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The Relationship Between Temperamental Traits and the Level of Performance of an Eye–Hand Co-Ordination Task in Jet Pilots

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When assessing the psychological suitability for the profession of a pilot, it is important to consider personality traits and psychomotor abilities. Our study aimed at estimating the role of temperamental traits as components of pilots' personality in eye–hand co-ordination. The assumption was that differences in the escalation of the level of temperamental traits, as measured with the Formal Characteristic of Behaviour—Temperament Inventory (FCB-TI), will significantly influence eye–hand co-ordination. At the level of general scores, enhanced briskness proved to be the most important trait for eye–hand co-ordination. An analysis of partial scores additionally underlined the importance of sensory sensitivity, endurance and activity. The application of eye–hand co-ordination tasks, which involve energetic and temporal dimensions of performance, helped to disclose the role of biologically-based personality traits in psychomotor performance. The implication of these findings for selecting pilots is discussed.

eye–hand co-ordination   temperament   personality

1. INTRODUCTION

The purchase of a completely new kind of aircraft makes heavy demands on people whose assignment is to select and prepare pilots for training. In such a situation there are always many questions to be asked about selection goals and methods. When the Polish Air Force bought F-16 aircraft we, aviation psychologists, were asked to select pilots who would cope with the requirements of the new aircraft and, of course, with highly advanced aviation training. Realistically, all of the Polish F-16 candidates were pilots with a great deal of experience on the Su22 and Mig29 aircraft, so we could either assume that all of them should join the F-16 training programme or we could try to re-evaluate the role of psychological traits in pilots' performance. Providing an answer to a scientific challenge of such magnitude, however, requires time. To systematically strive to achieve our goal, we introduced a longitudinal scientific programme. Its first step was to assess the role of personality traits in mediating the level of eye–hand co-ordination in jet pilots. It is assumed that jet pilots have a special personality profile [1, 2, 3], but also that they differ in levels of escalation of certain personality traits, and that such escalation might affect their executive functions [4]. Our study investigated the role of temperamental traits in mediating the level of performance of pilots' eye–hand co-ordination tasks.

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2. TEMPERAMENT AND EYE–HAND CO-ORDINATION

The Formal Characteristics of Behaviour—Temperament Inventory (FCB-TI) is a perfect tool to test this hypothesis [5, 6]. It is based on the regulative theory of temperament formulated by Strelau and inspired by Hebb's concept of the optimal level of arousal [7, 8]. According to this theory, temperament refers to basic, relatively stable personality traits, which are manifested in the formal aspects of reactions and behaviour (energetic and temporal characteristics). These traits are present from early childhood and they are common to both people and animals. Inborn physiological mechanisms primarily determine temperament, but maturation and certain environmental factors can alter it [7, 8]. Moreover, temperament refers to the mobility of the central nervous system, which in accordance with individual needs of stimulation plays a significant role in regulating the stimulative value of the surroundings and people's own actions [7, 8].

FCB-TI consists of six scales of 20 items each [5, 6, 9]. They have internal consistency (Cronbach's alpha) ranging from over .70 (for sensory sensitivity and briskness scales) to over .80 (for the other scales), and temporal stability (r = .55–.83, after 6 months) [5, 6, 9].

- Briskness (BR): a tendency to react quickly, to maintain a high tempo of performing activities and to shift easily from one behaviour (reaction) to another in response to contextual changes.
- Perseveration (PE): a tendency to continue and to repeat a particular behaviour after cessation of stimuli (situations) evoking this behaviour.
- Sensory sensitivity (SS): an ability to react to sensory stimuli of low stimulative value.
- Emotional reactivity (ER): a tendency to react intensively to emotion-generating stimuli, expressed in high emotional sensitivity and in low emotional endurance.
- Endurance (EN): an ability to react adequately in situations demanding long-lasting or high stimulating activity and under intensive external stimulation.
- Activity (AC): a stable tendency to look for or avoid stimulation and to adjust the stimulation level to individual needs.

