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Factor structure of time-sharing performance at different levels of practice

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Previous attempts to identify a general time-sharing ability have been investigated at the low level of practice and have proven unsuccessful. Therefore, in the present study we examined whether the hypothetical time-sharing ability would emerge at a higher level of dual-task practice. To test this possibility, 111 participants performed various tracking and choice-reaction tasks during 10 consecutive days of practice both singly and concurrently. Under single-task conditions participants carried out seven simple tasks two times a day, while under dual-task conditions they carried out 14 different combinations of two simple tasks, three times each. This yielded 20 performance measures for each simple task and 30 performance measures for every dual-task combination. The data were analyzed with a series of factor analyses, separately for every level of practice: the low level (the first 3 days), intermediate level (the following 4 days), and high level one (during the last 3 days). The results showed that practice has no significant impact on the factor structure of single- and dual-task measures. Almost identical factor solutions have been obtained for all three levels of practice, and the general time-sharing factor representing hypothetical ability has not been identified at any level of practice. Instead, at all levels, three group time-sharing factors have been obtained. These findings support the idea of a multifactor model of time-sharing performance suggesting that performance on various multiple tasks would depend on several relatively independent time-sharing abilities.

Keywords: time-sharing ability, individual differences, dual-task performance, practice

Modern studies aimed at identifying the ability structure in multiple task performance began in the middle of 1970s. They were run under the assumption that efficient performing of simultaneously presented tasks would not depend solely on the abilities and skills necessary to perform these tasks presented singly, but also on a distinct time-sharing ability (e.g. Levine, Romashko, & Fleishman, 1973; Parker, Reilly, Dillon, Andrews, & Fleishman, 1965; Pew & Adams, 1975). Thus, hypothetical ability is general in nature and "enables some individuals to work more easily and successfully than others under high workload conditions when several tasks have to be performed concurrently" (Šverko, Jerneić, & Kulenović, 1983, p.151).

The assumption on the time-sharing ability had been largely accepted among instructors, as well as researchers involved in selection and training of operators on complex jobs. Instructors in air-traffic control and flying training have often emphasized trainees being eliminated because of their deficiency in the concurrent performance on a variety of tasks that such jobs usually are composed of, and not because of the possible lack of specific abilities or skills (Jennings & Chiles, 1977). Similar viewpoint had been shared by applied researchers (e.g., Alluisi, 1967; Danhaus & Halcomb, 1975; Passey & McLaurin, 1966; Waldeisen, 1974) opposing the traditional "serial" approach to ability assessment in which individual tasks or discrete subtests are administered independently, one by one. Instead, they believed this approach should be replaced by a "parallel" one, allowing concurrent presentation of several tasks – that would permit a better prognosis of the operator's success in complex jobs, because it resembles more to the real work situation.

Two groups of studies have pointed to the correctness of the assumption that simultaneously presented tasks bring forth a special ability. One group of studies ascertained that concurrently performed tasks have a greater predictive validity for complex jobs in comparison to tasks performed singly (e.g., Chiles, Jennings, & West, 1972; Fournier & Stager, 1976; North & Gopher, 1976). The second group of studies established that the performance of complex, concurrently performed tasks appeared to be relatively independent of the performance of their component tasks executed singly (e.g., Fleishman, 1965; Freedle, Zavala, & Fleishman, 1968; Hoppe, 1874). However, this support is moderate as the mentioned investigations have not been planned nor conducted so to allow for the clear test of the

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hypothesis on the existence of the general time-sharing ability. To support the notion of the hypothetic ability it is necessary to demonstrate not only the relative independence of the performance in singly and concurrently presented tasks, but also the consistency of individual differences within different dual task combinations. That is why Šverko (1977) and Jennings and Chiles (1977) conducted investigations using different combinations of simultaneous tasks in order to check the viability of the hypothetical ability. The results proved contradictory. On the one hand, Jennings and Chiles succeeded in identifying one time-sharing factor related to visual scanning in multiple-task monitoring, while on the other hand, Šverko proved that under solitary and concurrent conditions same abilities are elicited.

Later studies also speak of such contradictory results. Some studies confirmed Šverko's findings and have entirely rejected the idea of the time-sharing ability (e.g. Lansman, Poltrock, & Hunt, 1983; Wickens, Mountford, & Schreiner, 1981); while other studies accepted the existence of specific time-sharing factors (e.g. Braune & Wickens, 1986; Brookings, 1990; Jerneić & Šverko, 1994). Also, two studies have isolated the general time-sharing factor (Ackerman, Schneider, & Wickens, 1984; Fogarty & Stankov, 1982). A lack of a clear support of the general time-sharing ability is mainly linked to the conceptual, methodological and statistic-analytical inadequacies of particular studies which could mask, individually or in combination, the reality of such an occurrence (see Ackerman et al. 1984; Brookings & Damos, 1991; Jerneić, 1988a). However, the cumulative empirical findings, particularly the results of recent studies, bring about the conclusion which makes the above less than likely. Recent studies have avoided the majority of the above-mentioned shortcomings. On the conceptual level explicit models of the time-sharing performance have been used (Brookings, 1990; Fogarty, 1987; Jerneić 1988b) with the recognizable rationale and/or theory underlying the choice of experimental tasks. Thus, the simple and complex tasks have been chosen within the context of contemporary attention theory (Brookings, 1990) of the accepted intelligence model (Fogarty, 1987) and an already known taxonomy of psychomotor abilities (Jerneić, 1988a). The non-existence of the general factor seems not to be caused by methodological inadequacies related to the control of priorities, to the way of scoring dual-tasks performance (Fogarty, 1987; Jerneić, 1988a), individual differences arising from the practice effects (Jerneić, 1988b), between-participants speed-accuracy trade-off differences (Brookings, 1990; Jerneić, 1988a), and particularly not to the method of data analysis - since the confirmatory factor analyses (Brookings, 1990; Fogarty, 1987), factor analyses of partial correlations (Bitner & Damos, 1986; Jerneić, 1988a), and exploratory factor analyses have been conducted.

Though neither theoretical diversity, nor strict methodological control and sophisticated statistic procedures helped in identifying a general time-sharing ability, they added to a clearer and unambiguous identification of group time-sharing factors. Majority of recent studies have isolated at least one factor with such characteristics (Bittner & Damos, 1986; Braune & Wickens, 1986; Brookings, 1990; Fogarty, 1987; Jerneić 1988a; Jerneić & Šverko, 1994; Morrin, Law, & Pellegrino, 1994; Salthouse & Miles, 2002; Šverko et al., 1983; Šverko, Maslić-Seršić, Jerneić, & Gurdulić-Šverko, 1994), or on the grounds of the correlation analyses the existence of such factors could have been concluded upon (e.g., Ben-Shakkar & Sheffer, 2001; Yee, Hunt, & Pellegrino, 1991; Yee, Laden, & Hunt, 1994). Taking into account the results of previous studies which found specific time-sharing factors (Chiles & Janning, 1978; Jennings & Chiles, 1977), as well as the results of reanalyzes (Bittner & Damos, 1986) performed on the data of Šverko (1977) or Wickens, Mountford, and Schreiner (1981), their existence should be questioned. Repeated presence of the same or similar factors in different experiments speaks in favor of this conclusion. This is in itself important because with the repetition of structural analyses there is always a possibility for artificial factors to emerge (Humphreys, Ilgen, McGrath, & Montanelli, 1969). It seems that it is precisely the emergence of artificial factors that accounts for the two general time-sharing factors identified in the studies of Fogarty and Stankov (1982) and Ackerman et al. (1984). In the very interpretation of their results, Fogarty and Stankov expressed doubts as to whether it was the matter of a real or artificial factor. The reason for their dilemma appears to be twofold. First, primary scores[1] in competing tasks had, contrary to the expectation, reflected the structure of singly administered tasks instead of defining the time-sharing factor together with the secondary task scores. Second, some participants used a specific strategy of responding by guessing which of the component tasks will serve as a primary task at a given moment. The possibility for the isolated factor representing some sort of instructional or strategic artifact had been confirmed in later studies, since in his repeated investigation, by using the same methodology and similar tasks, Fogarty (1987) did not succeed in isolating a general time-sharing factor. On the contrary, Stankov (1988) confirmed that primary and secondary scores appeared to be measuring the same single-task abilities. On the other hand, a general time-sharing factor, identified by Ackerman, Schneider, & Wickens (1984) in an attempt to reanalyze the data of Wickens et al. (1981), had probably been isolated due to the specifically designed structural hypothesis. Namely, hypothetic model was analyzed with the assumption of the perfectly reliable data. Owing to a small percentage of variance reserved for

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[1] Fogarty and Stankov used postcuing technique to control participant's allocation policies in competing tasks so participants did not know in advance which component task is of primary importance. Only if the answer to the cued task was correct (primary score) were the participants allowed to answer to the other component task (secondary score).

the time-sharing factor (25%) it could, partially or completely, be a consequence of error and specific variance of every variable. Besides, both single- and dual-task measures have moderate loadings on isolated time-sharing factor, making its identification as a time-sharing factor questionable (Bittner & Damos, 1986). Finally, it should be mentioned that the general time-sharing factor was isolated neither by the classical exploratory analysis in the original empirical study (Wickens et al., 1981), nor by the factor analysis of partial correlations conducted by Bittner and Damos (1986) on the same data.

Hence, the empirical data do not support the existence of a general time-sharing ability, but point to the existence of group time-sharing factors. Qualitative comparison of the results of structural analyses and the type of tasks used in different studies could bring us to the conclusion that at least two group factors represent real and replicable time-sharing components. One well defined time-sharing factor is the factor related to the visual scanning and sampling strategies in complex monitoring tasks (Jennings & Chiles 1977; Chiles & Jennings, 1978; Braune & Wickens, 1986; Brookings 1990), the other is the time-sharing factor in complex choice-reaction tasks (Šverko et al., 1983; Jerneić, 1988b; Jerneić & Šverko, 1994; Šverko et al., 1994).

