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The correlation between intelligence, creativity and the parameters of sensorimotor integration in children of different ages

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Introduction. Analysis of the literature suggests that the particular nature of the interplay between a person's creativity and intelligence is determined not only by the conditions in which a person develops and their personality traits, but also their age.

Objective. The purpose of this study was to compare the interaction between the levels of creativity and intelligence of 7 to 8 year-old children and 12 to 13 year-old teenagers, by studying how 7–8 year-old children and young teenagers (12–13 years old) with different levels of intelligence and creativity assimilate stochastic signals.

Design. A total of 160 children took part in the study, 80 first- and second-graders who were 7–8 years old (37 boys and 43 girls), and 80 fifth-graders, aged 12–13 (40 boys and 40 girls). We used the following procedures: Raven's Progressive Matrices; a battery of creative thinking tests, amounting to a modification of the Guilford and Torrance's tests in a Russian adaptation created by E. Tunik; and the computer reflexometric method.

Results. Our findings showed that the relationship between the level of intelligence and the level of creativity is different in the two age groups. With 7–8 year-olds, the two parameters are independent of each other, whereas with 12–13 year-olds, there is a weak but significant link between them. With the 7–8 year-old children, the level of creativity predetermines the child's ability to detect the structure of a sensory stream that is organized in a complex way. At the ages of 12–13, neither the level of creativity nor the level of intelligence is correlated with the parameters of sensorimotor integration, but the two parameters are interconnected.

Keywords: creativity, intelligence, children, teenagers, reaction time, simple and complex sensorimotor reactions

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Introduction

The correlation between intelligence and creativity is fraught with all sorts of complexities. First of all, there are no generally accepted definitions for either of these concepts, which is why the result of any study, to a considerable extent, depends on the approaches employed by the authors. Even so, the existence of commonly used methods for evaluating each of these parameters makes it possible to compare the psychometric data, and make some predictions within the context of the ideas central to the tests that are used (Nikolaeva, 1998).

One of the clearest examples of why it is impossible to predict a person's level of creativity using tests designed to assess intelligence is a study conducted by L. Terman (1925). He screened more than 150,000 schoolchildren and then selected out 1,500 of them who had an IQ (according to the Stanford-Binet test) of more than 136. This longitudinal study of the children's achievements continued for many years. Almost all of the children from the sample group with a high order of intellect went on to attain elevated social status; two-thirds of them graduated from universities; and the incomes in this group were four times higher than the national average. The sole Nobel laureate in the first screening, however, came up just shy of the 136 mark (he scored 132), and did not make it into the sample group.

The results of further studies on the connection between creativity and intelligence have been extremely contradictory. On the one hand, there are findings that show a significant correlation between these two parameters (Hennessey, Amabile, 2010); on the other, there is data that shows such a link to be insignificant. There is an opinion that any and all combinations of intelligence and creativity are possible (Deary, 2012), which is why there are individuals with high levels of both parameters and low test scores, as well as people with a high level of one parameter and a low level of the other.

It can be assumed that the particular nature of the interplay between creativity and intelligence is determined not only by the conditions in which a person develops and their personality traits (Haier, 2009), but also by their age.

The right hemisphere of the brain, which is usually pointed to as the psychophysiological basis of creativity (Goldberg, Perfetti, & Schneider, 2006), matures later than the frontal regions of the cerebral hemisphere, which are responsible for decision-making (Byrge, Sporns, & Smith, 2014). Thus, an increase in the levels of creativity and intelligence in an individual's ontogeny can happen at different times, a disparity which can also be reflected in the correlation between these parameters for any particular test subject.

One longitudinal study with a complex design showed intricate alterations in the cerebral cortex at different ages. Three hundred and seven children between the ages of 7 and 19 were examined one to three times on an fMTR scanner at two-year intervals. Their general intelligence and the cortical thickness of their brains were compared (Shaw et al., 2006). The children were divided into three groups: those with superior intelligence, those with high intelligence, and those with average intelligence. It turned out that the group with a superior level of intelligence differed from the other two groups in respect to the changes in their cortical thickness at different ages: the difference was minimal up to the age of 7, when it sharply increased, becoming the most sizeable at around the age of 12. Then it returned to average size at the age of 19. Thus, significant changes occurred between the ages of 7 and 12.

