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The structure of intuitive abilities and their relationships with intelligence and Openness to Experience

Agata Sobkow[a,*], Jakub Traczyk[a], Scott Barry Kaufman[b], Czeslaw Nosal[a]

[a] *SWPS University of Social Sciences and Humanities, Wroclaw Faculty of Psychology, Wroclaw, Poland*
[b] *University of Pennsylvania, Philadelphia, United States*

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ABSTRACT

In this study, we aimed to explore the relationships between intuitive abilities, intelligence (explicit cognitive ability) and personality. We found that intuition is not homogenous and there are three types of intuitive ability: *Coherence & Insight*, *Implicit Learning* and *Subjective Intuitive Abilities* that showed different patterns of relationships with explicit cognitive ability and personality. *Coherence & Insight* was predicted by intelligence and Openness to Aesthetics. *Implicit Learning* was weakly predicted by explicit cognitive ability. *Subjective Intuitive Abilities* was predicted only by Openness subscales: Fantasy, Action and Ideas. We demonstrated that intuition is not a unitary psychological construct but rather a complex cognitive conglomerate that incorporates diverse processes and mechanisms and these intuitive abilities are largely independent from psychometric intelligence.

1. Introduction

1.1. *The intelligence of the unconscious*

An increasing body of evidence points to the important role of implicit processes and intuition in social cognition (Greenwald et al., 2002), creativity (Dorfler & Ackermann, 2012; Pétervári, Osman, & Bhattacharya, 2016; Raidl & Lubart, 2001), expertise (Klein, 2011), and decision making (Bechara, Damasio, Tranel, & Damasio, 2005; Gigerenzer, 2008; Kahneman, 2011; but also see Newell & Shanks, 2014, for a critical perspective).

However, there is still little known about individual differences in intuitive abilities and their structure, and whether intuition is really 'the intelligence of the unconscious' (Gigerenzer, 2008; Kaufman, 2011). Is there one intuition or are there more intuitive abilities? Can people differ in the extent to which they use and benefit from using their intuitions? In this study, we aimed to explore relationships between intuitive abilities, intelligence and personality. Moreover, we attempted to test whether intuition is a unitary psychological construct or, alternatively, a complex cognitive conglomerate that incorporates diverse processes and mechanisms.

In intuition research there is no mainstream, golden standard or key theory. Rather, there are different paradigms and theoretical models which have their roots in very different traditions, such as decision making or Gestalt psychology. Because of this, it is difficult to provide a satisfactory universal definition of intuition (for a review, see Hodgkinson, Langan-Fox, & Sadler-Smith, 2008). The majority of researchers agree that intuition predominantly operates implicitly, without cognitive control and awareness. Nevertheless, other characteristics of intuitive processes (for example, complexity, time, and metacognition) are disputable and depend on the phenomenon studied. We decided to define intuition as *the ability to implicitly learn and detect cognitive patterns, and to subconsciously combine information in complex ways to make correct judgments based on fragmentary cues*.

Intuition is based on various cognitive processes and mechanisms. One of the most fundamental and evolutionarily old of these is the ability to spontaneously acquire complex patterns on the basis of the procedural memory (i.e., implicit learning; Reber, 1993). For example, Reber (1967, 1993) showed that people can unintentionally learn artificial complex grammars (in the Artificial Grammar Learning task; AGL). Despite an absence of explicit knowledge about the rules, participants performed above the chance level (recognizing items as compatible vs. incompatible with a specific grammar), indicating the existence of implicit learning. Evidence for implicit learning has also been provided using different paradigms, for example, detecting hidden covariations (Lewicki, 1986; Lewicki, Hill, & Czyzewska, 1992) and by using the Serial Reaction Time task (SRT, Kaufman et al., 2010).

Furthermore, intuitive abilities are likely to govern the integration of cues into a whole in a complex way, without aware access to this

* Corresponding author at: SWPS University of Social Sciences and Humanities, Wroclaw Faculty of Psychology, Ostrowskiego 30b, Wroclaw 53-238, Poland.
Email address: asobkow@swps.edu.pl (A. Sobkow)

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process. Individuals can correctly recognize things based on little information (Westcott, 1968a), or even subconsciously combine them in order to find new solutions (Bowers, Regehr, Balthazard, & Parker, 1990; Mednick & Andrews, 1967; Zander, Öllinger, & Volz, 2016). Even when people do not consciously know a solution, they can correctly guess which item is coherent with it (Bowers et al., 1990), and a solution to a problem can suddenly, and often surprisingly, appear in consciousness in the form of an insight. The latter effect is often accompanied by feelings of coherence, positive emotions and subjective certainty about the solution (Danek & Wiley, 2017; Nosal, 2011; Topolinski & Strack, 2009a, 2009b; Webb, Little, & Cropper, 2016). The ability to solve problems requiring insight is related to both convergent and divergent thinking, as well as to the ability to break a frame, allowing transitions between convergent and divergent thinking (DeYoung, Flanders, & Peterson, 2008). Furthermore, insightful individuals show greater diffuse activation in the visual cortex (which is related to more diffuse attention), and greater right hemisphere activation during resting-state EEG brain activity (Kounios et al., 2008; Kounios & Beeman, 2014), suggesting differences in brain structure (e.g., in gray and white matter volume; Smit, Boomsma, Schnack, Hulshoff Pol, & de Geus, 2012) between insightful and analytic individuals.