At the moment it appears rather difficult to say whether there are more stable or identical time-sharing factors. There are several potential candidates, but a large variety of tasks used coupled with the limitations of qualitative comparisons precludes the possibility of coming to a more convincing conclusion. Future investigations should unify some of the isolated factors, testing for their stability and determining their interrelations. This might improve our knowledge on relevant dimensions of the timesharing performance allowing for new possibilities of re-examining the notion of a general time-sharing ability. This represents the basic idea of the hierarchical model suggested by Braune and Wickens (1986) – timesharing components would allow us to reach the general factor. Apart from this, all the previous research has analyzed the data obtained at the low levels of practice, which could have represented one of the main reasons why the general ability had not yet been isolated. As the practice is a mighty modifier of behavior, the general factor of time-sharing could manifest itself only at the high level of practice (e.g., Adams, 1987; Damos & Smist, 1980; Fleishman, 1967).

The results of two lines of investigations may support this assumption. One group is represented by experimentally oriented investigations mainly engaged in the development, identification and transfer of the time-sharing skills. The development of the time-sharing skills had been examined in a number of studies. It has been distinctly shown that under the dual-task conditions special time-sharing skills are developed – those which cannot be acquired under single-task conditions when the same component tasks are performed one by one (e.g., Damos & Smist, 1980, 1981; Gopher & North, 1977; Kalsbeek & Sykes, 1967; Spelke, Hirst, & Neisser, 1976). Practice on dual-tasks seems to be more efficient than the practice on component-tasks (e.g., Adams & Hufford, 1962; Briggs & Naylor, 1962; Detweiler & Lundy, 1995; Folds, Gerth, & Engleman, 1987; Stammers, 1980), and training solely on component tasks shows a small or almost no impact to the success of performing concurrent tasks (e.g. Rieck, Ogden, & Anderson, 1980; Schneider & Detweiler, 1988) even after the extensive practice (e.g., Scheider & Fisk 1984). It is less obvious what exactly constitutes the time-sharing skill. There are some possibilities, but efforts to isolate and identify them are relatively small in number. However, some have been successfully identified in several different studies: among them skills of visual scanning of several sources of information – when and to which source of information to attend to (Braune & Wickens, 1986; Brookings, 1990; Gabriel & Burrows, 1968; Jennings & Chiles 1977), skills of variable and controlled allocation of resources – how to best allocate resources to a single component tasks, with which priorities and to what extent (e.g., Fabiani, Buckley, Gratton, Coles, Donchin, & Logie, 1989; Gopher, 1992; Gopher & Brickner, 1980; Gopher, Weil, & Siegel, 1989; Kramer, Larish, & Strayer, 1995; Kramer, Larish, Weber, & Bardell,1999), as well as skills linked to various strategies of responding spontaneously adopted when faced with simultaneous tasks (Damos & Smist, 1980, 1981; Damos, Smist, & Bittner, 1983; Damos & Wickens 1980). How general these skills may be is difficult to say right now. It seems possible that some are of a more restricted range or even specific for certain dual-tasks, while others are of a more general nature and are extended to various combinations of tasks. The transfer of time-sharing skills has been confirmed not only between the similar tasks (e.g., Bherer, Kramer, Peterson, Colcombe, Erickson, & Becic, 2005; Detweiler & Lundy, 1995; Hirst, Spelke, Reaves, Caharak, & Neisser, 1980), but also between entirely different tasks (e.g., Damos & Wickens, 1980; Kramer, Larish, & Strayer, 1995; Kramer, Larish, Weber, & Bardell, 1999; Rieck et al., 1980). The existence of transfer among various combinations of concurrent tasks points to the general aspect of time-sharing skills and appears to be in accordance with the assumption that, on the higher levels of practice, a general time-sharing ability might emerge. The research findings of Damos and Wickens are of particular significance here. Apart from the fact that they had established the generality of time-sharing skills which they identified as response strategies of unequal efficacy (simultaneous, alternating, and massed strategy), they had also shown that in selecting and stabilizing the strategies a multiple performing of dual-tasks is needed, which of course requires higher instances of practice.

The second group is represented by differentially oriented investigations interested in determinants of individual differences in cognitive and psychomotor tasks in various phases of skill learning and acquisition. At the very beginning it has been discovered that correlations between repeated measures on the same tasks follow a robust and regular pattern (Perl 1933, 1934) –what was later called super-diagonal matrix or quasi-simplex (Humphreys, 1960; Jones, 1962). What seems to cause such regular and systematic changes in the participants' rang-order has thus become a key research question. Two conflicting hypotheses were tested to find the answers (e.g., Woodrow, 1938, 1939a,b; Humphreys, 1960; Corballis, 1965). According to one of them, a reorganization of the abilities during the training seems to occur so that the successful performance of tasks at the beginning and at the end of practicing apparently depends on a different constellation of abilities. According to another hypothesis, the contribution of certain abilities in different phases of training remains the same while the degree of the development of the abilities in question is the one that is changing (because not all abilities necessarily remain stable and well taught). Empirical verifications have massively supported the first hypothesis. Numerous investigations (e.g., Ackerman, 1987, 1988, 1990; Adams, 1953; Fleishman, 1960; Fleishman & Hempl, 1954, 1955; Reynolds, 1952ab; Woodrow, 1938, 1939b) have unequivocally confirmed that the training changes the factor structure of criterion tasks, i.e. the restructuring of abilities occurs as a function of training. At the beginning and at the end of the practice the performance had been determined by various abilities. However, the second hypothesis, though less verified, had not been completely rejected. For example, the findings of Alvares and Hulin (1973; Hulin & Alvares, 1971) had suggested that abilities could be strengthened with practice. As both hypotheses gained support, they made the conclusion that processes and changes occurring at the time of adopting of various skills are best represented by a third hypothesis - which is predicting even the changes in the strength of the abilities, as well as changes in its structure. Jones (1980,1981) seems to agree with their viewpoint, while examining various tasks and ability tests he found that when practicing is allowed the tests behave as does the majority of other tasks: the performance seems to increase with practice, correlations between successive trials take on the typical superdiagonal form, and as practicing goes on the correlations with criterion variables, even with other tests, are changing (Jones, 1980, 1981; Jones, Kennedy, & Bittner, 1981ab; Pepper, Kennedy, & Bittner, 1980; Seales, Kennedy, & Bittner 1980). This is the reason why Jones (1981) expressed the opinion that only when the test reaches the point of the differential stability (i.e. when as a function of practice correlations between successive trials remain relatively stable), then it is the time to analyze the data and identify which are the abilities that the test really measures. Accordingly, the factor analysis of differentially stable data in different dual-task combinations would represent the real test of the existence of general time-sharing ability (e.g., Damos, Bittner, Kennedy, & Harbeson, 1981).

To summarize: the results of the investigations on the acquisition and the transfer of the time-sharing skills, as well as those on individual differences in skill learning offer an empirical and theoretical basis for the hypothesis that general time-sharing ability could emerge at higher levels of practice. However, until now no research had been made to investigate this assumption. Investigations so far have been treated the problem of individual differences in multiple-tasks, mainly testing this hypothetic ability at the early levels of practice. Considering the aspect of skill learning, the number of trials to ensure a more substantial development of general time-sharing skills, thus arriving at the change of the factor structure of performed tasks as a function of practice, was certainly much too small. This applies to practically all research testing the impact of practice on the ability structure, particularly in those using the concept of differential stability. Insufficient practice could be the main reason why the present-day attempts to identify general time-sharing ability appear unsuccessful.

In this study we tried to eliminate the abovementioned shortcoming by ensuring sufficient amount of practice to learn and acquire skills. The main goal was to examine the ability structure in singly and concurrently applied tasks at various levels of practice. This should give us the insight in the possible changes of abilities that might appear during practice and, thus, bring up the answer whether the general time-sharing ability is emerging at high level of practice.

METHOD

Tasks

Seven simple, i.e. singly presented tasks and 14 complex (dual) tasks have been used in this research. Single tasks represent two frequently used types of laboratory tasks: the so-called graded response tasks, suitable in examining the exact control of movement, and the so-called ungraded response tasks, suitable to examine time necessary for response selection (Legge & Barber, 1976). Two pursuit tracking tasks were chosen from the first group, as well as two compensatory tracking tasks, while three choice-reaction time tasks were selected from the second group. Task selection was based on Fleishman taxonomy of psychomotor abilities (Fleishman, 1967, 1972; Fleishman & Quaintance, 1984) and the results of our previous studies (Jerneić, 1988a; Jerneić & Jukić, 1996; Jerneić & Šverko, 1994). The tasks were selected to enable us to anticipate the factor structure of the single tasks. Single-tasks were chosen to define three factors in structural analyses: choice-reaction factor, pursuit tracking factor and compensatory tracking factor:

(1) *Pursuit tracking (PT1)*. This is a target acquisition task in which a small square (8 x 8 mm) representing the target appears randomly every 1.5 seconds in a different place along a 12 cm horizontal line. Besides the small square (target) there also appears a short vertically po-

sitioned line or cursor (8mm) which is operated by the participant using the knob. The task of the participant is to superimpose the cursor to the target by adequately turning the knob, as quickly as possible.

(2) *Pursuit tracking (PT2)*. Similar to the previous task, but now the target does not seem to "jump" but is moving continuously along the line. The target is a 1 cm space bordered by two small lines placed apart next to the upper horizontal line and a cursor is now represented by a short vertical line next to the lower horizontal line. The movement of the target is under the influence of random forcing function mathematically defined as the sum of 5 sinusoid waves of different frequencies: 0.1304, 0.2222, 0.3750, 0.6383, 1.1111 Hz. The participant's task is to bring the cursor in the position between the two small lines and keep it there following the movement of the target. This is done by operating the knob, as well.

(3) *Compensatory tracking (CT1)*. There are two version of this compensatory tracking task: horizontal and vertical. The horizontal version of the task requires the participant to manipulate the knob with the left hand, compensating the movement of vertical bar (1,6 cm) and keeping it centered on stationary horizontal 1.6 cm bar. The vertical bar is moving from left to right in accordance with the input function composed as the sum of sinusoid waves of the following frequencies: 0.1123, 0.2738, 0.4222, 0.6771, 1.0234 Hz. In the vertical version of the task the participant needs to control the knob with his right hand by compensating the movement of the horizontal bar and keeping it across the vertical bar. The horizontal bar is moved by the same kind of random function, but is recorded in another time fraction.