Consequently, when analyzing the relationship between intelligence and creativity, consideration must be given to the nature of the processes underlying the maturation of the cerebral structures.

Practically all of the data indicates that there is no single region of the brain responsible for the level of a person's intelligence. Neural networks distributed throughout the parietal and frontal regions of the brain account for the quality of intelligence (Haier, 2009). Such an explanation is called the parieto-frontal integration theory of intelligence. During the process of thinking, the brain uses complex aural and visual cues simultaneously. When information is being processed, in the early stages the occipital and the temporal lobes are involved. Visual information is also processed in the extrastriate cortex (areas 18 and 19, according to K. Brodmann) and the fusiform gyrus (Brodmann area 37). These regions are responsible for the recognition and processing of visual information. Area 22, which handles verbal information and is related to Wernicke's area, also participates in the processing.

This sensory information then goes to the parietal cortex, first to the supramarginal gyrus (area 40), then the lower parietal (area 7), and the angular gyrus (area 39), where abstract information is processed.

The parietal cortex cooperates with the frontal region (areas 6, 9, 10, and 45–47), where possible solutions to problems are reviewed. If a solution arises, neural networks in the dorsal anterior singulate cortex (area 32) are activated; this leads to the suppression of other possible solutions and provides support for the one that has been chosen. This process hinges on how accurately information is transferred from the dorsal to the frontal regions of the brain.

One means of transfer might be sensorimotor integration (Fotowat & Gabbiani, 2011), which is essentially the interplay between sensory input and motor output. It should be noted that the activity of the sensory neurons presupposes preparation for the ensuing motor act, and feedback from the act, once it has been carried out, leads to its being elaborated in accordance with the context (Anochin, 1975).

In the event that there is uncertainty about the goal, the brain immediately plans a multitude of possible acts, adjusting itself to the constantly changing situation (Gallivan et al., 2016). Sensorimotor integration underlies not only intellectual activity but also many other mental processes, reflecting the integrative functions of the brain when cognitive processes are being carried out (Deary & Der, 2005; Haier, 2009). There is evidence that the level of intellectual activity is dependent on the condition of the neuronal network (Martindale & Hines, 1975), which perhaps, in turn, is explained both by genetic factors and the context in which particular events take place (Lyons et al., 2009).

The speed of the brain's processes has been associated with the level of intelligence for a long time (Deary, 2012) whereas brain plasticity and a variety of mutual interactions have been linked with creativity (Hennessey & Amabile, 2007). A meta-analysis of 172 studies, in which a total of 50,000 test subjects participated, revealed that the coefficient of correlation between the two parameters is 0.31 (Sheppard, 2008).

Therefore, an individual's reaction time correlates significantly with his/her psychometric intelligence, although there is as yet no description of the mechanism behind such a connection.

According to such an approach, the speed of sensorimotor integration should correlate to a greater extent with the parameters of intelligence than with those of creativity. But it is possible that a child's intelligence depends on the speed of the sensorimotor reactions only during the early stages of their life. The older a person is, the greater the role played by experience and decision-making (Santos & Rosati, 2015), which suggests that the connection between intelligence and the parameters of sensorimotor integration is rather complex.

PET scans show that the people who receive the highest scores on the Raven's test expend the least amount of energy (Haier, 2009). The authors of this study concluded that intelligence is connected with more efficient brain activity. This notion has been confirmed many times ever since (Neubauer & Fink, 2009).

If a child's level of intelligence can depend upon the speed of their reactions, then it is entirely possible that his or her creativity might be determined by his/her sensitivity (not necessarily conscious) to the structure of the sensory flow, making it possible to predict its changes and trends. This ability, in turn, might depend on the condition of the neuronal circuits in the child's brain at a certain stage of the ontogeny.

