/V)		Similarities (V) with Scram. Words	Hidden Words with Hidden Figs.	Hidden Words(V) with Chord Decomposition
(Gv) (A/V)				Hidden Figures with Tonal Memory
(Ga) (A/A)				Tonal Memory with Chord Decomposition

28 subjects. This ensured that performance on any given test was not unduly influenced by its position in the battery. Competing tasks were intermingled with the single tests. Due to the complex and novel nature of these tasks, however, care was taken to ensure that subjects had always completed the two relevant single tests before undertaking each competing task. This feature left wide open the possibility of practice effects, but this drawback must be set against the obvious necessity for having subjects understand the nature of the two tests that they were trying to combine.

Data Collected

For each computer-administered test, all items were scored as 1 if correct, and 0 otherwise. Total-scores were kept for the paper-and-pencil tests.

Details of scoring for the competing tasks must be prefaced by some remarks about their administration. In the case of competing tasks, subjects were instructed to attend to both of the tasks. The computer requested answers for each task separately; that is, subjects were asked to answer one task before answering the other. Inappropriate responses were usually detected and rejected. Subjects never knew which task they were going to be asked to answer first. The ordering of responses was done at random with the proviso that the two components each received an equal number of first prompts over the whole test.

In the Letter Reordering and Number Series combination, which consisted of

20 items, there was a total of 10 occasions when the subject was required to respond to Letter Reordering before responding to the Number Series item. These responses were known as primary. On the other 10 occasions, the answer to the Number Series task was requested first; thus, there was a set of primary scores for it as well. Other responses were known as secondary. It can be seen, therefore, that for each competing task there were four sets of scores: two primary and two secondary. Information relating to age, sex, years of musical training, and educational level was also collected.

Equipment Used

All tests, with the exception of tests 7, 8, 16, and 18 were individually administered and were presented by an Apple II Europlus microcomputer. A Nakamichi LX-3 cassette tape recorder was connected to the Apple via an interface built by departmental technical staff. This interface enabled the Apple to control the presentation of auditory tests. It also made possible the simultaneous presentation of auditory and visual material. The auditory stimuli were delivered through Sony stereo headsets.

Procedure

Total testing time for the whole battery was approximately five hours although the time taken varied from subject to subject because the computer-administered tests were all self-paced. Testing was broken up into two sessions with approximately the same number of tests in each session. A familiarization program introduced the subjects to the main features of the keyboard and allowed them to practice on the keyboard. All correct responses were signaled by a quiet but cheerful combination of two tones.

RESULTS AND DISCUSSION

There are two broad groupings of data: single test scores and competing task scores. For the single tests, total scores were used as the measure of performance. In the case of the competing tasks, primary and secondary scores were combined. This meant that each competing task yielded two scores, one for each of the components.

Descriptive Statistics for All Variables

The initial stage of data analysis involved the calculation of reliability estimates for all new scales used in this study. This section of the analysis served two purposes: (1) it provided useful information about the extent of measurement error in the data, and (2) it provided an opportunity for pruning unreliable items and tests from the battery. The basic aim was to ensure that all subsequent analyses would be conducted on scales that had satisfactory reliability estimates.

As a result of these reliability analyses, some items were deleted from various tests. Any item that reduced the reliability of the scale was deleted, and the reliability of that scale was then reassessed. Reliabilities for the standard paper-and-pencil tests were not reported.

It is interesting to see that with the longer length of the competing tasks, the reliabilities of the tests administered under both conditions are roughly the same: the average reliability of the single tests is .70 compared with an average figure of .71 for the components of the competing tasks. This is worth noting for it indicates that, from an applied point of view, one can achieve satisfactory reliability estimates for these complex tasks without making them excessively long. It was hoped the the tests constructed for this study would allow for the expression of individual differences. An inspection of Table 3 indicates that even though means and standard deviations vary considerably from test to test, most tests appear neither too easy nor too difficult for the sample used. As expected, subjects experienced much more difficulty with the competing tasks than with the single tests upon which they were based. Table 3 does not show this clearly, however, since the competing tasks included a higher proportion of easier items and were longer in length than the single tests. The net effect is that scores on components of competing tasks appear higher in Table 3 than one might have expected. Performance comparisons can still be made between single and competing tasks, however, by rescoring variables so that only those items which were common to both single and competing task measures are taken into consideration. The net effect of this procedure is to redress the imbalance in difficulty levels across the two conditions.

Table 4 presents the mean proportion correct for a given variable and the number of items upon which the comparison is based. It also indicates whether there was a significant increment (+), decrement (−), or no change (=) in scores under competing conditions.