(4) *Compensatory tracking (CT2)*. This is also a compensatory tracking task in which the participant manipulates the knob attempting to compensate for the disturbances of the forcing function. It is now represented by horizontal forcing function composed of the wave sums of 0.1771, 0.2903, 0.4411, 0.5922, 0.7132, 0.9507 and 1.41553 Hz, so to hinder keeping the small cross (5x5 mm) within the defined area of 1.3 cm size.

(5) *Lights*. This is a choice-reaction task in which, at random but regular time-intervals, one of four 1cm diameter circles in horizontal series lights up. The lighted circle represents the stimulus to which participants are to respond as quickly as possible, by pressing the adequate response key. The arrangement of keys from left to right corresponds to the sequence of circles from left to right.

(6) *Numbers*. In this choice-reaction task a number from 1 to 4 is presented to participants at random. At the appearance of the number the participant is to press, as quickly as possible, the corresponding key. The corresponding key for number 1 is on the far left, the numbers following in the right order, with key number 4 on the farthest right position.

(7) *Letters*. This task resembles the previous one, but now the letters (A, B, C, D) appear at random. The participant's task is to respond by pressing the appropriate key at the appearance of the letter. These keys are arranged from left to right in the alphabetic order of the letters.

The total of 14 complex tasks has been formed from these 7 simple tasks. Every complex task represented a different combination of 2 simple tasks. Though, at the very beginning the goal was to form complex tasks representing all possible combinations of simple tasks, the time-length of the research coupled with technical difficulties limited our choice to some dual-task combinations. This is the reason for not pairing the choice-reaction tasks with tracking tasks. There are two explanations for giving the priority to the homogeneous dual-tasks: (1) with this kind of simultaneous tasks the possibility of favoring one of the component task to the disadvantage of the other one is adequately reduced and (2) should the timesharing ability be understood as the expression of the amount of available resources than the hypothetic ability will disclose itself more clearly if the tasks share the same resources than if they are sharing different ones (e.g. Brookings, 1990). Apart from that, if the general time-sharing ability does exist on higher levels of practice, then basically it should not matter whether the simultaneous tasks represent combinations of the same or of different abilities. In accordance with this rationale the following dual-tasks have been chosen: (8) *PT1 & PT1*, (9) *PT2 & PT2*, (10) *PT1 & PT2*, (11) *CT1 & CT1*, (12) *CT2 & CT2*, (13*) CT1 & CT2*, (14) *PT1 & CT2*, (15) *CT1 & PT2*, (16) *concurrent lights*, (17) *concurrent numbers*, (18) *concurrent letters*, (19) *lights and numbers*, (20) *letters and lights*, and (21*) numbers and letters*.

Considerable attention had been given to the visual aspect of the particular tasks so that, on the screen, they would occupy the smallest possible space and the peripheral interference among the tasks could be avoided. Within the dual-tasks the maximal visual angle (7.7° x 5.9°) was occupied by the compensatory tracking task "Concurrent CT1".

Both simple and complex tasks lasted for a minute. In simple choice-reaction tasks the interstimulus interval was 1.5 seconds and in complex task 2 seconds. In the complex tasks the stimuli appearance was synchronized, but in every component task the stimuli followed their own random sequence which was never repeated. This was also true for the appearance of successive stimuli in the target acquisition tasks, but here the targets in concurrent conditions were changing position every 1.5 seconds. In other tracking tasks independent input functions of the same or different difficulties have been recorded at distinct time intervals, so that the target courses in particular tasks and trials were never the same.

Performance measures. Several performance measures were recorded, but due to the better reliabilities two main measures were selected for the final analyses: *percentage of the time on target* (*TOT*) for the tracking tasks and *mean reaction time of correct responses* (*CRT)* for the choice-reaction tasks. Percentage of time on the target is often used in tracking tasks and represents the percentage of time the cursor remains superimposed on the target within the total time of the given task. Similarly, the frequent performance measure in choice-reaction tasks is the mean time of correct reactions since the percentage of wrong reactions regularly seemed very low. As in our previous studies (Šverko et al., 1983; Jerneić & Šverko, 1994) in the dual tasks conditions the *combined* performance was recorded. In concurrently presented tracking tasks the time on target was measured only when both cursors superimposed the targets at the same time, and in the concurrently presented choice-reaction tasks the correct reaction has been scored only when the participant has responded successfully to the stimuli in both component tasks.

Apparatus

All the tasks were presented on standard 14" monochrome CRT monitors. Four IBM compatible PCs were used to generate the stimuli, record the participants' reactions and manage the complete experiment session. Tracking tasks have been simulated on the two computers which had in-built analogue-digital converters. The digital signals had been recorded in advance and then converted to analogue inputs. The participants have been reacting to the input functions with two rotary knobs of about 150 kiloohms impedance and maximal pitch angle of 300 degrees. All tracking tasks have been of zero-order (position) control dynamics. The choice-reaction tasks have been displayed on two other computers. In responding to the stimuli participants used two anatomically adapted control keyboards. Both keyboards had 4 keys, arranged in a semi-circle, to make the position of fingers as natural as possible while reacting to the stimuli. The experiment had been performed in 4 sound-proof booths with constant artificial lighting.

Participants

A number of 111 participants took part in this study: 90 female and 21 male psychology students, aged between 18 and 27, with normal vision and no apparent sensory or motor deficiencies. All of them have participated in the testing of the time-sharing ability for the first time and did not have previous experience with the applied tasks. They were offered class credits or money reward for their participation.

Procedure

The research consisted of two parts: pretesting and main experiment. During the pretesting period participants were acquainted with the procedure and experimental tasks. Before a particular task participants were given written instructions. The instructions contained the descriptions of the tasks, the task requirements and the ways to activate the tasks, while the experimenter explained, in detail, how their performance would be scored. The participants performed the tasks singly and concurrently in the same order as in main experiment. All single tasks have been performed in 1 minute, with each hand, and all of the dual-tasks first for 20 and then again for a minute.

During the second part of the research the testing of each participant lasted for 10 days. The participants did same tasks every day in two sessions with a 30 minute break after each session. In one session the single- and dual tracking tasks have been included and in the other single and dual choice-reaction tasks. The participant did the single tasks once with his left and once with his right hand, while the concurrent tasks had to be executed three times consecutively. Accordingly, during the testing period every participant performed all single tasks 20 times over and all concurrent ones 30 times. The sequence of the tasks within the sessions has not been changed during the whole experiment. Half of the participants began the testing with the choice-reaction tasks, while the other half began with tracking tasks. Within the sessions the tasks have been applied in the following order:

Session with tracking tasks – 1. pursuit tracking (PT1); 2. PT1 & PT1; 3. pursuit tracking (PT2); 4. PT2 & PT2; 5. PT1 & PT2; 6. compensatory tracking - CT1; 7. CT1 & CT1; 8. compensatory tracking - CT2; 9. CT2 & CT2; 10. CT1 & CT2; 11. PT1 & CT2; 12. CT1 & PT2;

Session with choice-reaction tasks – 1. lights; 2. concurrent lights: 3. numbers; 4. concurrent numbers; 5. letters; 6. concurrent letters; 7. lights and numbers; 8. letters and lights; 9. numbers and letters.

After each task the participants had a short one-minute break, and after about two thirds of the performed tasks in each session there was another 5 minute break. Including these pauses, each tracking tasks session lasted about 60 to 65 minutes, while the choice-reaction tasks sessions lasted about 30 to 40 minutes.

As it was a very long, relatively monotonous and tedious experiment, the participants were additionally motivated by a system of performance bonuses for the achieved performance. After each task participants were shown his/her score was and whether this score was any better from the task performance of the previous day[2]. For every improved performance participant was awarded a point, but in case of worse performance one point was taken away. In that way

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[2] The displayed score in the choice-reaction tasks was the average correct response interval (CRI), a derived measure which took into the account both speed and accuracy of responses. Since participants were instructed to respond as fast and as accurately as they could, CRI score reinforced this instruction.

participant was competing with him/herself to collect as many points as possible. At the end of the experiment the points were given money value and the sum was paid to the participant. The mean sum of the paid value was something over one tenth of the average monthly salary and, as participants stated, it was high enough to motivate them to improve their performance and make the experiment more interesting to them.

RESULTS

Practice effects on the task performance

Data has been analyzed in several successive phases. In the first phase three performance scores have been computed for each task, representing the participant's performance on three levels of practice: the low, the intermediate and the high level one. The first performance score represented the average performance during the first three days of the experiment; the second performance score represented the average performance during the following four days, while the third score represented the average performance in the last three days of the experiment. Therefore, the average scores at the beginning and at the final level of practice have been defined on the basis of 6 trials in single tasks and 9 trials in dual-tasks, while on the intermediate level of practice they have been computed on the basis of 8 trials in single and 12 trials in dual-tasks. Dealing with only 3 different performance scores, instead of 10 (for each day) the number of structural analyses has been reduced, the comparison of the obtained factors was made easier, and the presentation of the main findings of the study was simplified.

Table 1 shows descriptive statistics for the performance measures on each level of practice: means, standard deviations, *F*-ratios and reliabilities. The results could be considered from two perspectives: (1) the perspective of practice effects, and (2) the perspective of time-sharing decrements within each level of training.