It is now known that the brain is constantly predicting the future, orienting itself on the rather indeterminate, stochastic flow of signals from the external environment. A stochastic flow is a stream of signals that is subject to random processes. It can be assumed that by changing the structure of the flow in an experiment, it will be possible to determine the region of a child's neuronal circuits that are the most sensitive.

With this in mind, we set as our objective the study of how 7–8 year-old children and young teenagers (12–13 years old) with different levels of intelligence and creativity assimilate stochastic signals. We chose these particular ages based on data that shows this (ages 7–13) to be precisely the age range in which the essential restructuring takes place in children that will determine the development of their intelligence and creativity.

Method

A total of 160 children took part in the study, 80 first- and second-graders who were 7–8 years old (37 boys and 43 girls), and 80 fifth-graders, aged 12–13 (40 boys and 40 girls).

In order to achieve our goals, we used the following procedures.

Raven's Progressive Matrices (Raven, Raven & Court, 2003). For the 7 yearsold children we used the colored version. The stimulus material was divided into three sets (A, AB, and B)

Each task is basically a rectangular-shaped matrix containing different figures and sets of figures that are composed so that they logically form a whole; the elements are arranged according to a consistent pattern. Each set begins with a relatively easy problem, and then the tasks become gradually more involved. Such a progression can also be observed from one set to the next. All three of the Raven's sets are organized in accordance with the following principles: set A is based on the principle of a correlation of matrices; set AB, on the principle of analogy between pairs of figures; and set B, on the principle of progressive changes in the figures of a matrix.

Set A calls for analyzing the pattern in an image, recognizing the connection between elements in the pattern, and, based on this, identifying a missing element.

Set AB requires examining disconnected elements and establishing analogies.

Set B necessitates understanding the logical principles behind the changes in position of figures from one space to another.

Administering the test involved the following procedure: the experimenter showed a child a card on which a "carpet" and six "patches" were depicted. In order to "mend the carpet," the child had to scrutinize its pattern and the pattern of all the "patches," and then choose the one that fits the pattern of the "carpet." The child designated the number of the missing element in the picture, and it was written down in the protocol.

When processing the results, we tabulated the scores in percentages, and interpreted them in accordance with how frequently a particular score was attained in a given age category.

A battery of creative thinking tests, amounting to a modification of Guilford and Torrance's tests, in a Russian adaptation created by Tunik (2002)

The stimulus material included seven subtests: *Use of Objects*, *Consequences*, *Words* and *Sentences*, *Word Associations*, *Image Construction*, *Sketches,* and *Hidden Forms*.

It took 40 minutes to administer these tests, which are intended for an age group of between 5 and 15. For children from 5 to 8 years old, they are conducted one on one. With 9- to 15-year-olds, they can be done either in a group or individually.

It should be noted that Subtest 3 had two versions — *Words* and *Sentences*. The first is intended for children from 5 to 8 years old, and the second, for those between the ages of 9 and 15.

The first through fourth subtests are designed to assess verbal creativity, while the fifth, sixth, and seventh reflect the test subject's graphic creativity.

Processing of the tests is connected with the parameters established by Guilford in his studies, to wit:

1) *Fluency (facility, productivity):* This factor characterizes how effective a person's creative thinking is, and it is determined by the total number of answers.
2) *Flexibility:* This factor indicates how flexible a child's creative thinking is, and shows how good the child is at switching his/her attention quickly from one thing to another. It is determined by the number of categories (groups) in the answers given.
3) *Originality:* This factor shows how distinctive and unique the child's creative thinking is, and how unusual his/her approach to a problem is. It is established by assessing how divergent the answers are from those of other test subjects, how unusual the terminology is, and how original the structure of the answers.

4) *Elaboration:* This factor reflects how orderly and consistent a person's creative thinking is, and how appropriate and relevant their answers are.

For each factor, a number of points is calculated, according to formulas which differ for each subtest.