The arrangement of these scales indicates four types of temperament structure [6, 9].

- A harmonized structure with a high capacity for processing stimulation: individuals with this kind of temperament structure show remarkable EN, low ER and high AC. They also have high SS and high BR with low PE. This kind of structure of temperamental traits indicates an effective regulation of stimulation and a general tendency to search for stimulation. Such people can adapt easily to new and extreme situations. Galen typology would classify them as sanguine.
- A harmonized structure with a high capacity for processing stimulation: individuals with this kind of temperament structure show remarkable EN, high ER and low AC. They also have low SS, but low BR and high PE at the same time. This kind of structure of temperamental traits indicates an effective regulation of stimulation and a general tendency to avoid stimulation. The adaptability level is low due to low SS and EN levels. People with these temperamental characteristics tend to perform optimally in situations with a low stimulation level. Galen typology would classify them melancholic.
- A disharmonized structure with a high capacity for processing stimulation: people with this kind of temperament structure show low levels of EN, ER and AC. They also have low or moderate SS, BR and PE. This kind of structure of temperamental traits indicates an inefficient regulation of stimulation and general tendency to avoid stimulation due to low level of initial arousal. Galen typology would classify them as phlegmatic.
- A disharmonized structure with a high capacity for processing stimulation: people with this kind of temperament structure show low EN, high ER and high AC. They also have high or moderate SS, BR and PE. This kind of structure of temperamental traits indicates the inefficient regulation of stimulation and

general tendency to relieve the tension related to a high level of general arousal. Such people do not avoid stimulation and have a tendency towards impulsive reactions. Galen typology would classify them as choleric.

Several studies have provided strong empirical support for a unitary conceptualization of pilot personality [1, 2, 3, 4, 10, 11]. Those studies described pilots' personality as more achievement-oriented, outgoing, active, competitive, dominant and less introspective, emotionally sensitive and self-effacing than that of their nonflying counterparts. Picano [3] suggested that there were three distinct types of experienced military pilots: (a) methodical extroverts (48% of military pilots) were outgoing and had a structured approach to problem solving; (b) introvert worriers (36% of pilots) were more emotionally controlled, inhibited, apprehensive and socially retiring. They preferred stability, security and predictability in their environment; (c) competitive individualists (16% of pilots) were highly independent, competitive and decisive. They appeared to be the least emotionally sensitive and emphatic [10, 11].

Figure 1 compares temperamental traits of experienced (jet) and cadet pilots, with both additionally compared with their peer groups. Experienced pilots and cadets shared common temperamental characteristics and both groups differed from their respective peers, i.e., both groups of pilots displayed a harmonized temperament structure with a high capacity for processing stimulation (a characteristic of a sanguine person). However, our study investigated only the role of individual differences in the escalation of temperamental traits among experienced pilots and its relation to the performance of an eye–hand co-ordination task.

There are different types of psychomotor tasks and only some of them may help to disclose the role of personality factors. A task that involves significant perceptual and response load should be used to assess psychomotor ability [13, 14]. It should entail complex perceptual discriminations or trigger a complex motor response. The perceptual input in a psychomotor task can be visual, auditory or tactile, and the motor output can involve the manual (one or more limbs), ocular or vocal motor systems. Psychomotor time should be continuous, time-critical and it should meet the time-sharing requirement (i.e., multiple things are done at the same time). These features tend to increase perceptual or response load. A classic psychomotor task stresses continuity (it involves the translation of a continuous