The practice effects. If M's as a function of practice (M1, M2, M3) are compared, it is evident that participants' proficiency has improved: M's in tracking tasks increase, while

Table 1
Means, standard deviations, F- values, and reliability estimates of single- and dual-task performance measures at three levels of practice

Task	Measure	*M1*	*M2*	*M3*	*SD1*	*SD2*	*SD3*	*F***	α1	α2	α3
Pursuit tracking - PT1	%TOT	61.4	64.8	66.1	4.22	3.31	3.10	157.3	.87	.95	.91
Pursuit tracking - PT2	%TOT	56.6	62.0	65.2	5.31	5.73	5.50	421.8	.93	.97	.95
Compensatory tracking - CT1	%TOT	56.4	62.8	67.1	6.80	7.32	6.94	319.3	.94	.97	.95
Compensatory tracking - CT2	%TOT	38.7	43.3	45.9	4.41	5.31	5.84	269.9	.94	.97	.96
Lights	CRT	425.9	385.0	374.9	54.70	38.56	33.15	184.9	.95	.96	.95
Numbers	CRT	499.0	458.1	446.1	60.14	44.48	36.07	181.6	.96	.95	.94
Letters	CRT	519.2	479.0	462.5	65.20	46.76	39.46	170.0	.96	.96	.95
PT1 & PT1	%TOT	34.5	43.5	47.9	6.86	6.58	6.08	860.1	.97	.98	.98
PT2 & PT2	%TOT	19.2	24.7	28.2	3.75	5.08	5.67	685.4	.96	.98	.97
PT1 & PT2	%TOT	20.0	27.4	31.6	4.68	5.68	6.09	875.0	.97	.98	.97
CT1 & CT1	%TOT	26.8	37.9	44.4	6.88	8.60	9.35	699.3	.97	.98	.98
CT2 & CT2	%TOT	11.1	14.7	17.8	2.46	3.69	4.59	453.3	.95	.98	.97
CT1 & CT2	%TOT	17.0	22.1	25.9	3.92	5.17	5.73	487.8	.96	.98	.97
PT1 & CT2	%TOT	16.6	21.8	24.9	3.42	4.08	4.37	670.4	.96	.97	.97
CT1 & PT2	%TOT	22.2	28.8	32.8	5.09	6.29	7.18	511.9	.97	.98	.97
Concurrent lights	CRT	1104.2	883.3	794.9	135.83	124.14	107.35	1617.0	.97	.99	.98
Concurrent numbers	CRT	1012.7	865.1	804.3	130.57	111.68	105.49	877.9	.98	.99	.99
Concurrent letters	CRT	1017.7	869.0	824.6	135.42	108.92	99.50	748.0	.98	.99	.98
Lights and numbers	CRT	994.2	862.3	770.1	151.15	131.05	121.79	820.1	.99	.99	.99
Letters and lights	CRT	1056.6	920.1	851.6	144.63	115.02	104.09	618.4	.98	.98	.98
Numbers and letters	CRT	1037.9	915.6	840.4	143.44	119.34	105.64	582.0	.98	.99	.99

Note. CRT denotes the reaction time of correct responses (in msec), and %TOT is the percentage of time on target. All F-values are significant at p<.0001.

in the choice-reaction tasks they appear to be dropping. As the obtained F-ratios (2,110) revealing these differences are highly significant ($p<.0001$) both, in singly (tasks 1 through 7) and concurrently performed tasks (tasks 8 through 21). Also, there appears to be a difference in the magnitude of F-ratios in single and dual-tasks, indicating that with practice performance seems to improve faster in concurrent task than in single task conditions. Faster improvement in concurrent tasks was confirmed by d-indices (Cohen, 1988) expressing the size of the effect in performance of simple and complex choice-reaction and tracking tasks at the low level and high level of practice. Comparison revealed that effect size of averaged d-indices for dual choice-reaction tasks ($d = 1.79$) was larger than for single choice-reaction tasks ($d = 1.08$). It was also larger for complex tracking tasks ($d = 1.96$) than for simple tracking tasks ($d = 1.45$).

The effect of practice on the standard deviations (SD1, SD2, SD3) is not that simple or unambiguous as it was with M's though certain regularities do appear. What can be noticed immediately is the obvious reduction of variability in all of the choice-reaction tasks. It occurs with both simple and complex tasks. Such reduction is seen in other studies (e.g., Ackerman, 1987, 1990; Fleishman & Hempel, 1955), as well as in Ackerman's theory on individual differences in skill acquisition (Ackerman, 1986, 1987, 1988, 1990), and is due to the highly consistent tasks which enable the development of automatic information processing (Schneider & Shiffrin, 1977). However, the situation regarding tracking tasks differs somehow. In simple tasks clear regularity is missing: SD's reveal a slight decrease (*Pursuit tracking – PT1*), remain stable (*PT2, CT1*), or even show a slow increase (*Compensatory tracking -CT*2). On the other hand, there are some regular changes in between-participants variability in complex tracking tasks. With the exception of concurrent pursuit tracking (PT1 & PT1), the variability as a function of practice appears to be increasing in all of the other concurrent tracking tasks. Such a trend may be explained in at least two ways. On the one hand, the increase of variability could be explained as the consequence of the type and complexity of the concurrently practiced tasks because these tasks require a higher degree of controlled information processing and have a much lesser degree of consistency than the choice-reaction tasks. On the other hand, the increase of variability may be explained by the "bottom effect". In fact, the concurrent tracking tasks are too difficult (notice the low percentage of time on target) so that performance appears to be artificially limited at one end of the distribution. The limitation of the performance at one end of distribution could have reduced the variability rather significantly in the tasks at the low level of practice. At the intermediate, and particularly at the high level of practice, the "bottom effect" is gradually lost due to the improved performance, thus allowing the increase of variability.

(2)Task-complexity effects. Similar regularities exist even when statistical parameters are considered as differences between single- and dual-tasks within the same levels of practice. It is evident that, for example, performance scores in dual-tasks are markedly degraded in comparison with the performance scores in corresponding component tasks performed singly regardless of the practice level. Mean reaction times are twice as long, and percentage of time on target considerably smaller. This is confirmed by checking statistically significant differences which has been done by t-tests for dependent samples. All the differences between the corresponding performance means proved statistically significant ($p< .01$). Such a decrement in performance on the time-shared tasks indicates the possible interference between component tasks and their high workload, both considered necessary prerequisites in eliciting the hypothetic ability.

If we consider the SD's of simple and complex tasks in the same way, we may observe systematic changes of variability only in the complex choice-reaction tasks. In comparison with singly presented tasks the SD's in concurrently presented choice-reaction tasks are 2-3 times larger, with a clear trend of having even greater differences at the higher levels of practice. In tracking tasks such regularity does not occur. The differences in variability between the corresponding single and dual tracking tasks are not pronounced; they have different direction and seem to diminish with the practice.

Task reliability. Reliabilities of performance measures are shown in the last three columns of Table 1. They have been estimated by Cronbach's alpha coefficient of internal consistency. Alpha coefficients have been calculated separately for all three levels of practice on the basis of performances in particular trials. As the number of trials on the intermediate level of practice is a bit larger than the number of trials at the low and final level, it has been expected that the reliabilities would be somewhat higher. Due to the same reason, the reliabilities of dual- tasks are a bit higher in comparison with the reliabilities of the single tasks. The reliability of less than 0.90 was obtained only in the pursuit tracking tasks (PT1), and at the low level of practice (0.866). All the other coefficients of reliability have been very high, the majority of them greater than 0.95. Such high reliability estimates point to the high consistency in all performance measures irrespective of the level of practice or the performance conditions.

Impact of practice on the factor structure of performance measures. In the next phase of the data analysis the correlations between mean performance scores of 21 tasks have been calculated for every level of practice. Thus, three matrices of intercorrelations (Tables A, B, C in the Appendix) have been obtained and factor analysis was performed. The objective of these analyses was to determine, as precisely as possible, the structure of performance measures in single- and dual-tasks on all three levels of practice by various factor-analytic methods. Therefore, the methods of extraction have been systematically varied (principal component analysis, principal axis factoring, maximum likelihood analysis), as well as the number of extracted factors (three, four, five, six) and the method of rotation of referent axis (orthogonal and oblique rotation). This multitude of performed analyses had very similar outcomes. All the analyses confirmed the existence of one or more group time-sharing factors, but none of them have yielded evidence for the existence of a general time-sharing factor.

Since both, common factor and principal component analysis, have yielded very similar structural outcomes at all levels of practice, the six-factor solution derived by the principal component analysis with equamax rotation has been selected for the final interpretation of the results. Instead of varimax rotation typically chosen when seeking a simple structure, the equamax rotation was chosen because it distributes the variables evenly on factors. That was done taking into account recommendations of Ackerman et al. (1984), as well as the assumption that the concurrent tasks represent factorially complex variables (Damos & Smist, 1980, 1981; Šverko et al., 1983). The solution with six factors has been chosen because it was the most interpretable when compared to other obtained solutions, and congruent with the conceptual model anticipating the existence of several independent time-sharing abilities (Braune & Wickens, 1986; Jerneić, 1988a; Jerneić & Šverko, 1994).

Tables 2, 3, and 4 show the results of component analyses at the low, intermediate, and high level of practice. Beside the six rotated factors, these Tables contain the usual indicators of the efficacy of the performed analyses: communalities of variables and percentages of the explained

Table 2
Rotated six-factor solution: low level of practice

		Factor						
	Task	S1	S2	S3	TS1	TS2	TS3	h^2
1.	Pursuit tracking - PT1	-.25	.21	**.91**	-.04	.10	.14	.97
2.	Pursuit tracking - PT2	-.33	.39	.46	-.03	.30	.55	.86
3.	Compensatory tracking - CT1	-.16	**.80**	.29	-.09	.31	.25	.93
4.	Compensatory tracking - CT2	.00	**.70**	.32	-.06	.52	.20	.90
5.	Lights	**.85**	-.20	-.25	.29	.03	-.08	.91
6.	Numbers	**.85**	-.10	-.24	.39	-.02	-.11	.95
7.	Letters	**.84**	-.04	-.28	.38	-.07	-.11	.95
8.	PT1 & PT1	-.04	.21	.53	-.30	.23	**.62**	.86
9.	PT2 & PT2	-.19	.31	.23	-.02	.44	**.75**	.93
10.	PT1 & PT2	-.11	.38	.37	-.17	.27	**.74**	.94
11.	CT1 & CT1	-.07	.57	.09	-.09	.53	.42	.82
12.	CT2 & CT2	.01	.34	.13	-.02	**.87**	.24	.95
13.	CT1 & CT2	.01	.37	.25	-.10	**.80**	.32	.96
14.	PT1 & CT2	.01	.37	.30	-.21	.40	**.60**	.80
15.	CT1 & PT2	-.10	.34	.19	.00	.57	**.66**	.92
16.	Concurrent lights	.26	-.26	-.13	**.84**	.01	-.13	.88
17.	Concurrent numbers	.49	-.16	-.14	**.80**	-.06	-.15	.95
18.	Concurrent letters	.49	-.13	-.18	**.79**	-.11	-.14	.95
19.	Lights and numbers	.52	-.12	-.15	**.77**	-.12	-.13	.93
20.	Letters and lights	.42	-.04	-.29	**.78**	-.16	-.16	.93
21.	Numbers and letters	.47	-.05	-.29	**.77**	-.16	-.15	.95
	Percent of the total variance	17.3	12.6	11.2	2.8	14.6	15.2	91.6

Note. The loadings equal or greater than .60 are in bold-face.

variance. The values appear to be similar and very high in the three analyses. Regardless of the level of practice, the communalities were higher than 0.80, the majority exceeding 0.90. The consequence of the high and equally spread communalities appears to be a large percentage of the explained variance of observed variables: 91.6% of variance at the low level of practice, 92.4% at the intermediate level and 91.8% at high level. Above all, there appears to be a marked congruence in the structure of factor variance. The corresponding share of the factors from one level of practice to the other appears to be very similar, practically the same (e.g. for the TS1 they are 20.8%; 20.6% and 20.9%).Thus, balanced shares of comparable factors, with equally leveled values of communalities and percentages of the totally explained variance, point to the considerable conformity of factor structures.