The computer reflexometric method (Nikolaeva & Vergunov, 2013)

This method consisted of three stages, each of which contained a sequence of 64 visual and acoustic stimuli (signals). The visual stimuli were represented by red, blue and green circles, the colors being of equal intensity. For the acoustic stimulus, a sound was emitted at a frequency of approximately 900hz, a volume level of 60 decibels, and a duration of 100 msec. During each stage, each of the stimuli was presented 16 times.

The first stage called for simple sensorimotor reactions, in which the structure of the inter-stimulus intervals was organized in a fractal manner. The second stage involved simple sensorimotor reactions, with the signals having a bi-dimensional fractal structure (the stream of the groups being organized in a fractal way, and within each group the signals were set up in a random fashion). The third stage required complex sensorimotor reactions, and, as in the first stage, the structure of the inter-stimulus intervals was organized in a fractal manner, but here the test subject was not allowed to react to the red circles.

In all three stages, the fractality of the time lapses, after which the stimuli are presented, was computer-generated, so that at each stage, the way in which the signals were presented was determined by a specific algorithm.

Fractal sequences are successions of stimuli, and the variance in the time intervals between their presentations has fractal properties of the same type. In our case, the fractal properties were evaluated with recourse to the Hurst exponent (H), and they were of the following types:

$0<H<0.5$: As a rule, high values are followed by low values (or low values by high values); the closer the Hurst component is to 0, the more pronounced this pattern is; at a value of 0, there are no fractal properties (the fractal dimension coincides with the topological dimension);

$H=0.5$: "white" noise, with random alternation of high and low values; as a practical matter, this range is from 0.45 to 0.55;

$0.5<H<1.0$: As a rule, high values are followed by high values, and low values by low values; the closer the Hurst component is to 1, the more pronounced this pattern is; at a value of 1, there are no fractal properties (the fractal dimension coincides with the topological dimension);

$H>1$: various noises, including "pink" noise (vibrating, flicker noise, with a spectral density of $1/f$) and Brownian (red and "brown" with a spectral density of $1/f^2$).

In a simple sensorimotor reaction, the correlation dimensionality is 2.25 (three orthogonal exponents are needed to describe a model of a time series), and the Hurst component is equal to 0.75. When calculated according to a formula with cumulative amplitude, the Hurst component is 0.66. Recursive sequences are in evidence, and they are two stimuli long. They amount to 0.2 percent of all possible sequences. (The presence of such sequences indicates that there is no physical sense in assessing the fractal properties of sequences composed of two stimuli.) A direct calculation of sequences with between 3 to 64 stimuli gives a Hurst component equal to 0.86 (the variation from 0.75 might be due to the "rejection" of the Hurst component values for instances of two stimuli).

In the stage calling for complex sensorimotor reactions, red stimuli play a special role: there is to be no reaction to them. Moreover, an accidental break in the sequencing of the stimuli that are supposed to be reacted to, by the emission of one or more stimuli that are *not* supposed to be reacted to, causes both streams of stimuli–the one that calls for a reaction and the one that doesn't–to degenerate into noise. In other words, there are no consistent patterns in either stream of stimuli.

The second stage involves simple sensorimotor reactions, and the signal flow has a binary fractal structure. The correlation dimensionality is 1.57 (the fractal structure is two-dimensional, i.e., there are more recurrent components than in the stage calling for complex sensorimotor reactions), and the Hurst component for the dimensionality is equal to 0.43. The Hurst component, when calculated according to a formula with cumulative amplitude, is 0.50. Recursive sequences are in evidence, and they are two stimuli long. They amount to 0.5 percent of all possible sequences. A direct calculation of sequences with from 3 to 64 stimuli gives a Hurst component equal to 0.55.

Thus, although the sequences in this stage are not as chaotic as in the first stage, the succession of stimuli in its time flow should be perceived by the test subject as random (random events are a part of white noise; 0.55 is the upper limit of the range for white noise, and 0.43 is very close to its lower limit). As a result, test subjects perceive this sequence of simple sensorimotor reactions, with its signal flow structured in a binary way, as a sequence of stimuli which, over time, has a distinct succession of small groups of stimuli (higher-higher and lower-lower), while large groups of stimuli have the opposite tendency (higher-lower and lower-higher).