When the individual competing task measures are examined, some interesting findings emerge. All but five (out of 28) competing task measures show a significant decrement in performance. Four of these five measures actually showed performance improvement under competing task conditions. One plausible explanation for this finding is that, in particular cases, subjects benefited from the practice provided by the single tests, which were always attempted prior to the competing tasks. Another plausible explanation is that, as suggested by Kahneman (1973, pp. 17–24), the competing task itself may induce an increase in arousal. Navon and Gopher (1979, p. 226) argue that such an outcome could lead to a situation where performance under competing task conditions is actually better than it was in the single tests. In the absence of physiological measures of arousal, it is not possible to choose between these explanations.

Factorial Structure Among Variables

The second stage of analysis involved an investigation of the structure underlying the matrix of intercorrelations obtained with the present battery of tests. The

TABLE 3
Means, Standard Deviations, and Reliabilities

Test		Mean	Standard Deviation	No. of Items	Rel
1. Number Series	(NSA)	8.59	2.54	13	.68
2. Number Series	(NSV)	7.46	3.01	13	.74
3. NSA with LR	(NSA/LR)	8.37	3.42	19	.68
4. NSV with LR	(NSV/LR)	9.02	3.76	18	.77
5. Letter Reordering	(LR)	11.53	2.83	15	.73
6. LR with NSA	(LR/NSA)	7.16	3.19	20	.60
7. LR with NSV	(LR/NSV)	10.71	4.33	19	.82
8. Tonal Counting	(TC)	5.21	3.68	15	.82
9. TC with SPA	(TC/SPA)	3.19	3.13	18	.80
10. TC with SPV	(TC/SPV)	2.99	2.89	18	.77
11. Sets	(STA)	11.18	2.28	14	.65
12. Sets	(STV)	11.18	2.59	14	.74
13. STA with HF	(STA/HF)	12.68	3.67	19	.78
14. STA with TM	(STA/TM)	10.71	3.15	18	.70
15. STV with TM	(STV/TM)	11.34	3.68	19	.75
16. Matrices		5.57	1.76	13	
17. Spelling	(SPA)	5.33	1.68	8	.51
18. Spelling	(SPV)	7.85	2.37	13	.57
19. SPA with TC	(SPA/TC)	9.32	2.69	17	.51
20. SPV with TC	(SPV/TC)	11.09	3.09	18	.63
21. Similarities	(SMA)	9.65	2.02	12	.65
22. Similarities	(SMV)	10.75	2.96	15	.73
23. SMA with SW	(SMA/SW)	7.49	3.07	19	.58
24. SMV with SW	(SMV/SW)	8.25	3.36	19	.67
25. Scrambled Words	(SW)	9.79	2.94	15	.74
26. SW with SMA	(SW/SMA)	5.24	3.25	18	.72
27. SW with SMV	(SW/SMV)	10.22	4.18	19	.81
28. Hidden Words	(HWA)	6.38	2.24	15	.74
29. Hidden Words	(HWV)	5.47	2.05	14	.71
30. HWA with HF	(HWA/HF)	10.07	4.07	19	.80
31. HWA with CD	(HWA/CD)	10.51	4.08	19	.78
32. HWV with CD	(HWV/CD)	13.09	3.11	19	.70
33. Verbal Analogies		15.74	4.68	30	
34. Memory Span		13.09	1.99	18	
35. Hidden Figures	(HF)	6.63	2.89	13	.68
36. HF with STA	(HF/STA)	11.37	3.68	19	.76
37. HF with HW	(HF/HW)	12.12	3.92	18	.81
38. HF with TM	(HF/TM)	14.19	3.75	18	.84
39. Card Rotations		52.11	14.36	80	
40. Tonal Memory	(TM)	11.92	2.37	15	.74
41. TM with STA	(TM/STA)	9.64	3.27	17	.70
42. TM with STV	(TM/STV)	10.28	3.62	19	.69
43. TM with HF	(TM/HF)	12.64	3.55	17	.80
44. TM with CD	(TM/CD)	10.71	3.8	19	.77
45. Chord Decomposition	(CD)	8.02	2.85	15	.63
46. CD with HWA	(CD/HWA)	7.29	2.84	17	.55
47. CD with HWV	(CD/HWV)	8.24	2.85	18	.60
48. CD with TM	(CD/TM)	3.63	1.88	15	.43