The conformity of structures is supported by the fact that the factors within each level of practice could be ranged in two groups. The first group consists of the factors primarily defined by singly performed tasks, while the factors defined primarily by concurrent tasks appear to fall into the other group. They are sorted in Tables according to these types, so in the first three columns ranged factors of single tasks can be found (S1, S2, and S3), following the factors of complex tasks in the next three columns (TS1, TS2 and TS3). Comparing the factor structure of all three matrices, it is relatively easy to establish the similarity of the homonymous factors at the different levels of practice.

Correlations between factor scores and Tucker coefficients of congruence (Tucker, 1951) – quantitative indicators of similarity calculated for each pair of factors – show that we are dealing with not just similar but identical fac-

Table 3

Rotated six-factor solution: intermediate level of practice

		Factor						
	Task	S1	S2	S3	TS1	TS2	TS3	h^2
1.	Pursuit tracking - PT1	-.21	.26	**.87**	-.09	.17	.24	.96
2.	Pursuit tracking - PT2	-.14	.44	.53	-.09	.28	.55	.89
3.	Compensatory tracking - CT1	-.14	**.73**	.31	-.01	.44	.25	.90
4.	Compensatory tracking - CT2	-.09	**.63**	.34	-.02	**.61**	.19	.93
5.	Lights	**.81**	-.29	-.20	.34	.02	-.04	.91
6.	Numbers	**.86**	-.11	-.18	.38	-.12	-.16	.96
7.	Letters	**.87**	-.07	-.16	.39	-.13	-.15	.97
8.	PT1 & PT1	-.11	.20	.60	-.27	.23	.56	.85
9.	PT2 & PT2	-.11	.36	.32	-.10	.38	**.74**	.95
10.	PT1 & PT2	-.10	.28	.54	-.20	.30	**.66**	.94
11.	CT1 & CT1	-.07	**.70**	.20	.02	.42	.40	.87
12.	CT2 & CT2	-.05	.42	.16	-.02	**.80**	.30	.94
13.	CT1 & CT2	-.06	.42	.23	-.03	**.77**	.34	.95
14.	PT1 & CT2	-.08	.29	.43	-.16	.59	.45	.86
15.	CT1 & PT2	-.13	.41	.29	-.02	.51	**.63**	.93
16.	Concurrent lights	.33	-.30	-.10	**.81**	.11	-.20	.92
17.	Concurrent numbers	.48	-.01	-.17	.82	-.05	-.11	.94
18.	Concurrent letters	.53	.01	-.20	**.77**	-.10	-.13	.94
19.	Lights and numbers	.48	-.11	-.17	**.77**	-.12	-.13	.90
20.	Letters and lights	.47	-.02	-.24	**.77**	-.14	-.18	.92
21.	Numbers and letters	.47	.06	-.25	**.79**	-.14	-.14	.96
	Percent of the total variance	17.2	13.0	12.9	2.6	14.8	13.9	92.4

Note. The loadings equal or greater than .60 are in bold-face.

Table 4
Rotated six-factor solution: high level of practice

		Factor						
	Task	S1	S2	S3	TS1	TS2	TS3	h^2
1.	Pursuit tracking - PT1	-.17	.27	**.88**	-.13	.12	.23	.95
2.	Pursuit tracking - PT2	-.09	.39	.53	-.11	.25	**.62**	.90
3.	Compensatory tracking - CT1	-.08	**.78**	.31	.03	.35	.31	.92
4.	Compensatory tracking - CT2	-.04	**.69**	.22	.01	.59	.21	.91
5.	Lights	**.88**	-.20	-.10	.30	.02	-.13	.93
6.	Numbers	**.83**	-.04	-.21	.43	-.09	-.12	.94
7.	Letters	**.83**	.01	-.25	.40	-.18	-.11	.95
8.	PT1 & PT1	-.23	.20	**.62**	-.17	.28	.51	.84
9.	PT2 & PT2	-.12	.33	.32	-.10	.40	**.73**	.93
10.	PT1 & PT2	-.11	.29	.52	-.12	.31	**.67**	.93
11.	CT1 & CT1	-.01	**.66**	.29	.06	.46	.34	.86
12.	CT2 & CT2	-.03	.48	.17	-.08	**.77**	.26	.93
13.	CT1 & CT2	-.08	.46	.19	-.04	**.74**	.38	.95
14.	PT1 & CT2	-.10	.31	.37	-.08	**.61**	.50	.87
15.	CT1 & PT2	-.12	.41	.24	.00	.59	.56	.90
16.	Concurrent lights	.36	-.21	-.03	**.83**	.08	-.20	.92
17.	Concurrent numbers	.45	.09	-.22	**.83**	-.06	-.01	.96
18.	Concurrent letters	.47	.09	-.23	**.81**	-.12	-.07	.96
19.	Lights and numbers	.50	-.15	-.11	**.76**	-.10	-.14	.88
20.	Letters and lights	.46	-.05	-.23	**.78**	-.07	-.19	.91
21.	Numbers and letters	.45	.12	-.28	**.79**	-.12	-.09	.95
	Percent of the total variance	16.7	13.4	12.6	20.9	14.6	13.7	91.8

Note. The loadings equal or greater than .60 are in bold-face.

tors. The indicators of similarity confirm that each factor at one level corresponds to only one factor of the other level of practice. Not a single Tucker coefficient of congruence between the corresponding factors at different levels of practice falls below 0.96, which is above the conventional criterion of 0.90 - treated as the limit value for factor invariance (Mulaik, 1972). The results unequivocally point to the conclusion that practice had not affected factor structure of performance measures and homonymous factors of different levels of practice could be considered essentially the same.

Interpretation of obtained factors. The congruency of factor structures makes the interpretation of isolated factors easier as the homonymous factors on all three levels of practice could be interpreted at the same time. As seen in Tables 2-4 main determinants of *Factor S1* are represented by three simple choice-reaction tasks (Lights, Number, and Letters). Lower loadings (mainly between .40 and .50) belong to their concurrent combinations. Noticeable projections of dual tasks have been expected on the factor, as it appears reasonable to suppose that the abilities relevant for single tasks performance will be also engaged when these same tasks are performed concurrently. The projections of other variables seem to be negligible, so it is most certainly the matter of an unambiguously structured factor which differentiates the participants depending on the speed of selecting the correct response. Accordingly, Factor *S1* may be interpreted as the *factor of simple choice-reaction.*

Rather high loadings on *Factor S2* can be found only on tracking tasks. The projections may be graded in three levels: relatively low projection of the pursuit tracking tasks, a bit higher projections allowed for variables containing at least one compensatory tracking task, while the greatest projection belongs to two simple compensatory tracking tasks *(CT1, CT2*). Thus, a structured factor is closely associated to the capability of the participants to compensate for the perturbations imposed by the forcing function with precise control movements, so that *Factor S2* can be interpreted as the factor of *simple compensatory tracking*.

The tracking tasks have substantial saturations on the *Factor S3,* too. It differs from the previous factor as it is primarily defined by the task "*Pursuit tracking - PT1*" and to the lesser extent by the task "*Pursuit tracking - PT2*" and their concurrent combinations. Since these tasks reflect one's capabilities to track the target's trajectory it seemed justified to interpret *Factor S3* as *the factor of simple pursuit tracking*.

The other three factors represent dimensions of time-sharing performance. Every one of them has its counterpart among the single-task factors, but now the greatest projections on the dimensions belong to the concurrent tasks. Thus *Factor TS1* is the counterpart of *Factor S1* as the high correlations with this factor belong exclusively to the choice-reaction tasks applied in the concurrent conditions (variable 16 to 21). Accordingly, *Factor TS1* can be treated as *the factor of time-sharing performance in the choice-reaction tasks*.

The counterpart of the factor of simple compensatory tracking is the *Factor TS2*. The main determinants of this factor are complex tasks "*CT2 & CT2*" and "*CT1 & CT2*", but it is also substantially saturated with other compensatory tracking tasks performed both, alone (variables 3 and 4) or in combination with other tracking task (variables 11, 14 and 15). Since the projections of the complex tasks seem to be disproportionately greater in comparison with single tasks projections, *Factor TS2* can be interpreted as the *factor of time-sharing performance in compensatory tracking tasks.*

Similarly profiled seems to be the *Factor TS3.* However, it mainly refers to the pursuit tracking tasks. From the tasks performed alone this factor seems to be related only to the "*Pursuit tracking - PT2*", while the substantial or high projection belongs to all the concurrently performed pursuit tracking tasks (variable 8, 9 and 10) and their two combinations with the compensatory tracking tasks (variables 14 and 15). Thus, described factor may easily be interpreted as *the factor of time-sharing performance in pursuit tracking tasks.*

To conclude, though a general time-sharing factor which would underlay the performance of all concurrently presented tasks had not been isolated in any of the analyses, the obtained results point clearly to the existence of group time-sharing factors. Three such factors emerge repeatedly on all levels of practice. The existence of these factors has been confirmed by factor analyses of partial correlations. These analyses represented another attempt to check the ability structure in dual-task performance by using slightly different statistical and analytical procedure. The objective has been to analyze the time-sharing performances after the contribution of abilities and skills relevant for the tasks performed alone had been eliminated. Namely, analyzing single- and dual-task performance measures together could have hidden the appearance of a general time-sharing factor, due to the complex relation among the variables. Apart from this, it is true that three group time-sharing factors identified with the abovementioned analyses might have been related. Therefore, in the hierarchical factor analysis one general time-sharing factor might emerge.

