Brain processing speed and its relationship to the accuracy of performance of the skill of spiking diagonal and straight for young volleyball players

Lect. Dr. Muntadhar Saheb Mahdi Alnwyni
Faculty of Physical Education and Sports Sciences / University of Kerbala, Iraq.
Muntadhar.s@uokerbala.edu.iq

Abstract
The study included five chapters, where the first chapter included an introduction to the research and its importance, as the researcher stated that it is self-evident in sports circles that there is an inverse relationship between speed and accuracy. However, the concept of speed in this study is completely different from all other speeds, and the importance of the research lies in recognizing the relationship between the speed of brain processing and the accuracy of the skill of diagonal and straight spiking, using the latest international laboratory equipment prepared on the computer to measure this complex variable within this study. The research problem included that sports games depend on the speed of appropriate decision-making related to mental processes, which occur in fractions of a second, and the speed of information processing is the summary of the work of mental processes as a whole. Fast games that require high accuracy with speed of performance, as deciding a point requires speed, accuracy and high concentration this is not available without a high brain processing speed, especially the skill of crushing hitting, in which the player chooses the appropriate time and place to hit the ball in the desired direction in accordance with the movement of the prepared player or the lifter to execute the strike successfully and achieve points, and the researcher asked the following question: Is there a relationship between the speed of brain processing and the accuracy of performing the skill of diagonal and straight spiking skills? The objectives of the research included: identifying the level of brain processing speed among the members of the research sample and identifying the accuracy of performing the skill of spiking diagonal and straight and identifying the relationship between brain processing speed and accuracy Performance of the skill of diagonal and straight spiking among the research sample members. The hypothesis of the research was: There are statistically significant differences between the speed of brain processing and the accuracy of performing the skill of diagonal and straight spiking among the members of the research sample. The second chapter included theoretical studies related to the variables of the research, and the third chapter included the research methodology and its field procedures, where the researcher relied on the descriptive approach in the manner of correlative relations to suit the nature of his research. The fourth chapter included the presentation and discussion of the results, and the most important conclusions were: the emergence of a direct relationship between the speed of brain processing and the accuracy of skill performance, The most important recommendations: Attention to the development of mental abilities besides skill abilities and the use of
computerized methods and tests such as the Vienna Test System in measuring the mental abilities of players because they are of high accuracy.

**Introduction:**

The value of computers, tablets and mobile devices today depends mainly on the speed and capacity of their central processor, whose coil is usually made of gold, which is one of the fastest conductors. The matter is not much different for humans. Rather, the idea of processors in computers is derived from the mechanism of the human brain’s work, as the human brain’s ability to interact with the external environment, compare information, make decisions and appropriate reactions has become what distinguishes man from other creatures in nature.

It is clear and self-evident in sports circles that there is an inverse relationship between speed and accuracy. The higher the performance speed, the less accurate the performance. However, the concept of speed in this study is completely different from all other speeds, because the higher the brain processing speed, the more accurate the performance of different skills in most sports and intellectual games.

The importance of the research lies in identifying the relationship between the speed of brain processing and the accuracy of the skill of diagonal and straight spiking, and using the latest international laboratory equipment to measure this complex variable within this study.

**Research problem:**

Sports games depend on the speed of making the appropriate decision related to mental processes, which occur in fractions of a second, and the speed of information processing is the summary of the work of mental processes combined, and most importantly, choosing the right decision that results in an appropriate reaction to the required response, volleyball is one of the fast games that requires high accuracy with speed of performance, as deciding a point requires speed, accuracy and high concentration, and this is not available without a high brain processing speed, especially the spiking skill in which the player chooses the appropriate time and place to hit the ball in the desired direction in accordance with the movement of the prepared player or The lifter to successfully execute the strike and score points.

The researcher poses the following question: Is there a relationship between the speed of brain processing and the accuracy of performing the skill of diagonal and straight spiking?