TABLE 4
Proportion Correct

Test		Corrected Scoring	Total Items
1. Number Series	(NSA)	.57	15
2. Number Series	(NSV)	.50	15
3. NSA with LR	(NSA/LR)	.41 (−)	15
4. NSV with LR	(NSV/LR)	.46 (−)	13
5. Letter Reordering	(LR)	.77	11
6. LR with NSA	(LR/NSA)	.37 (−)	15
7. LR with NSV	(LR/NSV)	.52 (−)	14
8. Tonal Counting	(TC)	.35	10
9. TC with SPA	(TC/SPA)	.18 (−)	18
10. TC with SPV	(TC/SPV)	.17 (−)	18
11. Sets	(STA)	..80	14
12. Sets	(STV)	.80	14
13. STA with HF	(STA/HF)	.61 (−)	14
14. STA with TM	(STA/TM)	.58 (−)	13
15. STV with TM	(STV/TM)	.62 (−)	14
17. Spelling	(SPA)	.67	8
18. Spelling	(SPV)	.60	13
19. SPA with TC	(SPA/TC)	.55 (−)	17
20. SPV with TC	(SPV/TC)	.62 (=)	18
21. Similarities	(SMA)	.80	12
22. Similarities	(SMV)	.72	15
23. SMA with SW	(SMA/SW)	.39 (−)	19
24. SMV with SW	(SMV/SW)	.43 (−)	19
25. Scrambled Words	(SW)	.65	15
26. SW with SMA	(SW/SMA)	.29 (−)	18
27. SW with SMV	(SW/SMV)	.54 (−)	19
28. Hidden Words	(HWA)	.64	10
29. Hidden Words	(HWV)	.61	9
30. HWA with HF	(HWA/HF)	.53 (−)	19
31. HWA with CD	(HWA/CD)	.55 (−)	19
32. HWV with CD	(HWV/CD)	.69 (+)	19
35. Hidden Figures	(HF)	.52	8
36. HF with STA	(HF/STA)	.63 (+)	18
37. HF with HW	(HF/HW)	.67 (+)	18
38. HF with TM	(HF/TM)	.79 (+)	18
40. Tonal Memory	(TM)	.90	5
41. TM with STA	(TM/STA)	.57 (−)	17
42. TM with STV	(TM/STV)	.54 (−)	19
43. TM with HF	(TM/HF)	.74 (−)	17
44. TM with CD	(TM/CD)	.56 (−)	19
45. Chord Decomposition	(CD)	.54	15
46. CD with HWA	(CD/HWA)	.44 (−)	13
47. CD with HWV	(CD/HWV)	.47 (−)	15
48. CD with TM	(CD/TM)	.35 (−)	8

correlations to be treated in the following section are based upon the original scoring method. That is, all items except those which were rejected as unreliable were included in the analysis. The reason for using this scoring technique rather than the corrected method used in the previous section is that the measures based upon the original technique generally have higher reliabilities. Because the analysis does not demand the use of the corrected measures, it is preferable to make use of the more reliable scores.

Given the aims of this study, there are only two solutions of interest: the first assumes that the intercorrelations can be explained without the assumption of a timesharing factor; the second postulates the existence of such a factor.

Solution 1: Without a Timesharing Factor. In order to establish whether the hypothesized factorial structure was obtained, the correlation matrix (Appendix A) was subjected to the procedures of confirmatory factor analysis. This method of analysis is particularly appropriate in the present study where each variable is intended to fill a cell in a matrix representing a variety of within- and across-factor combinations. Deviations from the expected factorial pattern could indicate that the design indicated in Table 2 has not been achieved. McDonald's (1980) COSAN program was used for this purpose.

The proposed structure assumes that all tests are factorially simple and that components of competing tasks measure the same basic dimensions as their corresponding single tests. Accordingly, variables 1–16 have projected loadings on (Gf), variables 17–34 on (Gc), variables 35–39 on (Gv), and variables 40–48 on (Ga). All other projected loadings were set to zero. The obtained maximum likelihood solution is shown in Table 5.

There can be little doubt that the four factors in Table 5 represent broad fluid (Gf), broad crystallized (Gc), broad visual (Gv), and broad auditory functions (Ga), respectively. Tests that were selected as representative of these broad functions appear to have behaved in a typical way in the present battery. There are no exceptions. Not only are the loadings of all variables salient, but the pattern of correlations among the factors themselves, although higher than normal, is in line with expectations.