Factor analysis of partial correlations among dual-tasks. Factor analysis of partial correlations had been suggested by Bittner and Damos (1986) as the replacement for the classic exploratory and confirmatory factor analyses of single- and dual task data. Analysis is performed in two phases. In the first phase the complete variance associated with the single tasks is removed from each dual-task, so what is left is the variance related exclusively to concurrently performed tasks. This means that coefficients of partial correlations (of "*n*" order) should be calculated between every pair of dual-tasks, where "*n*" corresponds to the number of single tasks. In the second phase the obtained partial correlations are factorized by usual method of factor analysis, and then every extracted factor is a time-sharing factor by definition.

The described procedure has been used on our data as well. First, for each level of practice matrices of partial correlations between the complex tasks have been calculated (Tables D, E and F in the Appendix). They were then factorized in independent analyses using the principal axes method. Diagonal elements of correlation matrices have been defined by iterative procedure, and extracted factors have been rotated in the oblique position according to direct oblimin criterion (delta = 0). In all three analyses each of the three factors had been extracted and rotated. The number of extracted factors determined after using several different criteria suggested that in explaining the relation between variables it is necessary to keep 2 to 4 factors. Discussing the solutions with different numbers of factors we have decided to keep three factors as those solutions were not only the most interpretable ones, but also the number of extracted time-sharing factors was corresponding to the findings of previous analyses. The obtained results are shown in Table 5 for the low level of practice, Table 6 for the intermediate level of practice and in Table 7 for the final level of practice.

As the matrices of factor structure and factor pattern reveal, each factor in one analysis corresponds to one factor in the other two analyses. That is why the comparable factors have been marked with the same symbols (Roman numbers) and they follow the same order within the tables. Visual similarity of isolated factors is affirmed by Tucker coefficients of congruence which have been calculated for corresponding pairs of factors. None of the coefficients of congruence for the homonymous factors is less than 0.96.

Table 5
Rotated three-factor solution: low level of practice

		Pattern matrix			Structure matrix			
	Task / Factor	I	II	III	I	II	III	h^2
1.	PT1 & PT1	-.19	.03	**.63**	-.34	.30	**.69**	.51
2.	PT2 & PT2	.16	.24	**.68**	-.01	**.51**	**.74**	.62
3.	PT1 & PT2	-.01	-.20	**1.02**	-.24	.21	**.94**	.91
4.	CT1 & CT1	-.02	**.43**	.22	-.09	**.52**	**.40**	.31
5.	CT2 & CT2	-.01	**.89**	-.14	-.02	**.83**	.22	.71
6.	CT1 & CT2	-.10	**.92**	.01	-.15	**.93**	**.41**	.87
7.	PT1 & CT2	-.11	.06	**.60**	-.25	.31	**.65**	.43
8.	CT1 & PT2	.14	**.52**	**.44**	.01	**.69**	**.62**	.63
9.	Concurrent lights	**.80**	.06	-.01	**.80**	.02	-.18	.65
10.	Concurrent numbers	**.90**	.05	-.08	**.92**	-.02	-.27	.84
11.	Concurrent letters	**.92**	.03	-.02	**.93**	-.02	-.23	.86
12.	Lights and numbers	**.87**	-.07	-.01	**.88**	-.12	-.25	.78
13.	Letters and lights	**.88**	-.10	.03	**.88**	-.12	-.21	.78
14.	Numbers and letters	**.93**	-.04	.01	**.93**	-.08	-.23	.87
Percent of the total variance					34.6	16.4	18.7	69.7
1.	Factor I	1.00						
2.	Factor II	-.048	1.00					
3.	Factor III	-.237	.407	1.00				

Note. The loadings in excess of .40 are in bold-face.

Since the calculated coefficients of congruence appear to be high, we may consider the corresponding factors on different levels of practice to be essentially the same.

From all the isolated factors *Factor 1* is the most massive and best determined latent dimension. In the matrices of factor structure, as well as in the matrices of factor pattern, high loadings on this dimension seem to pertain only to dual choice-reaction tasks (variables from 9 to 14). As the factors loading on other variables appear to be negligible*, Factor 1* may unequivocally be interpreted as the *factor of time-sharing performance in the choice-reaction tasks.* Contrary to this factor other two factors (*Factor II and Factor III*) are defined exclusively by complex tracking tasks (variables 1 to 8). These tasks have been divided into two groups: compensatory tracking tasks which primarily define *Factor II* and the pursuit tracking tasks which primarily define *Factor III*. This differentiation is clearer in the factor pattern matrices than in the factor structure matrices. Thus, *Factor II* is best defined by "*CT2 & CT2*" and "*CT 1& CT2*", regardless of level of practice. These two compensatory tracking tasks have the greatest standardized regression coefficients and correlation coefficient in all of the analyses. In accordance with such distribution of factor coefficients, *Factor II* could be interpreted as *the factor of time-sharing in pursuit tracking tasks*. On the other hand, main determinants of *Factor III* are three simultaneously performed pursuit tracking tasks "*PT 1& PT1*", "*PT2 & PT2*" and "*PT1 & PT2*", while the sizable regression coefficients with this factor are shown in only one or both combined tasks - pursuit tracking and compensatory tracking, depending on the level of practice (variable 7 and 8). Thus, structured factor had been known already as the *factor of time-sharing performance in the pursuit tracking tasks*.

The results of factor analysis of partial correlations have confirmed the finding of previous analyses in which both, singly and concurrently performed tasks, were factorized together. In both types of analyses three identical time-sharing factors have been determined: *factor of time-sharing performance in the choice-reaction tasks* (Factor TS1/Factor I), *factor of time-sharing performance in the compensatory tracking tasks* (Factor TS2/Factor II*), and factor of time-sharing performance in the pursuit tracking tasks* (Factor

Table 6
Rotated three-factor solution: intermediate level of practice

		Pattern matrix			Structure matrix			
	Task / Factor	I	II	III	I	II	III	h^2
1.	PT1 & PT1	-.17	.01	**.56**	-.28	-.24	**.59**	.38
2.	PT2 & PT2	.07	-.09	**.73**	-.07	**-.42**	**.76**	.59
3.	PT1 & PT2	-.07	.18	**.90**	-.27	-.22	**.83**	.73
4.	CT1 & CT1	.13	-.23	.22	.10	-.33	.29	.15
5.	CT2 & CT2	-.04	**-.84**	-.03	.01	**-.82**	.35	.68
6.	CT1 & CT2	-.09	**-.94**	.02	-.04	**-.94**	**.46**	.90
7.	PT1 & CT2	-.13	-.23	.39	-.20	-.39	.52	.31
8.	CT1 & PT2	.15	-.33	**.52**	.06	**-.57**	**.63**	.52
9.	Concurrent lights	**.71**	-.10	-.18	**.75**	-.06	-.28	.59
10.	Concurrent numbers	**.94**	.03	.05	**.93**	-.04	-.16	.87
11.	Concurrent letters	**.94**	.06	.09	**.91**	-.03	-.12	.84
12.	Lights and numbers	**.81**	-.04	-.09	**.83**	-.05	-.23	.70
13.	Letters and lights	**.84**	.01	-.12	**.86**	.02	-.29	.76
14.	Numbers and letters	**.95**	.12	.09	**.93**	.02	-.16	.87
Percent of the total variance					33.3	13.8	16.4	63.5
1.	Factor I	1.00						
2.	Factor II	-.056	1.00					
3.	Factor III	-.204	-.448	1.00				

Note. The loadings in excess of .40 are in bold-face.

TS3/Factor III). However, taking into account the difference between procedures it may be said that among these factors there exists one essential distinction. While in the previous analyses the orthogonal factors have been isolated, in factor analyses of partial correlations the isolated factors were oblique. In this case such oblique solutions have the advantage of enabling us to see what relations exist among particular time-sharing factors and whether it may be possible to expect a general time-sharing factor had the structural analysis of higher order been used.

Judging by the correlation between factors determined within particular level of practice this may not be likely. At the low level of practice (Table 5) a substantial correlation exists only between the two time-sharing factors related to the tracking tasks (.41), while the correlation between the factor of time-sharing performance in the choice-reaction tasks and factor of time-sharing performance in pursuit tracking tasks appears to be low (-.24). Keeping in mind the absence of association with the factor of time-sharing performance in compensatory tracking tasks (-.05), it gives a clear indication that the general factor would not emerge in the hierarchical factor analysis either. The only thing to be expected in such an analysis would be the extraction of a higher order factor which would underlie the performance of concurrently presented compensatory and pursuit tracking tasks.

Similar relations between the factors exist on the intermediate level of practice (Table 6) while at the high level of the practice the situation appears to be quite clear (Table 7). Here the factor of time-sharing performance in the choice-reaction tasks is orthogonal on the two remaining factors (-0.043 and -0.034), and there seems to be no possibility for the extraction of a general factor upon which there would be significant loadings of all dual-tasks. Consequently, the results of analyses of partial correlations, as well as of the previous analyses, point to the fact that our initial assumption on existence of a general time-sharing ability at higher levels of practice is incorrect.

Table 7
Rotated three-factor solution: high level of practice

		Pattern matrix			Structure matrix			
	Task / Factor	I	II	III	I	II	III	h^2
1.	PT1 & PT1	-.07	.08	**.49**	-.09	.35	**.54**	.30
2.	PT2 & PT2	.02	.18	**.54**	-.01	**.47**	**.64**	.43
3.	PT1 & PT2	-.04	-.16	**.92**	-.06	.33	**.84**	.72
4.	CT1 & CT1	.10	.30	.16	.08	.38	.31	.17
5.	CT2 & CT2	-.15	**.76**	-.05	-.18	**.74**	.36	.56
6.	CT1 & CT2	-.02	**.99**	-.04	-.07	**.97**	**.48**	.94
7.	PT1 & CT2	-.01	.34	**.46**	-.04	**.58**	**.64**	.49
8.	CT1 & PT2	.12	**.47**	.25	.09	**.60**	**.50**	.42
9.	Concurrent lights	**.77**	.03	-.08	**.77**	-.05	-.09	.60
10.	Concurrent numbers	**.92**	-.05	.08	**.92**	-.05	.02	.86
11.	Concurrent letters	**.93**	.00	.03	**.93**	-.03	-.01	.87
12.	Lights and numbers	**.77**	.07	-.12	**.77**	-.02	-.10	.60
13.	Letters and lights	**.83**	-.01	-.05	**.84**	-.08	-.09	.70
14.	Numbers and letters	**.89**	-.11	.08	**.89**	-.10	-.01	.81
Percent of the total variance					31.8	15.6	13.1	6.5
1.	Factor I	1.00						
2.	Factor II	-.043	1.00					
3.	Factor III	-.034	.532	1.00				

Note. The loadings in excess of .40 are in bold-face.