The *testing procedure* was as follows: A lap-top computer was put on the table in front of the child, who was told that he or she had to turn off the colored circles and signals on the monitor screen as quickly as possible by hitting the space bar. In the last stage, which evaluated inhibitory processes, the child had to press down on the bar for all stimuli except for the red circles.

Interpretation of the data involved the following parameters:

- the mean reaction time for all stimuli, taking into account the reaction symbol;
- the mean reaction time without regard to the reaction symbol $|dt|$;
- the mean reaction time for acoustic stimuli, taking into account the reaction symbol *dt*-sound;
- the mean reaction time for visual stimuli, taking into account the reaction symbol *dt*-color;
- the number of motor reactions in advance of the stimuli (false starts);
- the number of stimuli that were missed;
- in the third stage, the number of reactions to the red circles ("errors") was tabulated.

Accuracy can indicate a test subject's sensorimotor integration. In this case, it can be demonstrated by first, little variation in the response times; i.e. stability, and, second, coordination between the sensory stimuli as they are presented, and the responses to them, i.e. proper timing. Therefore, in order to assess the +6 accuracy of the sensorimotor reactions as a statistical measure of the sensorimotor reactions over time to stimuli of varying modalities, the accuracy value K was calculated according to this formula: $K= dt/ |dt|$

For statistical processing of the data, SPSS Statistics 21 was used.

Results

Comparison of the mean parameters for the levels of intelligence and creativity did not bring to light any distinctions between the children of the two age groups (see Table 1).

Table 1. Means and standard deviations for the creativity, intelligence and reflexometry parameters of children and teenagers

Parameters	**Children of 7–8 years-old**	**Teenagers of 12–13 years-old**
Nonverbal intelligence (%)	76.55± 13.20	74.51±12.41
Verbal creativity (scores)	70.18±23.79	64.21±21.14
Pictures creativity (scores)	81.70±20.31	95.22 ±24.53
The time of the simple sensorimotor reaction (mc)	303.96±71.93	291.54±58.64
Coefficient of the quality of the simple sensorimotor reaction	0.51±0.35	0.78±0.18*
Number of false starts in the simple sensorimotor reaction	16.55±9.75	7.88±6.72*
Number of false starts in the complex sensorimotor reaction	7.67±4.10	4.82±3.01*

Note. *=differences for p≤0.05 (Student's criterion) between children and teenagers

The older children, however, were more proficient at carrying out the tasks, whether they called for simple or complex sensorimotor reactions. They had a higher quality coefficient for the simple sensorimotor reactions and fewer false starts.

A regression analysis revealed that, in terms of the groups of test subjects, the independent variable of intelligence had only a slight impact on the dependent variable of creativity ($R^2=0.070$, $\beta=0.265$, and $p=0.049$). Since we used a linear regression analysis, R^2 was a percentage of the explained variation of the dependent variable, due to a change in the independent variable (7%); p=the significance level; and β=the regression coefficient.

Overall, and on a group basis, however, neither of these parameters was connected in any way with sensorimotor integration. For this reason, further statistical analysis was conducted separately for each of the test groups.

Using regression analysis, the data that was obtained on the 7–8 year-olds was examined first. For this age range, no differences were found between the boys and the girls in terms of intelligence.

At the same time, the level of intelligence for the 7–8 year-olds was directly connected with the response rate for the simple sensorimotor reactions (See Table 2).