TABLE 5
Confirmatory Solution with Four Factors

Test		(Gf)	(Gc)	(Gv)	(Ga)
1. Number Series	(NSA)	.72			
2. Number Series	(NSV)	.78			
3. Number Series	(NSA with LR)	.65			
4. Number Series	(NSV with LR)	.75			
5. Letter Reordering	(LR)	.74			
6. Letter Reordering	(LR with NSA)	.40			
7. Letter Reordering	(LR with NSV)	.57			
8. Tonal Counting	(TC)	.68			

TABLE 5 (Continued)

Test		(Gf)	(Gc)	(Gv)	(Ga)
9. Tonal Counting	(TC with SPA)	.54			
10. Tonal Counting	(TC with SPV)	.55			
11. Sets	(STA)	.66			
12. Sets	(STV)	.56			
13. Sets	(STA with HF)	.67			
14. Sets	(STA with TM)	.68			
15. Sets	STV with TM)	.56			
16. Matrices		.58			
17. Spelling	(SPA)		.65		
18. Spelling	(SPV)		.46		
19. Spelling	(SPA with TC)		.39		
20. Spelling	(SPV with TC)		.45		
21. Similarities	(SMA)		.63		
22. Similarities	(SMV)		.66		
23. Similarities	(SMA with SW)		.50		
24. Similarities	(SMV with SW)		.65		
25. Scrambled Words	(SW)		.74		
26. Scrambled Words	(SW with SMA)		.60		
27. Scrambled Words	(SW with SMV)		.78		
28. Hidden Words	(HWA)		.70		
29. Hidden Words	(HWV)		.64		
30. Hidden Words	(HWA with HF)		.73		
31. Hidden Words	(HWA with CD)		.66		
32. Hidden Words	(HWV with CD)		.68		
33. Verbal Analogies			.67		
34. Memory Span			.55		
35. Hidden Figures	(HF)			.60	
36. Hidden Figures	(HF with STA)			.72	
37. Hidden Figures	(HF with HWA)			.74	
38. Hidden Figures	(HF with TM)			.82	
39. Card Rotations				.35	
40. Tonal Memory	(TM)				.60
41. Tonal Memory	(TM with STA)				.70
42. Tonal Memory	(TM with STV)				.82
43. Tonal Memory	(TM with HF)				.73
44. Tonal Memory	(TM with CD)				.58
45. Chord Decomposition	(CD)				.52
46. Chord Decomposition	(CD with HWA)				.59
47. Chord Decomposition	(CD with HWV)				.58
48. Chord Decomposition	(CD with TM)				.37

Factor Intercorrelation Matrix

	(Gf)	(Gc)	(Gv)	(Ga)
(Gf)	1.00			
(Gc)	.86	1.00		
(Gv)	.65	.57	1.00	
(Ga)	.67	.49	.50	1.00

An unsatisfactory feature of this solution is that, although the average residual correlation is low (.067), the χ^2 goodness-of-fit test is significant (χ^2 with 1074 df = 1869.15). In fact, exploratory maximum likelihood analysis showed that when using the root one criterion, it is necessary to extract 11 factors to obtain a satisfactory fit to the data. Many of these factors were narrowly defined and, from the point of view of this study, of no real psychological interest. As can be expected, solutions with fewer numbers of factors resulted in a less satisfactory fit, although the factors themselves became increasingly more meaningful. A promax, maximum likelihood solution that was restricted to four factors produced a factor pattern matrix very similar to that shown in Table 5. In defense of a four-factor solution, it can be argued that with a large number of degrees of freedom it becomes increasingly difficult to satisfy criteria of goodness-of-fit. The low average residual, combined with the psychological meaningfulness of the four factor solution, weighs heavily in its favor.

Solution 2: With Timesharing Factor. One way of improving the fit through the use of confirmatory techniques would be to postulate the existence of additional factors. In keeping with the aims of confirmatory analysis, the projected loadings on the extra factors would have to be based on sound theoretical principles. In the present case, there are substantive reasons for postulating a slightly broader structure than that depicted in Table 5. A second structure would incorporate the four-factor solution and also allow for the appearance of a hypothetical timesharing factor.

The predicted factorial structure is an extension of the first: components of competing tasks are still expected to load on the same factors as the corresponding single tests. This trend was very clear in the Fogarty and Stankov (1982) study. In addition, however, there are projected loadings for all 28 competing task measures on a hypothesized fifth factor. Once again, other projected loadings were set to zero. The obtained pattern is shown in Table 6.