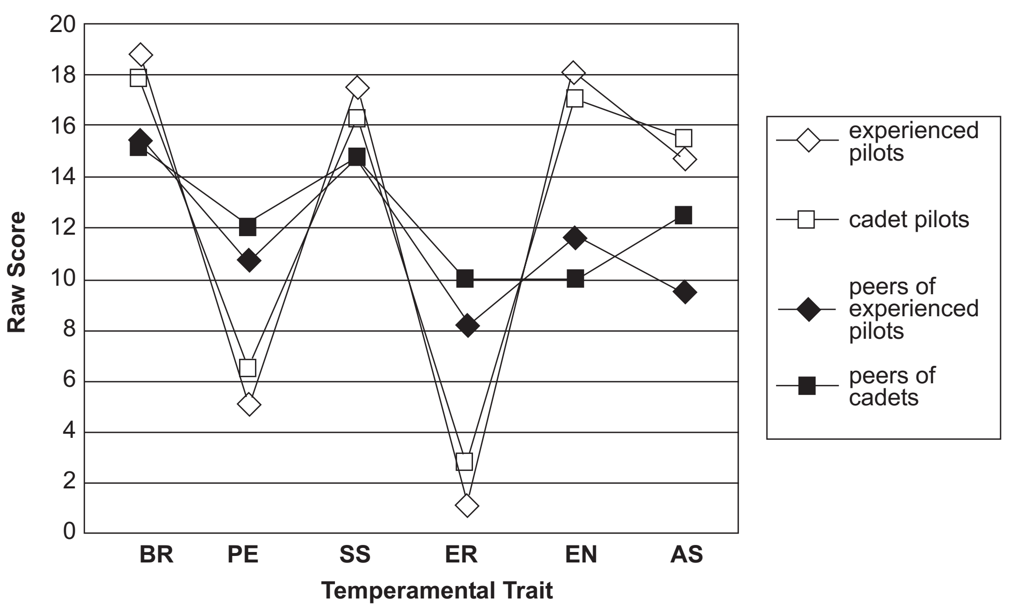

Figure 1. Mean level of temperamental traits in pilots and nonpilots [9, 12]. *Notes.* BR—briskness, PE—perseveration, SS—sensory sensitivity, ER—emotional reactivity, EN—endurance, AC—activity.

perceptual display into a continuous motor response), timing (it requires timing a response or estimating time accurately) and co-ordination (the task is done in conjunction with another one) [13, 14, 15]. Psychomotor performance has its own dynamics that can be identified in three phases of task performance [17]. General ability measures (e.g., abstract reasoning) underlie performance in phase 1. As production systems are created to provide consistent performance, the influence of those factors declines and perceptual speed abilities emerge as significant predictors of performance in phase 2. Finally, in phase 3, performance is primarily determined by noncognitive psychomotor abilities [16].

To conclude, although it is difficult to determine in detail the relationship between personality or temperamental traits and psychomotor variables, this issue is crucial in predicting pilots' performance [17, 18]. Many studies have focused on the role of temperamental traits in mediating the level of response to stimuli [8, 19, 20]. The results of those studies indicate that the level of the escalation of temperamental traits mediates the quality and quantity of response to visual stimuli as measured by event-related potentials, heart rate and reaction time.

DePascalis, Strelau and Zawadzki [20] found that individual differences in PE were reflected in individual differences in the N500 wave of the event-related potentials. A high level of the PE trait was related to a higher N500 peak. That result was interpreted in terms of differences in facilitatory processes in reaction to emotional and nonemotional material. Moreover, the results of the same study indicated that under emotional stimulation, a low level of the EN trait, in comparison with a high level of the EN trait, was reflected in lower performance and also in the experience of stronger negative emotions. The level of the SS trait also indicated interesting interrelations between temperament and psycho-physiological measures. Firstly, the results were congruent with the theoretical assumption that high SS individuals had lower sensory thresholds. Individuals with a high level of the SS trait had higher P300 peak amplitudes for pleasant words on the frontal cortical region and for unpleasant and nonsense words on the parietal region. Moreover, high SS subjects produced higher levels of fast alpha power (10.25 ± 12 Hz) than did low SS subjects. De Pascalis, Strelau and Zawadzki [20] and Klimesch [21] claimed that those findings were in agreement with the assumption that fast alpha activity was a good indicator of enhanced arousal. Finally, individuals with a high level of the AC trait, in comparison with low AC subjects, were more likely to exhibit higher prestimulus theta and alpha1 power [20].