DISCUSSION

Previous studies concerned with the ability structure of multiple tasks failed to support the existence of a single general time-sharing ability. The results of this study also support this. While earlier studies had tried to identify the hypothetical ability on the low levels of practice, this study aimed at its identification at the high levels of practice. This is why we have conducted the experiment in which participants have been intensively trained in performance of single and dual-tasks. The data that has been collected on the low, intermediate and high level of practice, and have been analyzed with two groups of analyses. In the first group the average scores of the participants have been factorized in order to determine the structure of singly and concurrently performed tasks, separately for each level of practice, while in the other group of analyses only the time-sharing performance measures have been factorized, after partializing out all of the variance attributable to the single-task measures. The results of both types of analyses were concordant: general time-sharing factor does not emerge in any of them, not even at the high level of practice.

Instead of one general factor, in all the analyses three group time-sharing factors have been isolated and interpreted*: Factor of time-sharing performance in the choice reaction tasks* (Factor TS1/FactorI), *Factor of time-sharing performance in the compensatory tracking tasks* (Factor TS2/Factor II) and *Factor of time-sharing performance in the pursuit tracking tasks* (Factor TS3/Factor III). By their structure these factors represent counterparts of the single-tasks factors. That is to say, when performances of both, singly or concurrently presented tasks have been analyzed (apart from the time-sharing factors), three single tasks factors have been also extracted. They refer to the same categories of tasks as the time-sharing factors; ones are primarily defined by singly applied tasks, the others by their dual-task combinations. The occurrence of such single-task factors confirmed our expectations that the factor structure of choice-reaction, compensatory and pursuit tracking tasks performed alone will be defined by three different factors.

Regarding the practice effects, both kinds of factors represent invariant components of individual differences in single- and dual-task performance. Qualitative and quantitative comparisons of manifestly similar factors, isolated on different levels of practice, reveal that the factor structure of tasks has not been significantly affected. This is particularly true for the time-sharing factors. In all of the analyses the main determinants of these factors are the same, and calculated coefficients of congruence and correlation between factor scores are relatively high. Thus, three identical time-sharing factors have been isolated on all levels of practice.

The relationship between the obtained time-sharing factors were tested using the factor analyses of partial correlations. This had the advantage of enabling the analysis of relationship between the complex tasks, after separating the part of the variance attributed to the performance of component tasks. The oblique solutions of extracted time-sharing factors demonstrate what their intercorrelations are and whether a general time-sharing factor in the higher order analyses exists. Unfortunately, in the performed analyses the between-factor correlations have not supported such a possibility, because substantial and consistent relationship has been determined only between the two time-sharing factors in the compensatory and pursuit tracking tasks, but they did not seem to be related on either level of practice (Tables 5, 6 and 7).

The probability of finding a general factor becomes lower as a function of practice, and all three factors seem to be explaining less and less total variance of time-shared tasks with an increase of practice. At the low level of practice, the time-sharing factors accounted for 69.7% of variance, and at high level of practice they accounted for only 60.5% of variance. Quite opposite to our expectations, this decrease in total variance associated with time-sharing factors suggests that abilities and skills relevant for single-tasks become more important with the advancement of practice.

The results of factor analyses of partial correlations, as well as of other analyses, seem to draw to the conclusion that a general time-sharing ability does not exist on either level of practice. But how firm and exact the conclusion is depends mainly on the potential objections that could be made to the performed study. The first and, because of the imposed problem, the most important objection may be posed with regards to the achieved level of practice. Insufficient amount of practice might have represented the main cause of the general time-sharing ability not being manifested at the high level of practice. The studies which used the concept of differential stability as empirical criteria for the necessary quantity of training (e.g., Damos et al., 1981; Damos & Smist, 1980; Jones 1980; Jones et al., 1981a,b) seem to justify the objection. According to these studies the structure of time-sharing performance should be determined after all the tasks have reached the level of differential stability, as it is only then when they seem to reflect the real ability structure which will not change with the advancement of practice (Jones, 1981). The problem of this criterion is the unknown amount of practice needed for one's performance to become differentially stable. The amount of necessary practice varies from task to task, and empirical data on differentially stable dual-tasks are really very rare (see Damos, 1991; Damos & Smist, 1980; Damos et al., 1981). In such a situation the researcher has three options at disposal: (1) to estimate when particular tasks could become differentially stable on the basis of available data, (2) to make extensive pre-experiments which would represent the studies in themselves, or (3) to test all the participants and to test statistically when the rang-order of the participants proves relatively constant from trial to trial in each task, i.e. when correlation matrix between consecutive trials does not represent superdiagonal form any more. Considering the number of participants and tasks we maintained the necessity of obtaining stable and replicable factor structures, so none of the three options appeared to be acceptable as the length of the already long experiment would increase, with no guarantee that the anticipated number of trials will allow all of the tasks to gain the degree of differential stability (1st option), or such a matter is almost really impossible to accomplish in the real study conditions (2nd and 3rd option). Therefore, we decided on the compromise: a kind of balance between the acceptable number of participants and tasks on the one hand, and acceptable amount of practice on the other.

When using the term acceptable amount of practice we, first of all, think about the long enough training period allowing for the appearance of a general time-sharing factor. The amount of practice needed for the appearance of such a trend has been, to our opinion, quite sufficient. Every participant participated in the experiment for 25 hours, performing more than 20 times single and over 30 times concurrent tasks. To make a comparison: the comparable amounts of practice were applied in the studies of Ackerman (1988, 1990) and Fleishman (1969; Fleishman & Hempel, 1955). Considering the length of practice for each task, our study does not differ from other studies in which individual differences in learning and skill acquisition had been examined on one criterion task only.

The fact that practice period has been long enough appears to be corroborated by the results of performed factor analyses, as well as by the results of additional analyses, in which the correlations were calculated for ten consecutive days of experiment and for every particular task. As expected, the latter analyses showed that correlation matrix between successive ten days performance scores has the superdiagonal form, typical for the changes that occur with advancement of practice. A more detailed analysis of the changes of the size of correlations shows that after a definite number of daily sessions (mainly in the second week of the experiment), correlations seem to stabilize, i.e. they do not show the superdiagonal form any more. Though it is not possible to claim, on the basis of a qualitative insight into the correlation changes, that all of the tasks have reached the differential stability in the last three days of the experiment, the relations among the correlations seem to suggest that the majority of tasks did so. That is important as it means that additional practice would not affect the factor structure of variables any further.

The results of performed factor analyses may confirm this. They showed that even starting differential instability of tasks did not substantially change the correlation relations between particular groups of variables. On all of the three levels of practice identical factors have been isolated, and the consistency of the factor structure is a decisive criterion which should be taken into account in bringing the judgment on the practice effects. The non-appearance of the general time-sharing factor is not the consequence of insufficient amount of practice. This is also confirmed by the correlations obtained between the isolated time-sharing factors in factor analyses of partial correlations. Anyhow, low correlation between the factor of time-sharing performance in the choice reaction tasks and the factor of time-sharing performance in compensatory tracking tasks declined even more as the training proceeded to reach practically zero at the highest level of practice. Such a trend in between-factor correlations shows that with the advancement of practice the likelihood that the general time-sharing ability will be found diminishes. In short, all the available empirical evidence suggests that the amount of practice was sufficient and that more extensive practice would not contribute to detection of the hypothetical ability.

The second criticism of this study refers to averaging of the performance measures to three results representing participant's score at the 3 different levels of practice. Such averaging could have precluded the finding of general factor, and artificially increase the equivalency of obtained factor solutions. That was the reason for the control analyses in which the performance measures of the day one and day ten of the experiment have been factorized. The results have been analyzed with standard factor analyses and with the factor analyses of partial correlations. In both cases the general time-sharing factor has not been isolated, nor was there a tendency of its forming. However, in both kinds of analyses three group factors were isolated, which appear to be identical to the time-sharing factors as they have been identified in earlier referent analyses. Also, the averaging of the performances in referent factor analyses did not mask the appearance of the general time-sharing factor.

Finally, the criticism could also be directed towards the choice of experimental tasks. The choice of tasks might be criticized from the construction aspect, i.e. the ways particular tasks have been presented to the participants. For example, the concurrently presented tracking tasks may have used a large visual angle which might have led to the peripheral interference between the stimuli. In that case participants would not have been able to receive information concurrently from both component tasks and would have been forced to visual scanning and strict serial performance strategy (e.g. Brookings, 1990; Jennings & Chiles, 1977).

Though the appearance of visual scanning could not be excluded in some combinations of dual tracking tasks, the effects of visual scanning on the extraction of general factor could have only minor consequences. The extreme positions of the cursor – according to which the maximal visual angle has been defined – have been rare and of short duration so that their possible contributions to the total score would have been very small. Except perhaps for the concurrent pursuit tracking task (PT1&PT1) which appears to have required the greatest visual acuity, the majority of other tasks enabled the participants to see even the extreme position of cursors/target (at least by using peripheral vision).

Complex choice-reaction tasks could be criticized in a similar way. All the choice-reaction tasks have been presented in the same sensory and reaction modality. According to the experimental evidence that makes the time-sharing performance more difficult (e.g., McLeod, 1977; Wickens, 1992). Also it may encourage the participants to adopt an alternating strategy instead of simultaneous response strategy and parallel processing of information. That is to say they could switch the attention rapidly between two component tasks (Damos & Wickens, 1980; Damos et al., 1983). Because some researchers (Brookings, 1990) consider that an alternating strategy does not reflect a "true" time-sharing ability, the application of complex choice-reaction tasks could have had unfavorable effect on the detection of such ability.