Solution 2 preserves much of what was found in Solution 1. The first four factors are virtually intact, although loadings are reduced for those variables which also load on the timesharing factor. The timesharing factor does not cover

TABLE 6
Confirmatory Solution with Timesharing Factor

Test		(Gf)	(Gc)	(Gv)	(Ga)	TS
1. Number Series	(NSA)	.74				
2. Number Series	(NSV)	.80				
3. Number Series	(NSA with LR)	.51				.26
4. Number Series	(NSV with LR)	.77				
5. Letter Reordering	(LR)	.72				
6. Letter Reordering	(LR with NSA)	.20				.35
7. Letter Reordering	(LR with NSV)	.33				.40
8. Tonal Counting	(TC)	.69				

TABLE 6 (Continued)

Test		(Gf)	(Gc)	(Gv)	(Ga)	TS
9. Tonal Counting	(TC with SPA)	.57				
10. Tonal Counting	(TC with SPV)	.58				
11. Sets	(STA)	.65				
12. Sets	(STV)	.58				
13. Sets	(STA with HF)	.50				.29
14. Sets	(STA with TM)	.40				.48
15. Sets	(STV with TM)	.36				.34
16. Matrices		.59				
17. Spelling	(SPA)		.63			
18. Spelling	(SPV)		.44			
19. Spelling	(SPA with TC)		.38			
20. Spelling	(SPV with TC)		.31			
21. Similarities	(SMA)		.64			
22. Similarities	(SMV)		.70			
23. Similarities	(SMA with SW)		.54			
24. Similarities	(SMV with SW)		.68			
25. Scrambled Words	(SW)		.75			
26. Scrambled Words	(SW with SMA)		.20			.52
27. Scrambled Words	(SW with SMV)		.58			.27
28. Hidden Words	(HWA)		.67			
29. Hidden Words	(HWV)		.63			
30. Hidden Words	(HWA with HF)		.32			.54
31. Hidden Words	(HWA with CD)					.86
32. Hidden Words	(HWV with CD)		.51			.21
33. Verbal Analogies			.69			
34. Memory Span			.54			
35. Hidden Figures	(HF)			.60		
36. Hidden Figures	(HF with STA)			.72		
37. Hidden Figures	(HF with HWA)			.74		
38. Hidden Figures	(HF with TM)			.82		
39. Card Rotations				.35		
40. Tonal Memory	(TM)				.58	
41. Tonal Memory	(TM with STA)				.65	.27
42. Tonal Memory	(TM with STV)				.81	.20
43. Tonal Memory	(TM with HF)				.69	.26
44. Tonal Memory	(TM with CD)				.55	
45. Chord Decomposition	(CD)				.59	
46. Chord Decomposition	(CD with HWA)				.59	
47. Chord Decomposition	(CD with HWV)				.64	
48. Chord Decomposition	(CD with TM)				.34	.20

Factor Intercorrelation Matrix

	(Gf)	(Gc)	(Gv)	(Ga)	TS
(Gf)	1.00				
(Gc)	.83	1.00			
(Gv)	.64	.59	1.00		
(Ga)	.59	.36	.41	1.00	
TS	.44	.68	.37	.05	1.00

the complete range of competing tasks. In fact, it covers 15 out of the 28 measures of competing task performance, and some of these loadings are not impressively high. The remaining 13 measures had nonsignificant loadings and these are properly indicated as zeros in Table 6.

From a purely statistical viewpoint, it is clear that both solutions can be supported by the data. Solution 1 is the more parsimonious of the two because it explains the data in just four factors. Solution 2, on the other hand, does manage to give a better account of the correlations: the average residual is .057 (χ^2 with 1053 df = 1735.77; p = .0000) compared with a value of .067 for the four-factor solution (χ^2 with 1074 df = 1869.15; p = .0000). Joreskog (1974) suggests that one can use the differences between the two chi-square values to test whether the second solution represents a statistically better fit. With df = 21 (1074–1053) and χ^2 = 133.38 (1869.15–1735.77), the fit is indeed better with the second solution.

Interpretation of this fifth factor, however, is not easy. A notable feature is the high loading of test number 31 (Hidden Words presented with Chord Decomposition). The second highest loading comes from test number 30 (Hidden Words with Hidden Figures). Other variables with high loadings include Letter Reordering, Sets, and Scrambled Words. Four other tests—Tonal Counting, Spelling, Similarities, and Hidden Figures—have no shared variance with this factor. Despite the high loadings of the two HWA measures, this fifth factor does not appear to be particularly narrow: six of the markers are associated with (Gf), five with (Gc), and four with (Ga).

An interesting aspect of the six (Gf) markers is that they all had salient loadings on the (Gc) factor extracted in exploratory factor analytic solutions which, for reasons of space, are not reported here. This, together with the high correlation between the TS factor and (Gc), suggests that the factor taps processes which are perhaps more closely related to (Gc) than to (Gf). The one feature that most of the markers for this factor have in common is that they require some manipulation of letters. Letter Reordering, Sets, and Scrambled Words definitely share this feature. In the Hidden Words test, the embedded word is not scrambled, but some manipulation of the letter string will be required to find the starting point of the word.