3. RESEARCH PROBLEMS AND HYPOTHESES

Performance of continuous tasks [12], which required continuous processing of inflowing data for adequate and incessant motor response, was expected to be in step with temperamental traits. Individual differences in BR, PE, SS, ER, EN and AC were assumed to be significantly related to performance (at the level of perceptual input and motor response) [5, 6, 7, 8, 18, 20]. In particular, the level of some temperamental traits was hypothesized to indicate the level of psychomotor performance at different points of the task.

In comparison with pilots with a low level of AC, pilots with a high level of that trait were expected to perform a psychomotor task significantly better in its initial phase. In the middle phase, the level of performance would be comparable in both groups, because individuals with a high AC level would tend to overstimulate in the initial phase and they would exhaust their activity resources. A decrease in the quality of task performance in the early middle phase of the test would be caused by their inability to deal with the monotony of the task. In comparison with pilots with a low level of EN, pilots with a high level of that trait would perform a psychomotor task significantly better in all its phases. The same would be true for pilots with high levels of BR and SS, in comparison with pilots with low levels of those traits. Pilots with a high level of BR would tend to react quickly and efficiently to the changing requirements of the task, which would help them to achieve a high score [7, 8, 9]. Because all pilots had very low levels of ER and

PE, no hypotheses concerning those traits were posed. There were only 4 pilots whose scores of ER and PE fell into the 4th quartile.

4. METHODS

4.1. Subjects

Fifty-two jet pilots, candidates for the F-16 training programme, participated in the study. They were advanced pilots with Mig 29 or Su-22 experience, individually tested in the laboratory of the Military Institute of Aviation Medicine in Warsaw, Poland.

4.2. Tests and Procedures

In addition to the FCB-TI inventory, the Sensorimotor Co-Ordination (SMK) test was administered. The quartiles for individual temperamental traits were determined to differentiate groups of subjects with the highest and lowest levels of the escalation of individual temperamental traits.

The SMK test is part of the Vienna Test System [22]. There is a three-dimensional room on the screen in which there are a target position (green bars forming an upside-down T) and a manoeuvrable element (a triangular segment) (Figure 2a). The triangular segment starts moving around the room in unpredictable directions, X_n, Y_n, Z_n. The task consists in co-ordinating the triangular element and placing it as closely as possible to the ideal range (Figure 2b).

The SMK test measures the following variables [22].

- Mean score for deviation from the horizontal line, X_n (in pixels). This value indicates how well the respondent is able to control and influence the horizontal motion, regardless of the ideal position.
- Mean score for deviation from the vertical line, Y_n (in pixels). This value indicates how well the respondent is able to control and influence the front-to-back motion, regardless of the ideal position.
- Mean score for deviation from the correct angle, Z_n (in degrees). This value indicates how well the respondent is able to control and influence the tilting motion, regardless of the correct position.
- Time in the ideal range (as percentage): time the triangular segment was in the ideal range within a given interval (100% = the triangular segment never moved from the ideal position). The ideal range is deviation of maximum 25 pixels in the horizontal and vertical motions, and deviation of maximum 25^{o} in the tilting motion.

The SMK test was a continuous task of 10 min 27 s. Additionally, the level of individual variables was evaluated at 11 points of the task (Figure 3).