Table 2. Regression analysis parameters showing the influence on the dependent variable *Level of Intelligence* for children of 7-8 years-old

Independent variables	**R^2**	**β**	**P**
Reaction time for simple sensorimotor reactions	0.110	-0.332	0.042
Reaction time to red circle for simple sensorimotor reactions	0.136	-0.369	0.023
Reaction time to green circle for simple sensorimotor reactions	0.160	-0.400	0.013
Reaction time to blue circle for simple sensorimotor reaction	0.109	-0.330	0.043
Reaction time to a sound for simple sensorimotor reaction	0.118	-0.133	0.035

All of the speed parameters for the simple sensorimotor reactions had an effect on the dependent variable “level of intelligence”: see the independent variable “reaction time for the simple sensorimotor reactions” (where R^2=0.110, β=0.332, and p=0.042). The reaction time was the time taken in absolute magnitude, ignoring the sign. Since the children could hit the space bar before the circles appeared, the reaction time could even be negative.

Accordingly, the independent variables “reaction time to the red circles for simple sensorimotor reactions” (where R^2=0.136, β=-0.369, and p=0.023); “reaction time to the green circles for simple sensorimotor reactions” (where R^2=0.160, β=-0.400, and p=0.013); “reaction time to the blue circles for simple sensorimotor reactions” (where R^2=0.109, β=0.330, and p=0.043); and “reaction time to sound for simple sensorimotor reactions” (where R^2=0.118, β=0.343, and p=0.035) all had an effect on the dependent variable “level of intelligence.”

For the 7 to 8 year-old children, there was no significant correlation between the levels of intelligence and creativity.

A radically different situation was observed with the young teenagers (the 12–13 year-olds), for whom there was a link between the level of intelligence and the level of creativity (where R^2=0.074, β=0.272, and p=0.043). On the other hand, neither of these parameters had any connection with the parameters of sensorimotor integration.

While the intelligence of the 7–8 year-old children intelligence was correlated with practically all of the parameters of the simple sensorimotor reactions, with the young teenagers there were no such connections. It should be emphasized that in neither group was there any connection of intelligence with the complex sensorimotor reactions, which, for children in these age groups, require great exertion and were poorly performed by all children.

Our findings demonstrate that creativity is connected with intelligence only in the 12–13 year-old age range (See Table 3). Before that age, such a close correlation between the two parameters is not observed. It can be hypothesized that the change in this situation with the 12–13 year-olds has something to do with a change in the connections between the neurons caused by the hormonal changes that begin during early adolescence.

Table 3. Regression analysis parameters showing the influence on the dependent variable *Level of Intelligence* for teenagers 12–13 years old

Independent variable	R^2	β	P
Creativity	0.074	0.272	0.043

The regression analysis showed that with the 7 to 8 year-old children, creativity is connected with the parameters of sensorimotor integration, not with the simple sensorimotor reactions, as was found with respect to intelligence, but in the stage where the signal flow has a bi-dimensional structure. Creative children sense the structure of the large blocks inside of which signals are presented in a random manner, and this allows them to react more effectively to the signals during this stage.

Table 4. Regression analysis parameters showing the influence on the dependent variable *creativity* for children 7–8 years old

Independent variable	R^2	β	P
Sex	0.100	–0.317	0.050
Reaction time to red circle for series with bi-dimensionally structured signal flow	0.149	–0.375	0.017
Reaction time to green circle for series with bi-dimensionally structured signal flow	0.106	–0.326	0.046
Reaction time to blue circle for series with bi-dimensionally structured signal flow	0.137	–0.369	0.022
Reaction time for complex sensorimotor reaction	0.131	–0.362	0.023

Accordingly, the independent variable "reaction time to the red circles in the series with the bi-dimensionally structured signal flow" (where R^2=0.149, β=–0.375, and p=0.017); "reaction time to the green circles in the series with the bi-dimensionally structured signal flow" (where R^2=0,106, β=–0.326, and p=0.046); "reaction time to the blue circles in the series with the bi-dimensionally structured signal flow" (where R^2=0,137, β=–0.369, and p=0.022); and "reaction time for the complex sensorimotor reactions" (where R^2=0.131, β=–0.362, and p=0.023) all had an effect on the dependent variable "level of creativity."

No connection was found between the parameters for creativity and sensorimotor integration for the young teenagers. The only connection, described earlier, was between the level of intelligence, assessed according to the Raven's test, and the level of creativity.