Beyond this, it is difficult to be precise about the nature of the processes represented by this factor. The markers do not appear to come from competing tasks with readily identifiable characteristics setting them apart from other competing tasks. That is, they are not distinguishable by mode of presentation, type of stimuli used, mode of response, and so on; or can they be distinguished by patterns of performance decrement, trade-off asymmetries, or degrees of factorial complexity from the other competing tasks in the battery.

Applying the maxim that a factor should not be postulated unless the evidence for its existence is clear and unequivocal, it would seem prudent at this stage to favor the four-factor solution as the more psychologically plausible of the two. These data do not support the argument for a timesharing factor.

CONCLUSION

As mentioned previously, there is a belief that competing tasks (as well as measuring whatever processes are tapped by the single tests) can measure a separate timesharing ability. It has been difficult to establish firm empirical support for this latter proposition in the present study. On the positive side, a factor was extracted which did encompass a reasonable number of competing task measures. This factor cut across the four extracted, which did encompass a reasonable number of competing task measures. This factor cut across the four major factors identified by the single tests, and it resulted in a better overall fit. In these respects, it satisfied some of the requirements demanded of a timesharing factor by Ackerman et al. (1982). On the negative side, almost half of the competing task measures in the study failed to achieve a salient loading on this timesharing factor.

A further problem with the timesharing factor concerns its correlation with (Gc). Although few theorists have actually addressed the issue of the relationship between a hypothetical timesharing factor and other broad intellective functions, there appears to be a general feeling that it would be more closely related to (Gf) than to (Gc). Horn, Donaldson, and Engstrom (1981), for example, postulate that the ability to divide attention forms an important component of (Gf).

There are a number of possible reasons for the discrepancy. One possibility is that the character of a timesharing factor varies with the nature of the tasks used to define it. This would imply that the factor does not occupy a fixed place in the structure of abilities but can change ground considerably. A second possibility is that the hypothetical timesharing factor really is more closely related to (Gc) than to (Gf). This would imply that a unitary ability to divide attention can be acquired as a result of acculturational experiences.

There is one further possibility: in this analysis, primary and secondary scores have been combined to yield a single measure of competing task performance for each variable. It is possible, of course, to separate these measures and, by so doing, extend the number of variables in the present battery to 76. An analysis of the factorial structure of the present battery of tests would be incomplete without consideration of the possibility that a hypothetical timesharing factor could be defined by secondary scores alone, as in the Fogarty and Stankov (1982) study in which the secondary scores appeared to be measuring something that was not present in either the single or the primary scores.

For reasons of space, the details are not reported here, but all the indications are that primary and secondary scores in the present study measured the same thing. They were highly correlated and produced identical factor pattern loadings in all solutions obtained. This basic similarity was confirmed by substituting either primary or secondary scores for the combined scores. The solutions obtained were very similar.

More evidence is needed about the types of competing tasks that will reliably define this timesharing factor before it can be considered a serious candidate for a place in the structure of abilities. This does not mean that the tasks themselves have no psychological interest. On the contrary, there is an increasing body of evidence which indicates that the tasks can shed new light on cognitive functioning (Stankov, 1983a). There is also a growing expectation in some quarters that individual competing tasks are better indicators of success in complex situations than any of the current range of psychometric instruments (Fogarty & Stankov, 1987).

Research on applications of individual competing tasks will undoubtedly continue. Against this general research background, it is important that psychologists continue the effort to define the behavior domain—if indeed there is a separate, unitary domain—to which these tasks belong. The present study falls into this category. It confirms that tasks presented under these conditions continue to measure the same basic abilities that they measured as single tests. Although other changes may take place, there is no obvious shift in factor structure as a consequence of the altered conditions of presentation.

Lansman, Poltrock, and Hunt (1983) suggested that no single study will be sufficient to either prove or disprove the existence of a timesharing factor. Their prediction is likely to prove correct: the present study is similar to the first study conducted by the author in this area. The major difference lies in the fact that the variables selected for the present study were carefully chosen to cover a range of broad abilities. The major finding of a timesharing factor associated with competing task performance has not been replicated. At best, one could claim that the better statistical fit yielded by Table 6 offers some grounds for accepting the extra timesharing factor included in that solution. From a different perspective, however, the factor is not easily interpreted and certainly lacks the robustness of its counterpart in the Fogarty and Stankov (1982) paper. It appears that much of the variance associated with the hypothetical timesharing factor is captured by the other broad functions sampled in this study.