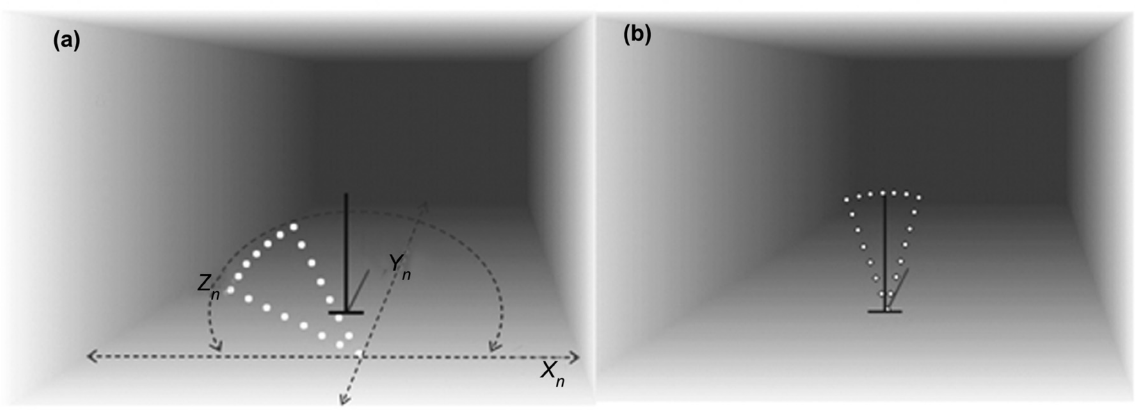

Figure 2. The sensorimotor co-ordination test screen; (a) axes of the movement of the triangle (lines X_n, Y_n and Z_n are not visible during the task); (b) ideal position of the triangle.

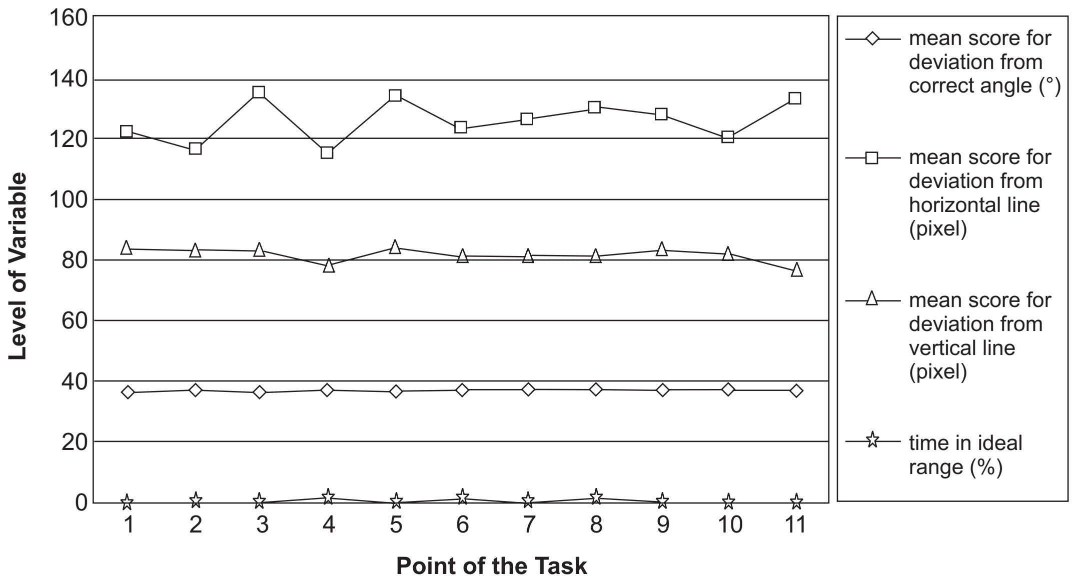

Figure 3. Level of sensorimotor co-ordination variables at different points of the task (task difficulty).

The task's objective was to decrease the level of deviation from the *X*, *Z* and *Y* angles and to increase time in the ideal range (which is zero to start with). This requires high levels of vigilance and skilful management of personal activity. The SMK test has similar cognitive demands as other popular tests (e.g., the Two-Hand Co-Ordination Test or the Complex Co-Ordination Test from the Basic Attributes Test) [23, 24].

5. RESULTS

As the task progressed, the subjects' performance in aligning the controlled element with the ideal area deteriorated; there were more unnecessary movements (supporting activities). Their number was negatively correlated with remaining in the ideal area for horizontal deviation; $r = .77$, $p < .001$; angle deviation, $r = .65$, $p < .001$; and vertical deviation, $r = .67$, $p < .001$. This means that the more unnecessary movements a subject made, the shorter was he able to hold the triangle in the ideal area. Control of the triangle was less stable. In the final phase, the level of performance gradually improved and instability was reduced (Figure 4).