**Research objective:**

The researcher aims through his research to:

- Identifying the level of brain processing speed of the research sample members.
- Recognizing the accuracy of the performance of the skill of the diagonal and straight spiking among the members of the research sample.
- Identifying the relationship between the speed of brain processing and the accuracy of performing the skill of diagonal and straight spiking among the research sample members.
Research hypotheses:
- There are statistically significant differences between the speed of brain processing and the accuracy of performing the skill of diagonal and straight spiking among the research sample members.

Research Fields:
The human field: Al Shabab volleyball players for the 2017-2018 season.
Time field: from 4-12-2017 to 2-4-2018.
Spatial field: The auditorium of the Specialized School in Baghdad.

Theoretical section:
Brain processing speed: The brain is the organic basis for all psychological processes, especially cognitive, from feeling, perception, remembering and thinking and all this is done through the complete complex function performed by the neurons that collectively make up the so-called human brain. (1)
Mental ability: is “the power to achieve mental effectiveness with or without training.” It is a term used to describe mental functions, and it includes different mental abilities such as memory, thinking, logical reasoning...etc, and that each of these abilities is self-contained. (2)
The knowledge tool is the functions that the brain performs (such as attention, thinking, coding, organizing, categorizing, integrating, remembering, retrieval) and others. (3)
Executive control deals with the process of storing information in long-term memory and is related to its recall to form a response, and these two components make up the Cognitive Strategy. (4)
The term executive processes is used to refer to this type of procedural knowledge, and executive processes also include both monitoring and regulating other thought processes, and executive control processes. Those processes directed at acquiring information about an individual's thought processes, executive organizational processes are those processes directed towards organizing the individual’s course of thought, and these processes include the individual’s decisions that help:
   A. Gather his resources for the current task.
   B. Determine the order of steps you take to finish the task.
   C. Adjust the intensity.
   D. The speed with which the individual should perform that task. (5)

(Hacker, 2000) believes that the executive processes include the decisions of the individual that help to:
A. Know what task the person is currently working on.
B. Examine the ongoing progress of that work.
C. Evaluate that progress.
D. Predict what the outcome of that progress will be. (6)
(Rizk, 1977) believes that mental capacity is the amount that an individual possesses of mental energy that qualifies him to make an appropriate solution to the various problems and dilemmas in the different fields of life. (7)

Mental ability is the hypothetical formations that we infer from the measurable methods of performance. (8)

(Flavell, 1979) indicates that the ability is the awareness, perception and organization of the knowledge of a person. (9)

The researcher was briefed on one of the scientific articles that dealt precisely with the executive functions of the brain, in which psychologists and neuroscientists described the executive functions as a unique bundle of mental functions performed by the frontal parts (the frontal lobe) of the cerebral cortex, in conjunction with the areas under the cerebral cortex (the lymphatic system). Executive functions have not been given a great deal of attention, except since the past decade, due to their impact on cognitive and emotional performance, and in particular, cognitive initiation and inhibition, self-regulation, and motor output. In general, executive functions are a set of interrelated although disparate facilities that contribute to intentional, purposeful actions, and include planning and organizing. These functions harmonize many intellectual and practical aspects. In conclusion, we find that executive functions have been described by many researchers using different terms, and although different vocabulary occasionally leads to confusion, the actual observations of researchers were generally similar, and to better understand the importance of executive control, consider the following list of functions Executive:

1. Harmonize the sources of working or short-term memory.
2. Organizing the storage of information in long-term memory.
3. Facilitate the retrieval of information from long-term memory.
4. Managing and regulating the speed of information processing.
5. Inhibiting unwanted behavioral responses.
6. Directing and maintaining attention when blocking interference.
7. Cutoff distractions to return to the psychological priority of attention.
8. Regulating social behavior, including empathy and social sensitivity.
10. The application of hindsight and precognition in information processing.
11. Performance adjustment based on feedback.

It is clear from the above list that executive functions have a tremendous impact on our ability to learn new information and adapt to new environments and challenges.

Field Research Procedures:

Research Methodology: The researcher used the descriptive approach using the survey method and correlational studies as a better method to solve the research problem due to its relevance and the nature of the current study.
Research community and sample:
The research community included the young volleyball players in the Al-Shabab Club in Baghdad governorate for the 2017-2018 sports season, which are 20 players who were chosen randomly.