The next step was to conduct a factor analysis, starting with the findings obtained for the 7 to 8 year-old children. The Kaiser-Meyer-Olkin measure in this group was equal to 0.555, and the explained variation was 70.6 %. A five-factor solution was obtained. The first factor (18%) included the level of intelligence (0.538). The second factor (14.8%) included different parameters of the sensorimotor integration. The third factor (12.8%) was comprised of several parameters: creativity (–0.639), the reaction time (0.436), and the quality of the reaction in the stage with the complex fractal signal flow. Consequently, the higher the level of creativity in this age range, the shorter the reaction time and the better the performance. More creative children discern the structure of a sensory stream composed of the large blocks inside of which signals are presented in a random manner.

Another factor analysis was then conducted (the Kaiser-Meyer-Olkin measure was equal to 0.548, and the explaned variation was 68.5%), and a three-factor solution was obtained. The first factor (28.5% of explained variation) included the level of creativity (0.641).

The second factor included the absolute reaction time (0.875) and the quality coefficient (–0.846) at the stage with the simple sensorimotor reactions, and with the signals having a bi-dimensional fractal structure.

Thus, our findings showed that the relationship between the level of intelligence and the level of creativity is different in the two age groups. With the 7 to 8 year-olds, they are independent of each other, whereas with the 12 to13 year-olds, there is a weak but significant link between them.

The level of intelligence is connected with the speed of the reaction time for the sensorimotor integration only with the 7 to 8 year-olds. Later on (at the ages of 12–13), intelligence does not depend on the speed of the reaction to sensory stimuli.

With the 7 to 8 year-old children, the level of creativity predetermines the ability to detect the structure of a sensory stream that is organized in a complex way.

At the ages of 12–13, neither the level of creativity nor the level of intelligence is connected with the parameters of sensorimotor integration, but they themselves are interconnected. We can hypothesize that the correlation between creativity and intelligence changes as children grow older, in the same way that the relationship between thinking and speech changes up to the age of three. Prior to that age, they develop separately, and then they begin to influence each other, and each of them begins to develop more intensively, which fundamentally alters the cognitive capabilities of the child.

In exactly the same way, intelligence and creativity develop in children in relatively independent fashions, although depending in different ways on the parameters of sensorimotor integration: intelligence depends on its speed, and creativity is based on the ability to detect the structure of a sensory stream and to predict it. The changes connected with the maturing of the brain's structure, described earlier, lead to the integration of the ability to predict the structure of a signal flow and the ability to solve problems, which prepares a child who is entering puberty to solve problems at a more complex level and to adapt to adult life. This hypothesis needs to be proven, but it also suggests a line of further research.

Conclusions

Our study found that the level of intelligence for 7 to 8 year-olds was directly connected with their response rate for simple sensorimotor reactions; the better the quality of sensorimotor reactions, the higher the level of intelligence. But for these children, there was no significant correlation between the levels of intelligence and creativity.

A radically different situation was observed with young teenagers (the 12-13 year-olds). The study showed that there is a link between the level of intelligence and the level of creativity. On the other hand, neither of these parameters had any connection with the parameters of sensorimotor integration.

It can be hypothesized that the change in this situation with the 12-13 year-olds has something to do with a change in the connections between the neurons caused by the hormonal changes that begin during early adolescence.

Creative children sense the structure of the large blocks inside of which signals are presented in a random manner, and this allows them to react more effectively to the signals during this stage.

Thus, our findings show that the relationship between the level of intelligence and the level of creativity is different in the two age groups. With the 7 to 8 year-olds, they are independent of each other, whereas with the 12 to13 year-olds, there is a weak but significant link between them.

Limitations

We have assumed that the correlation between creativity and intelligence changes as children grow older, in the same way that the relationship between thinking and speech changes up to the age of three. We think that the changes connected with the maturing of the brain's structure lead to the integration of the ability to adapt to adult life. But our data does not allow us to prove this assumption. Research based on EEG data and visualization is needed to substantiate our hypothesis about how this maturation process might work both for creativity and intelligence.

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