The subjects whose score of temperamental trait fell into the 1st quartile were assigned to a group with a low level of temperamental traits, whereas the subjects with scores in the 4th quartile were classified as high-level. Then, for each time unit, the value of the variable time in the ideal area was determined with the low or high level of temperamental traits taken into account (Figure 5).

A two-way analysis of variance (ANOVA) with repeated measures was conducted for each temperamental trait. The level of the temperamental trait was the between-subject factor and the moment of measurement was the within-subject factor.

For AC, the moment of measurement significantly affected the measurement itself; $F(10, 200) = 107.41$, $p < .001$. Interaction of the level of AC (4th and 1st quartiles) with the moment of measurement was statistically significant; $F(10, 200) = 3.49$, $p < .001$. However, the level of AC (4th and 1st quartiles) did not significantly affect the test score; $F(1, 20) = 1.65$, $p = .213$.

For EN, the moment of measurement significantly affected the measurement itself; $F(10, 330) = 131.37$, $p < .001$. Interaction of the level of EN (4th and 1st quartiles) with the moment of measurement was not statistically significant; $F(10, 330) = 1.21$, $p = .285$. The level

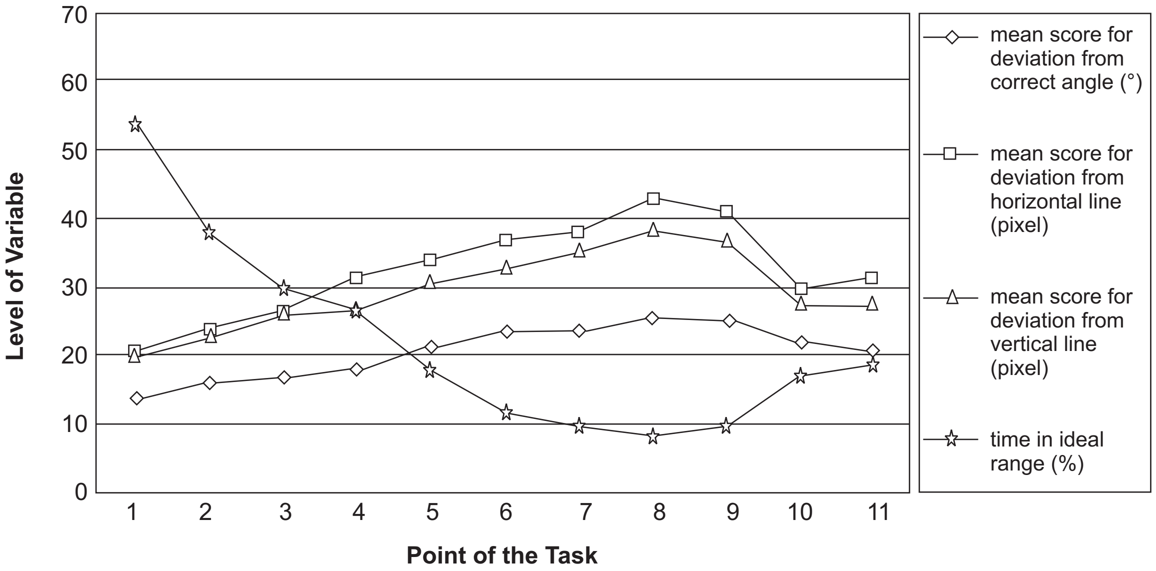

Figure 4. Mean levels of sensorimotor co-ordination variables at different points of the task (subjects' performance).