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APPENDIX A

Correlations Among 48 Variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																	
2	.66																
3	.61	.45															
4	.59	.73	.52														
5	.59	.59	.41	.51													
6	.17	.27	.16	.21	.33												
7	.36	.37	.28	.35	.60	.40											
8	.47	.53	.49	.49	.42	.25	.36										
9	.31	.42	.38	.40	.30	.28	.25	.55									
10	.30	.43	.40	.37	.35	.24	.25	.54	.65								
11	.51	.45	.45	.48	.52	.19	.31	.45	.23	.34							
12	.40	.53	.24	.40	.47	.20	.33	.41	.30	.37	.38						
13	.38	.46	.43	.52	.54	.41	.40	.33	.36	.37	.50	.32					
14	.48	.42	.62	.46	.46	.34	.43	.44	.22	.28	.49	.29	.53				
15	.31	.58	.36	.51	.35	.30	.31	.37	.26	.18	.27	.39	.34	.44			
16	.43	.47	.29	.46	.45	.18	.28	.38	.38	.34	.34	.38	.35	.40	.28		
17	.39	.35	.33	.31	.33	.19	.36	.35	.12	.11	.34	.15	.24	.45	.27	.24	
18	.33	.30	.26	.23	.30	.01	.28	.20	.04	.05	.23	.12	.14	.34	.27	.20	.48
19	.25	.12	.30	.15	.22	.15	.19	.25	.17	.15	.16	.05	.25	.27	.14	.13	.43
20	.28	.26	.19	.20	.21	.06	.28	.15	.00	.04	.21	.05	.21	.20	.25	.06	.51
21	.50	.30	.43	.33	.41	.16	.32	.32	.19	.28	.49	.21	.50	.55	.18	.26	.37
22	.46	.45	.39	.46	.49	.14	.40	.39	.25	.29	.42	.35	.45	.46	.30	.34	.45
23	.41	.36	.36	.35	.40	.28	.32	.30	.30	.39	.40	.32	.43	.38	.23	.27	.25
24	.45	.46	.42	.47	.45	.23	.43	.45	.38	.39	.41	.28	.45	.35	.38	.34	.36
25	.51	.48	.49	.47	.44	.29	.37	.49	.34	.34	.53	.31	.43	.54	.31	.30	.47
26	.29	.36	.47	.30	.30	.35	.37	.40	.21	.18	.27	.22	.38	.45	.43	.22	.39
27	.37	.40	.45	.40	.46	.32	.45	.42	.21	.28	.50	.29	.52	.65	.34	.37	.56
28	.37	.38	.40	.37	.46	.24	.35	.39	.24	.23	.44	.34	.38	.53	.35	.38	.46
29	.37	.58	.35	.55	.40	.25	.37	.45	.39	.31	.33	.39	.31	.33	.52	.36	.37
30	.41	.50	.38	.40	.51	.35	.54	.33	.18	.18	.33	.23	.50	.57	.47	.33	.48
31	.29	.28	.39	.22	.41	.35	.49	.29	.06	.11	.32	.14	.41	.53	.44	.22	.46
32	.35	.49	.44	.54	.41	.30	.29	.41	.26	.23	.46	.34	.47	.47	.46	.41	.39
33	.45	.40	.35	.40	.47	.23	.34	.42	.32	.27	.40	.46	.45	.46	.29	.45	.45
34	.41	.34	.41	.38	.41	.25	.43	.33	.15	.31	.41	.29	.32	.46	.25	.33	.35
35	.22	.30	.24	.19	.27	.16	.16	.25	.35	.23	.20	.09	.30	.23	.12	.31	.10
36	.36	.26	.36	.32	.33	.21	.29	.36	.43	.34	.38	.24	.41	.35	.06	.20	.22
37	.37	.36	.29	.35	.40	.16	.32	.28	.30	.21	.32	.28	.33	.39	.15	.32	.22
38	.40	.36	.40	.37	.38	.21	.26	.44	.34	.32	.42	.32	.34	.39	.20	.28	.16
39	.15	.24	.09	.18	.14	.06	.00	.13	.22	.16	.10	.20	.25	.11	.12	.16	.04
40	.31	.34	.09	.40	.40	.09	.28	.33	.32	.39	.34	.30	.30	.23	.14	.24	.12
41	.25	.34	.17	.35	.45	.31	.38	.30	.36	.37	.33	.15	.39	.24	.25	.34	.10
42	.39	.38	.19	.41	.37	.30	.30	.40	.50	.43	.29	.28	.36	.26	.28	.40	.24
43	.33	.40	.29	.45	.45	.17	.26	.45	.41	.46	.40	.36	.52	.34	.27	.38	.15
44	.30	.39	.25	.38	.32	.31	.12	.39	.40	.44	.40	.38	.41	.19	.33	.29	.16
45	.11	.13	.04	.09	.07	.06	.14	.24	.27	.29	.13	.23	.09	.03	.05	.18	.05
46	.23	.28	.22	.24	.21	.23	.19	.30	.31	.49	.31	.19	.18	.17	.08	.20	.23
47	.23	.21	.04	.23	.21	.10	.07	.18	.33	.32	.18	.22	.19	.08	.23	.24	.05
48	.04	.11	.11	.10	.19	.11	.16	.30	.34	.35	.19	.16	.19	.17	.15	.08	.19

APPENDIX A
Correlations Among 48 Variables (Cont'd.)