The homogeneity of the research sample:
Table (1) It shows the homogeneity of the members of the research sample in the extraneous variables.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Measure unit</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Median</th>
<th>Skewness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>Cm</td>
<td>181.3333</td>
<td>3.81768</td>
<td>180.0000</td>
<td>.490</td>
</tr>
<tr>
<td>Mass</td>
<td>Kg</td>
<td>73.1000</td>
<td>3.84484</td>
<td>74.0000</td>
<td>-.101</td>
</tr>
<tr>
<td>Training age</td>
<td>Month</td>
<td>27.7000</td>
<td>3.00746</td>
<td>28.0000</td>
<td>-.269</td>
</tr>
</tbody>
</table>

Research tools: For the purpose of achieving the objectives of the current research, a set of standardized tests was required, which were selected from solid scientific sources that pertain to the study variables, which are as follows:

First: TMT-L: (information processing speed) test.\(^{(10)}\)

Definition of the test (Application): It is the test that measures general neuropsychological functions such as the speed of processing visual-motor information and other executive functions. It is symbolized by TMT-L, which stands for Trail Making Test - Langensteinbach Version, which means Tracking Test - Langensteinbachs Version (who developed the original version of the test).

Theoretical background of the test: The current test is based on empirical models that were established to measure cognitive flexibility. It can be used to assess readiness for therapeutic interventions as well. It is one of the widely used tests worldwide to investigate different brain functions. It contains two parts. Competence within neuropsychological requirements, such as processing speed and some executive functions of the brain, such as cognitive flexibility and working memory, The TMT-A test primarily measures the speed of information processing, while the TMT-B assesses higher cognitive abilities such as mental flexibility. In the TMT-L test, some weaknesses in the old version of the test were corrected. In addition, in TMT-L the paths in Part B are similar to those in Part A; This makes it easier to control kinetic effects and compare results on two parts of the test.

Stages of test application: In the first stage, the person supervising the test explains a brief general idea of the meaning of the test, the purpose of the test, and what are the desired benefits from conducting it, so that the test person is aware and psychologically and mentally prepared to apply the test, then the supervisor records the laboratory data, to move to the second stage of training on how to perform the test, and then after making sure that the tester knows how to perform the test correctly, we move to the main stage of the test, which is conducting the test in its parts (A and B).

How to apply the test: Part A of the test is organized on the computer, and it is a revised version of the numbers 1-25 arranged randomly on the screen. The tester is asked to perform the task of
clicking or tapping the numbers in sequential order as quickly as possible. Touching or pressing is done with the index finger of the dominant hand, while the mouse is clicked if used and according to the desire of the examinee.

Then the test moves to Part B, which uses numbers (1-13) and letters A)- (L. Here the tester is asked to tap or click alternately and in ascending order as quickly as possible, using the index finger of the dominant hand or a computer mouse. Any time he clicks on a number and the other presses on the letter corresponding to it in the sequence, and so on, taking into account the exact sequence of numbers with randomly scattered letters without intersecting and as quickly as possible, knowing that in the event that the tester errs in the correct path, the computer will issue an alert sound to the tester. To avoid repeating this as it greatly weakens the test result, as in the picture listed in Appendix (1).

**Scoring:** The test reports on the main target variables, which are:

1. Working time in Parts A and B of the test.
2. The number of errors during the performance of the test.
3. The percentage of the degree.
4. The degree of difference.

Outliers are analyzed to determine if the results are affected by one weak aspect according to the searches.

**Stability:** The stability of the test is estimated by calculating alpha-Cronbach coefficient as well as using data from the standard sample. The stability of the test can be rated very high.

**Validity:** Extensive empirical evidence supports the validity of this test. The construct validity of the test was checked using the original version of the test, WAFA neuropsychological tests to assess executive functions (Task Switching, Tower of London - Freiburg version and n-back test) and other tests of basic cognitive function.