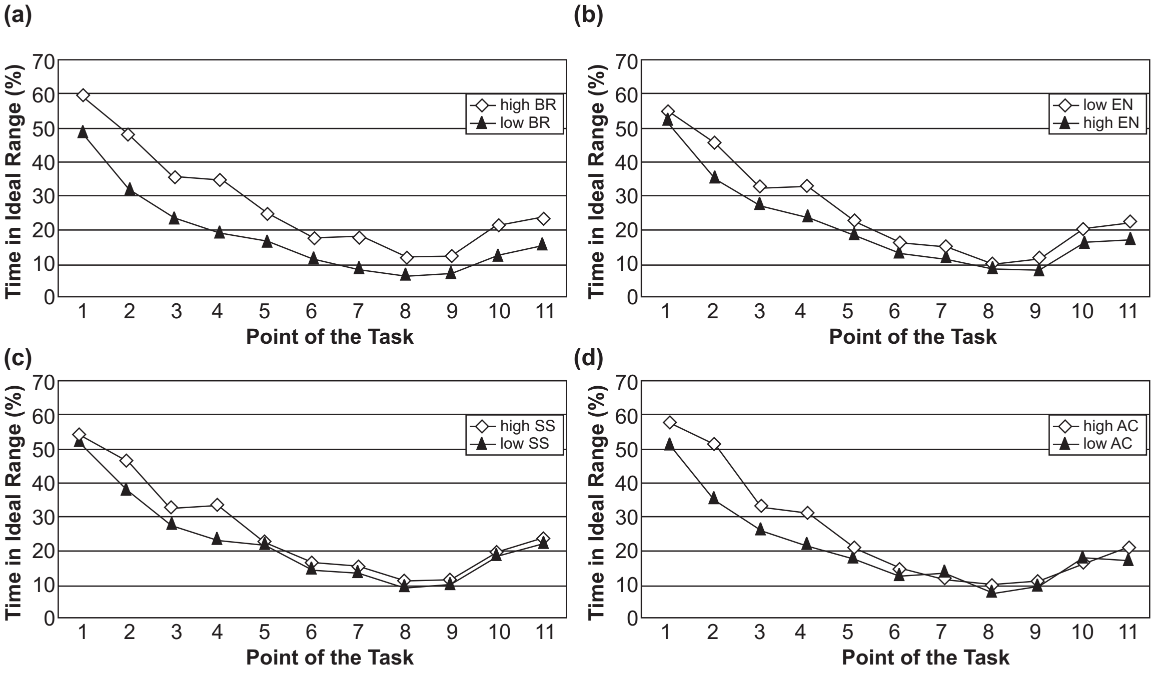

Figure 5. Mean time in the ideal range at different points of the task and the level of temperamental traits; (a) briskness (BR), (b) endurance (EN), (c) sensory sensitivity (SS), (d) activity (AC). *Notes.* High BR (n = 16), low BR (n = 9); high EN (n = 22), low EN (n = 13); high SS (n = 17), low SS (n = 11); high AC (n = 10), low AC (n = 12). 4th quartile = high, 1st quartile = low.

of EN (4th and 1st quartiles) did not significantly affect the test score; $F(1, 33) = 1.91$, $p = .177$.

For SS, the moment of measurement significantly affected the measurement itself; $F(10, 260) = 104.32$, $p < .001$. Interaction of the level of SS (4th and 1st quartiles) with the moment of measurement was not statistically significant; $F(10, 260) = 1.56$, $p = .116$. The level of SS (4th and 1st quartiles) did not significantly affect the test score; $F(1, 26) = 1.05$, $p = .315$.

For BR, the moment of measurement significantly affected the measurement itself;

$F(10, 230) = 94.21$, $p < .001$. Interaction of the level of BR (4th and 1st quartiles) with the moment of measurement was not statistically significant; $F(10, 230) = 1.74$, $p = .073$; but it was at a tendency level. However, the level of BR (4th and 1st quartiles) significantly affected the test score; $F(1, 23) = 122.62$, $p < .05$.