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
18																			
19	.28																		
20	.47	.38																	
21	.22	.33	.26																
22	.34	.28	.37	.51															
23	.15	.26	.19	.54	.54														
24	.34	.35	.30	.46	.60	.48													
25	.36	.26	.42	.42	.48	.32	.48												
26	.27	.30	.25	.24	.22	.13	.32	.48											
27	.35	.28	.30	.51	.50	.33	.51	.66	.47										
28	.23	.19	.17	.46	.38	.30	.32	.55	.48	.57									
29	.23	.05	.23	.25	.35	.19	.44	.50	.41	.45	.49								
30	.29	.26	.33	.45	.41	.27	.42	.45	.52	.59	.58	.54							
31	.37	.26	.41	.41	.25	.25	.28	.41	.55	.53	.58	.44	.66						
32	.30	.15	.26	.26	.39	.28	.43	.46	.52	.56	.53	.60	.48	.48					
33	.26	.28	.25	.56	.57	.48	.51	.47	.40	.46	.43	.40	.39	.32	.46				
34	.21	.17	.14	.43	.36	.24	.26	.40	.29	.41	.43	.29	.47	.40	.31	.35			
35	.07	.09	.12	.21	.10	.06	.14	.34	.19	.32	.25	.30	.22	.21	.25	.23	.16		
36	.11	.14	.17	.33	.33	.19	.32	.49	.16	.30	.26	.32	.16	.19	.33	.27	.16	.50	
37	.11	.01	.16	.41	.36	.23	.23	.37	.14	.38	.35	.32	.39	.26	.34	.31	.32	.47	.47
38	.18	.05	.17	.39	.33	.20	.38	.47	.25	.39	.30	.28	.24	.27	.39	.38	.22	.44	.62
39	.03	.09	.04	.11	.00	.05	.05	.07	.08	.09	.19	.11	.06	.16	.14	.20	.03	.31	.13
40	.01	.01	.09	.33	.24	.25	.17	.20	.07	.08	.25	.24	.26	.13	.18	.29	.23	.02	.24
41	.03	.04	.03	.25	.20	.27	.34	.22	.10	.21	.25	.34	.29	.23	.24	.16	.23	.16	.32
42	.05	.19	.10	.33	.28	.39	.35	.32	.18	.21	.21	.33	.23	.15	.26	.33	.21	.10	.27
43	.05	.08	.18	.37	.39	.31	.42	.40	.17	.32	.27	.34	.29	.19	.30	.43	.20	.25	.41
44	.01	.05	.07	.14	.17	.19	.32	.26	.22	.19	.21	.34	.16	.12	.31	.28	.11	.08	.25
45	.14	.01	.05	.13	.16	.13	.09	.12	.02	.02	.04	.12	.05	.11	.01	.12	.19	.03	.15
46	.14	.22	.19	.24	.35	.32	.37	.38	.20	.30	.25	.32	.16	.09	.24	.23	.24	.04	.21
47	.01	.12	.12	.17	.22	.17	.28	.26	.06	.11	.02	.21	.10	.09	.07	.12	.11	.01	.17
48	.02	.22	.01	.19	.20	.20	.27	.18	.18	.24	.27	.25	.13	.18	.16	.16	.10	.08	.24

APPENDIX A
Correlations Among 48 Variables (Cont'd.)

	37	38	39	40	41	42	43	44	45	46	47	48
37												
38	.62											
39	.35	.27										
40	.30	.16	.24									
41	.33	.30	.15	.45								
42	.32	.28	.24	.49	.61							
43	.33	.46	.27	.51	.49	.55						
44	.16	.27	.21	.35	.46	.44	.47					
45	.13	.23	.05	.27	.27	.44	.42	.20				
46	.16	.26	.01	.26	.40	.51	.36	.28	.47			
47	.13	.13	.01	.29	.32	.57	.37	.28	.48	.41		
48	.11	.14	.02	.16	.25	.23	.25	.23	.32	.40	.26	