However, this approach is not only based on the theoretically disputable and narrow understanding of the time-sharing ability, but also it has no foundation in the results of the studies concerned with the identification of strategies in time-sharing performance. Damos and Smist (1981; exp. III) used a rather difficult combination of choice-reaction tasks showing quite clearly that participants are adopting spontaneously, apart from the alternating strategy, the simultaneous strategy as well - despite the fact that both component tasks had been in the same sensory and reaction modality. Their results have been confirmed by our earlier investigation (Matanović, 1993) with the concurrently presented choice-reaction tasks same as the ones used in this study. Which strategy will be used by the participant depends primarily on his/her abilities and believe about which strategy will be more efficient in the given moment, and not so much on the problem whether the tasks are in the same sensory and reaction modality or not.

It seems that the aforementioned doubts do not seriously question the obtained results. Therefore, it appears that our primary conclusion regarding the existence of the general time-sharing ability is correct. The empirical data do not support the idea of such ability, irrespective the practice level. In this respect the obtained results are consistent with the findings of the previous studies. Also, there is an agreement on the existence of group time-sharing factors. Practically all of the recent studies have established at least one factor with such characteristics, and at least two of them may be considered as stable dimensions of time-sharing performance. These are: the factor of visual monitoring or visual scanning (Brookings, 1990; Chiles & Jennings, 1978; Jennings & Chiles, 1977) and the factor of time-sharing performance in the choice-reaction tasks (Jerneić 1988a; Jerneić & Šverko, 1994; Šverko et al., 1983; Šverko et al., 1994).

On the other hand, three time-sharing factors have been identified in the present study. Apart from the factor of time-sharing performance in choice-reaction tasks (Factor TS1/I) endorsed several times over, two "new" time-sharing factors found in complex tracking tasks have been identified (Factor TS2/II and Factor TS3/III). Isolating them meant confirming and generalizing the results of our previous studies (Jerneić & Šverko, 1994) when three isolated factors have also been identified at the early stage of practice. They refer to the concurrently presented tracking tasks: one is defined by various dual-tasks involving "*Pursuit tracking - PT1*" (i.e. PT1 & PT1") and the other one is specific for the complex compensatory tracking task – "CT1 & CT1". Since the same tasks have defined comparable time-sharing factors in this study, we are possibly dealing with the equivalent factors. The equivalence of factors identified in these two studies is an important finding because it shows that it is accidental factors we are dealing with. Instead, these are real and replicable components of time-sharing performance whose viability, as well as that of the other identified factors, could have important theoretical and practical implications.

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Appendices

Table A

Correlation matrix: low level of practice

	Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1.	Pursuit tracking - PT1	-																				
2.	Pursuit tracking - PT2	.686	-																			
3.	Compensatory tracking - CT1	.530	.719	-																		
4.	Compensatory tracking - CT2	.489	.689	.835	-																	
5.	Lights	-.499	-.491	-.381	-.228	-																
6.	Numbers	-.477	-.472	-.361	-.209	.902	-															
7.	Letters	-.502	-.482	-.342	-.207	.874	.964	-														
8.	PT1 & PT1	.631	.693	.587	.581	-.363	-.402	-.402	-													
9.	PT2 & PT2	.472	.844	.679	.683	-.324	-.323	-.333	.748	-												
10.	PT1 & PT2	.583	.818	.707	.696	-.353	-.371	-.384	.814	.889	-											
11.	CT1 & CT1	.380	.657	.743	.742	-.236	-.228	-.237	.617	.735	.722	-										
12.	CT2 & CT2	.312	.596	.642	.779	-.101	-.110	-.134	.493	.714	.607	.749	-									
13.	CT1 & CT2	.422	.656	.717	.808	-.171	-.182	-.213	.645	.755	.702	.815	.920	-								
14.	PT1 & CT2	.465	.686	.683	.706	-.249	-.274	-.289	.730	.761	.867	.681	.665	.765	-							
15.	CT1 & PT2	.433	.804	.694	.724	-.215	-.244	-.254	.704	.902	.831	.805	.786	.834	.756	-						
16.	Concurrent lights	-.305	-.373	-.359	-.278	.580	.621	.584	-.464	-.276	-.397	-.314	-.174	-.240	-.328	-.238	-					
17.	Concurrent numbers	-.350	-.409	-.377	-.269	.716	.805	.786	-.483	-.328	-.427	-.312	-.179	-.267	-.384	-.256	.858	-				
18.	Concurrent letters	-.382	-.433	-.371	-.288	.706	.794	.799	-.481	-.334	-.432	-.314	-.198	-.292	-.401	-.281	.836	.973	-			
19.	Lights and numbers	-.354	-.417	-.369	-.268	.748	.791	.777	-.452	-.332	-.417	-.292	-.200	-.287	-.376	-.279	.819	.920	.924	-		
20.	Letters and lights	-.437	-.474	-.370	-.276	.669	.745	.749	-.525	-.377	-.462	-.298	-.231	-.332	-.395	-.314	.829	.881	.892	.913	-	
21.	Numbers and letters	-.458	-.480	-.378	-.295	.695	.785	.795	-.519	-.374	-.475	-.308	-.221	-.331	-.418	-.309	.804	.926	.946	.926	.959	-

Table B

Correlation matrix: intermediate level of practice

Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1. Pursuit tracking - PT1	-																				
2. Pursuit tracking - PT2	.778	-																			
3. Compensatory tracking - CT1	.603	.771	-																		
4. Compensatory tracking - CT2	.605	.752	.880	-																	
5. Lights	-.453	-.388	-.360	-.324	-																
6. Numbers	-.454	-.428	-.369	-.321	.863	-															
7. Letters	-.436	-.392	-.334	-.291	.870	.969	-														
8. PT1 & PT1	.768	.759	.582	.591	-.397	-.452	-.439	-													
9. PT2 & PT2	.659	.864	.735	.728	-.318	-.388	-.366	.792	-												
10. PT1 & PT2	.775	.889	.686	.683	-.363	-.432	-.415	.843	.892	-											
11. CT1 & CT1	.555	.727	.825	.803	-.287	-.272	-.274	.600	.756	.694	-										
12. CT2 & CT2	.493	.668	.752	.857	-.215	-.263	-.254	.558	.742	.643	.784	-									
13. CT1 & CT2	.549	.713	.812	.859	-.243	-.297	-.281	.639	.770	.699	.806	.935	-								
14. PT1 & CT2	.663	.792	.731	.776	-.335	-.381	-.376	.726	.798	.863	.705	.768	.836	-							
15. CT1 & PT2	.644	.840	.789	.806	-.312	-.370	-.344	.722	.909	.841	.794	.817	.861	.819	-						
16. Concurrent lights	-.349	-.370	-.275	-.234	.686	.680	.661	-.475	-.350	-.426	-.239	-.168	-.201	-.342	-.283	-					
17. Concurrent numbers	-.362	-.319	-.197	-.169	.686	.794	.786	-.440	-.298	-.385	-.135	-.143	-.176	-.314	-.222	.853	-				
18. Concurrent letters	-.407	-.367	-.233	-.195	.704	.816	.827	-.453	-.332	-.433	-.175	-.177	-.214	-.351	-.267	.808	.969	-			
19. Lights and numbers	-.396	-.388	-.287	-.289	.748	.768	.783	-.474	-.372	-.458	-.229	-.239	-.263	-.400	-.316	.822	.883	.890	-		
20. Letters and lights	-.437	-.416	-.280	-.269	.727	.767	.791	-.542	-.402	-.491	-.211	-.238	-.285	-.441	-.348	.822	.884	.904	.916	-	
21. Numbers and letters	-.438	-.385	-.221	-.214	.683	.781	.795	-.500	-.358	-.446	-.163	-.205	-.239	-.382	-.296	.799	.941	.950	.902	.936	-

Table C

Correlation matrix: high level of practice

Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1. Pursuit tracking - PT1	-																				
2. Pursuit tracking - PT2	.760	-																			
3. Compensatory tracking - CT1	.568	.747	-																		
4. Compensatory tracking - CT2	.494	.671	.854	-																	
5. Lights	-.370	-.310	-.240	-.190	-																
6. Numbers	-.418	-.359	-.235	-.186	.852	-															
7. Letters	-.443	-.385	-.232	-.196	.841	.939	-														
8. PT1 & PT1	.782	.771	.602	.549	-.431	-.473	-.502	-													
9. PT2 & PT2	.626	.875	.730	.696	-.303	-.359	-.380	.773	-												
10. PT1 & PT2	.748	.889	.703	.646	-.330	-.381	-.409	.829	.882	-											
11. CT1 & CT1	.537	.719	.852	.800	-.169	-.157	-.201	.610	.741	.727	-										
12. CT2 & CT2	.461	.650	.743	.866	-.205	-.194	-.266	.577	.732	.660	.810	-									
13. CT1 & CT2	.495	.707	.796	.843	-.242	-.248	-.297	.652	.784	.719	.820	.917	-								
14. PT1 & CT2	.629	.770	.733	.747	-.275	-.325	-.368	.740	.818	.852	.761	.795	.869	-							
15. CT1 & PT2	.565	.793	.772	.813	-.276	-.292	-.317	.705	.856	.797	.770	.826	.897	.824	-						
16. Concurrent lights	-.310	-.299	-.177	-.142	.654	.690	.642	-.397	-.307	-.325	-.128	-.195	-.205	-.254	-.209	-					
17. Concurrent numbers	-.346	-.248	-.048	-.027	.653	.786	.764	-.385	-.223	-.270	-.009	-.121	-.120	-.204	-.115	.832	-				
18. Concurrent letters	-.367	-.314	-.099	-.085	.661	.807	.813	-.432	-.289	-.338	-.064	-.175	-.187	-.264	-.191	.824	.969	-			
19. Lights and numbers	-.371	-.345	-.226	-.235	.725	.775	.758	-.446	-.349	-.385	-.173	-.272	-.284	-.354	-.292	.827	.849	.850	-		
20. Letters and lights	-.445	-.401	-.226	-.163	.692	.786	.777	-.510	-.380	-.420	-.143	-.238	-.273	-.349	-.295	.839	.875	.894	.879	-	
21. Numbers and letters	-.417	-.338	-.097	-.079	.645	.809	.790	-.434	-.311	-.362	-.048	-.180	-.190	-.277	-.205	.791	.943	.952	.843	.910	-