**Criteria:** The sample of criteria for the test includes (309) (healthy) people. Entire adults.

**Test time:** This test consists of two parts (Part A and B) and the working time is about two minutes for each part, that is, approximately 4-5 minutes.

**Second: Testing the accuracy of the skill of diagonal and straight spiking, center (4). (11)**

The objective of the test: to measure the accuracy of the diagonal spiking and the central straight (4).

**Equipment:** a legal volleyball court, legal volleyballs, two mattresses of length 2 m and width 1m.

**Performance specifications:** The tested player hits the spiking from the center (4) by means of numbers from the coach from the center (3), and the tester must perform (5) spiking blows in the diagonal direction and (5) blows in the straight direction.

**Register:**

- (4) Points for each correct smash hit that the ball falls on the rank.
- (3) Points for each correct smash hit the ball falls in the yellow area according to the type of smash hit.
Third: Testing the accuracy of the skill of diagonal and straight spiking, center (2).

The objective of the test: To measure the accuracy of the diagonal spiking and the straight line (2).

Equipment: a legal volleyball court, legal volleyballs, two mattresses of length 2 m and width 1m.

Description of performance: The tested player hits the spiking from the center (2) by preparing the coach from the center (3), and the tester must perform (5) spiking blows in the diagonal direction and (5) spiking blows in the straight direction.

Register:
- (4) Points for each correct spiking, the ball falls on the rank.
- (3) Points for each correct spiking hit, the ball will fall in the yellow area according to the type of spiking.
- (2) Points for each correct spiking, the ball falls in zone (A) for the diagonal spiking and in zone (B) for the straight spiking.
- (1) One point for each ace, the ball falls to the rest of the field.
- (zero) for each failed crush.
- Test final score (40 points).
Figure (2)
Accuracy test of diagonal and straight spiking skill center (2).

Scientific Transactions for tested:
Table (2) Shows the scientific coefficients of the tests.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Validity</th>
<th>Reliability</th>
<th>Objectivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain processing speed</td>
<td>0.918</td>
<td>0.843</td>
<td>0.920</td>
</tr>
<tr>
<td>Accuracy of performing the skill of spiking diagonal and straight center (4)</td>
<td>0.914</td>
<td>0.835</td>
<td>0.948</td>
</tr>
<tr>
<td>Accuracy of performing the skill of spiking diagonal and straight center (2)</td>
<td>0.906</td>
<td>0.821</td>
<td>0.912</td>
</tr>
</tbody>
</table>

Presentation, analysis and discussion of the results:
The researcher presented the results of the tests for the research sample, by displaying the arithmetic means and standard deviations in illustrative tables after performing the necessary statistical operations for them, in order to facilitate the observation of the results, as well as making a comparison between the totals in the tests by analyzing and interpreting the results of all tests to know the reality of the differences and their statistical significance, According to the accurate scientific perspective, in order to achieve the objectives and hypotheses of the research.

First: Presentation, analysis and discussion of the results and reality of the research variables:
Table (3) shows the results of the tests of brain processing speed and the accuracy of performing the skills of diagonal and straight smash in centers 2 and 4.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain processing speed</td>
<td>41.9333</td>
<td>2.27328</td>
</tr>
<tr>
<td>Accuracy of performing the skill of spiking diagonal and straight center (4)</td>
<td>32.8000</td>
<td>2.80885</td>
</tr>
<tr>
<td>Accuracy of performing the skill of spiking diagonal and straight center (2)</td>
<td>32.3333</td>
<td>3.00956</td>
</tr>
</tbody>
</table>

Through Table (3), which shows the results of tests of brain processing speed and accuracy of performance of the skills of diagonal and straight smash in centers 2 and 4. Where it was found that the arithmetic mean of the variable brain processing speed reached (41.933) with a deviation of (2.273), while the arithmetic mean of the variable accuracy performance of the
skill of diagonal and straight smash hit center (4) (32.8) with a deviation of (2.273), and the arithmetic mean of the accuracy variable reached The performance of the skill of diagonal and straight smash hit center (2) (32.33) with a deviation of (3.009).