In the two-way ANOVA it is not possible to perform post-hoc comparisons, so *t* tests were used. Pilots with a high level of AC performed better in the 2nd minute of the task; $t(20) = –2.48$, $p < .005$; and in the 4th minute; $t(20) = –2.10$, $p < .005$; in comparison with pilots with a low level of AC. Pilots with a high level of EN performed better in the 4th minute of the task; $t(33) = –2.10$, $p < .005$; in comparison with pilots with a low level of EN. Pilots with a high level of SS performed better in the 4th minute of the task; $t(26) = –2.64$, $p < .005$; in comparison with pilots with a low level of SS. Pilots with a high level of BR performed better in the 2nd minute of the task; $t(23) = –2.09$, $p < .005$; in the 3rd minute; $t(23) = –2.24$, $p < .005$; in the 4th minute; $t(23) = –2.83$, $p < .001$; in the 7th minute;$t(23) = –2.37$, $p < .005$; and in the 10th minute, in comparison with pilots with a low level of BR.

6. DISCUSSION

The level of eye–hand co-ordination deteriorated over time [12, 16, 25]. At the same time, the instability of performance increased. The level of performance improved in the final phase of the test, which means that the method of performing the task coincided with the phases of the process of acquiring abilities [16, 25]. Finally, it was concluded that performance was connected with the level of specific temperamental traits. A high level of BR was connected with a high level of performance during the entire task. However, for specific parts of the test, the level of AC, EN and SS proved their regulative function in the executive process [7, 8, 19, 20].

Pilots with a high level of AC performed well in the task, but only until the early-middle phase of the test. After about the 4th minute, their level of performance dropped sharply, making their scores the same as those of the pilots with a low level of AC. Individuals with a high level of AC probably tended to overstimulate in the initial phase, exhausting resources necessary for efficient motor performance. Their inability to cope with the monotony of the task caused a sharp deterioration of their performance in the early-middle phase of the test, and the cognizance processes seemed to fluctuate.

Pilots with a high level of EN were expected to perform significantly better during the entire task. As it turned out, the level of EN played a role only in the early-middle phase of the task, when pilots with high EN performed better. In the next phase, however, their performance was the same as that of the subjects with a low level of EN. Pilots with a high level of SS performed significantly better in the initial phase of the task. In the middle phase the performance of both groups was the same, because pilots with a high level of SS started to lose their ability to react to the subtle changes of the location of the manoeuvred element. Pilots with a high level of BR performed significantly better during the entire task. A high level of BR enabled them to react quickly and adequately to the changing requirements of the task and helped them to regulate stimulation effectively.

The learning processes connected with attention and working memory were crucial in the initial phase of the task (up to the 4th minute of the test). This explains the high correlation between AC, BR, EN and SS, and performance. In the middle phase (between the 4th and the 9th minute), there was a gradual levelling of performance and an increase in the incidence of unnecessary movements in the time unit. This affected the level of performance, which proved to be lowest in the middle phase. A high level of BR was solely responsible for good results in this phase. A high level of AC, crucial in the initial phase of the test, resulted in a sudden decrease in executive processes in the middle phase. The results showed a different role of AC as a trait connected with the energetic characteristic of behaviour in individual phases of the test. In the final phase of the task, there was a gradual improvement in performance, for subjects with both high and low levels of the analysed temperamental traits. Nevertheless, the level of BR was significantly connected with the quality of performance in each phase.

The results are consistent with the postulate of the regulative theory of temperament that temper plays a regulative function of behaviour, modifying stimulus and response values. In eye–hand co-ordination, the level of temperamental traits played a mediating role between perceptual input and motor output, both at the level of general performance and of eye–hand co-ordination at different points of the task [7, 8].

To conclude, this study adds to the literature on the role of personality traits in predicting different aspects of pilots' performance [1, 2, 3, 4, 10, 24, 26]. Despite jet pilots' harmonized structure of temperament, i.e., a high capacity for processing stimulation, they differ in the escalation of some temperamental traits, and this modifies the processing of the task. Thus, the aim of future research is to improve tools that would help to choose missions optimal for pilots with different escalation of temperamental traits. For instance, pilots with a high level of BR and EN would be better suited for long flights, whereas pilots with a high level of AC would be ideal for short and dynamic missions [4].

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