The presented results show the emergence of a high level in the speed of brain processing capacity among the members of the research sample, and this was demonstrated by Suleiman Abdel Wahed: The sensory system, like other types of communication channels, exercises its functions well if the amount of information being processed is within its capabilities, but it fails if the amount of this information exceeds its capacity. (13)

The results showed high levels in the variables of the skill variable diagonal and straight smash in playing centers 4 and 2, as a result of the good skill preparation by the team coach, which reflected positively on the performance of the players, as when performing any movement that movement takes a certain period of time in which the exchange of power flow occurs. Motion means strength and weakness in motion. (14)

Second: Presentation, analysis and discussion of the results of correlational relationships:

Table (4) shows the relationship of brain processing speed to the accuracy of the skill of diagonal and straight spiking for central (4), (2)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlation coefficient</th>
<th>Level Sig</th>
<th>Relationship type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy of performing the skill of spiking diagonal and straight center (4)</td>
<td>0.700</td>
<td>0.000</td>
<td>Sig</td>
</tr>
<tr>
<td>Accuracy of performing the skill of spiking diagonal and straight center (2)</td>
<td>0.664</td>
<td>0.000</td>
<td>Sig</td>
</tr>
</tbody>
</table>

It is clear from the results presented in Table No. 4 the strength of the correlation between the speed of brain processing and the accuracy of the skill of diagonal and straight smash in centers 4 and 2. The researcher attributes this correlation to the direct relationship between the speed of information processing and accuracy in skillful performance, where the speed of brain processing depends on the quality of Mental processes that occur in the brain such as sensation, attention, perception, reaction, and motor response.

And (Ihsan Atallah) believes, “The living being is affected by the external influences that fall on it through the senses when the special ripples emanating from external things collide with the ends of the nerves, and these nerves transmit them and connect them to the brain, and the brain translates these signals into meanings”. (15)

Where cognition, which is one of the higher mental processes, represents the basis for all mental processes, as explained by (Mufti Ibrahim Hammad), which is the identification or interpretation of information discovered by the senses, and it includes the interaction of information recognized by the senses with the information in memory, and the extensive cognitive experiences that contribute to the selection of models From the previous experiences acquired by the individual to use it in the situations he is going through. (16)

Volleyball is one of the games that requires speed and accuracy together, where volleyball players use consideration to determine the place and direction of play, the ball, competitors and...
colleagues, as well as the need to have the ability to determine the distance with extreme accuracy between them and the aforementioned variables.

In conclusion, the development that occurs in the volleyball player’s abilities is the result of intensive training and practice, and this was confirmed by (Amer Al-Saadi): The volleyball player’s awareness develops through repetition, practice, personal experience, and the individual’s sufficiency and ability. For this skill, from here understanding similar movements and the possibility of separating them is a feature of perception.\(^{(17)}\)

**Conclusions and Recommendations:**

**Conclusions:**

1. The young volleyball players are characterized by the speed of brain processing.
2. The young volleyball players have high accuracy in performing the diagonal and straight spiking skills.
3. The results showed a significant relationship between the speed of brain processing and the accuracy of the performance of the skills of diagonal and straight spiking.
4. There is a direct relationship between the speed of brain processing and the accuracy of the skill performance of young players.

**Recommendations:**

1. Paying attention to kinesthetic exercises that develop the nervous system of players.
2. Attention to the development of mental abilities in addition to skill abilities.
3. Paying attention to the psychological aspect of young players and including it within the training curriculum.
4. The use of computerized means and tests, such as the Vienna Test System, to measure the mental abilities of players because they are of high accuracy.
5. Establishing computerized psychological laboratories in federations and clubs to find out the strengths and weaknesses of players in a scientific way that is guaranteed to develop the means of achievement.

**References:**

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16- Mufti Ibrahim Hammad; (1998); Modern Sports Training, i 1: (Cairo, Dar al-Fikr al-Arabi.
Appendix (1).
Brain Processing Speed Test Result Form

<table>
<thead>
<tr>
<th>Test results TMT for memo medio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test battery for Direct Testing</td>
</tr>
<tr>
<td>Test language</td>
</tr>
</tbody>
</table>

**Date:** 2/3/2018  **Start of testing:** 12:07 PM  **Duration:** 5 min.

**Language of test presentation:** English (USA)

### Test results

<table>
<thead>
<tr>
<th>Test Variable</th>
<th>Raw score</th>
<th>PR</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MAIN VARIABLE(S)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working time Part A</td>
<td>32.87&lt;sup&gt;2&lt;/sup&gt;</td>
<td>4&lt;sup&gt;1&lt;/sup&gt;</td>
<td>32 (27-37)</td>
</tr>
<tr>
<td>Working time Part B</td>
<td>36.78&lt;sup&gt;2&lt;/sup&gt;</td>
<td>32</td>
<td>45 (38-52)</td>
</tr>
<tr>
<td><strong>SUBSIDIARY VARIABLE(S)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference B-A</td>
<td>3.91</td>
<td>89</td>
<td>62</td>
</tr>
<tr>
<td>Quotient B/A</td>
<td>1.12</td>
<td>94 (76-99)</td>
<td>66 (57-75)</td>
</tr>
<tr>
<td>Errors Part A</td>
<td>0</td>
<td>52</td>
<td>51</td>
</tr>
<tr>
<td>Errors part B</td>
<td>0</td>
<td>74</td>
<td>56</td>
</tr>
<tr>
<td>Working time Part A corrected</td>
<td>32.87&lt;sup&gt;2&lt;/sup&gt;</td>
<td>4</td>
<td>32</td>
</tr>
<tr>
<td>Working time Part B corrected</td>
<td>36.78&lt;sup&gt;2&lt;/sup&gt;</td>
<td>26</td>
<td>44</td>
</tr>
</tbody>
</table>

**Comment(s):** Percentile rank (PR) and T-score (T) result from a comparison with the entire comparative sample. Representative norm sample (Selection based on Code for additional info). The confidence intervals given in parentheses next to the comparison scores have a 5% probability of error.

<sup>1</sup>Excludes working times of incorrect items
<sup>2</sup>Working time in seconds
Profile
Representative norm sample (Mouse)

<table>
<thead>
<tr>
<th>PR</th>
<th>0</th>
<th>16</th>
<th>25</th>
<th>50</th>
<th>75</th>
<th>84</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working time Part A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working time Part B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference B-A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quotient B/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Errors Part A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Errors part B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comment(s): The shaded area represents the usual average ranges on the norm score scale.

Test Protocol

<table>
<thead>
<tr>
<th>Subtest</th>
<th>Item</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part A (numbers only)</td>
<td>1 - 10</td>
<td>3.43</td>
<td>1.07</td>
<td>1.05</td>
<td>3.85</td>
<td>1.05</td>
<td>0.98</td>
<td>1.08</td>
<td>1.15</td>
<td>1.05</td>
<td>1.08</td>
</tr>
<tr>
<td>11 - 20</td>
<td>1.36</td>
<td>1.28</td>
<td>1.03</td>
<td>1.11</td>
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Comment(s):
The numbers in the fields indicate the number of errors; working time in seconds; --- item was not presented.

Comments and explanations on the test variables

**Working time Part A**
Working time part A is the sum of the working times of all the items in part A; it is used as a measure of the respondent's cognitive processing speed. A high percentile rank indicates a fast processing speed.

**Working time Part B**
Working time part B is the sum of the working times of all the items in part B; it is used as a measure of the respondent's ability to shift flexibly between different reference systems when necessary. A high percentile rank indicates that the respondent has good cognitive flexibility.

**Difference B-A**
Cognitive flexibility can be assessed not only by the working time for part B but also by using the difference score. Unlike the working time for part B, this index takes account of the respondent's personal cognitive processing speed. It can therefore be used to provide specific information that can be used to assess cognitive flexibility. A high percentile rank indicates good cognitive flexibility in relation to cognitive processing speed.
Appendix (2)
Vienna test system