1.2. The structure of intuition

The structure of intuition is still unexplored. Hogarth (2010) even believes that '*the greatest challenge facing intuition researchers is to determine more precise ways of classifying different types of intuitive phenomena*' (p. 350).

Historically, intuition was rather treated as an homogeneous construct. For example, Carl Jung defined it as a '*psychological function that unconsciously yet meaningfully transmits perceptions, explores the unknown, and senses possibilities which may not be readily apparent*' (Hodgkinson et al., 2008, p. 5; Jung, 2014), and placed it at the second end of a dimension of 'sensing': the direct receiving of information through the senses. On the other hand, dual-process theories view intuition as being opposed to a rational and analytical mode of processing (Evans, 2008; Kahneman, 2011; Stanovich & West, 2000). Importantly, most dual-process models have regarded intuition as a unitary construct, although, as an exception to this, Epstein and Pacini (Epstein & Pacini, 1999; Pacini & Epstein, 1999) in their Rational- Experiential Inventory (REI) distinguished two types of intuition: *Experiential Ability* and *Experiential Engagement*. However, such a distinction does not include the different types of processing that might plausibly underlie intuition (as mentioned in previous paragraphs), and only differentiates perceived ability from the motivation to use it.

The dual-process tradition's explanation seems unsatisfactory and some researchers (e.g., Glöckner & Witteman, 2010; Gore & Sadler-Smith, 2011) have strongly emphasized the need for differentiation within both processes/systems. Nonetheless, their proposals are based only on theoretical considerations and have not been investigated empirically.

An alternative classification, based on questionnaire and psychometric approaches, has been proposed by Pretz and colleagues (Pretz et al., 2014; Pretz & Totz, 2007). Their distinction between Heuristic/Inferential, Holistic (Abstract and Big Picture) and Affective intuition is very promising. This differentiation is based on mechanisms described in the literature, has been confirmed empirically, and the different scales predicted different outcomes. For example, Holistic intuition has been shown to predict performance in clinical case studies, while Inferential intuition has predicted musicians' performance (Pretz et al., 2014). However, this work has been limited to self-report questionnaires, and has not included objective cognitive tests of intuition (akin to intelligence tests). Thus, these studies have tested the structure of intuitive preferences but not abilities.

Intuitive abilities are generally underestimated in the field of individual differences, and little attention has been paid to developing cognitive tests that measure individual differences in implicit, non-conscious abilities (for notable exeptions, see: Danner & Funke, 2017; Kaufman et al., 2010; Westcott, 1968b). Because of this, only a few studies have explored relationships between different measures of intuition, what makes the understanding of the structure of intuitive abilities difficult. Moreover, inconsistent results have been found in research that has employed tasks measuring intuition. For example, implicit learning and self-report scales measuring intuition correlate positively but weakly (Kaufman et al., 2010), and have been shown to correlate only when participants are in a positive mood (Cicero, Hicks, & King, 2015), only where participants are not aware of a rule (Woolhouse & Bayne, 2000). Also, sometimes no significant relationship between these measures has been observed (Pretz, Totz, & Kaufman, 2010). Moreover, other studies have either found no significant relationship between two tasks testing individual differences in implicit learning (the AGL and SRT tasks: Pretz et al., 2010; Salthouse, McGurthy, & Hambrick, 1999), or that this relationship is significant only when explicit instructions to search for a rule are provided (Gebauer & Mackintosh, 2007). Similar patterns of results (non-significant correlation with an intuition questionnaire) have also been observed for the Accumulated Clues Task (ACT), which measures the amount of information required by a participant to produce a correct hypothesis/guess (Langan-Fox & Shirley, 2003), and the Remote Associates Test (RAT), which measures the ability to activate a broad sematic network and experience insight (Barr, Pennycook, Stolz, & Fugelsang, 2015). Furthermore, even correlations between the most popular self-report scales measuring intuition (the Intuition scale of the Myers–Briggs Type Indicator based on Jung's theory [(MBTI Intuition, Myers, McCaulley, Quenk, & Hammer, 1998)], and the Rational Experiential Inventory [REI Experiential, Pacini & Epstein, 1999], grounded in the dual-process tradition) are either low or not statistically significant (Kaufman, 2009; Pretz & Totz, 2007).

Different patterns of correlations have been observed between these traditional self-report measures and more recent subscales of the Types of Intuition Scale proposed by Pretz et al. (2014). This questionnaire consists of four largely independent subscales: Holistic-Big Picture, Holistic-Abstract, Inferential, and Affective. On the one hand, the Affective scale correlates strongly with the REI Experiential dimension, and weakly with MBTI Intuition. On the other hand, the Holistic-Abstract scale is strongly related to MBTI Intuition, and weakly to the REI Experiential scale. The Inferential scale is moderately related to REI Experiential but not to MBTI Intuition, and the Holistic-Big Picture scale does not correlate with the MBTI Intuition and REI Experiential measures.

Generally, these results show that each test/questionnaire measures a separate aspect of intuitive processing. Therefore, we argue that there is a strong need to empirically distinguish between different types of intuitive abilities.

1.3. Relationships between intuitive abilities and intelligence

Much research on individual differences in cognitive abilities focuses on controlled and explicit tasks: working memory tests, verbal analogies, Raven's Matrices, etc. Nevertheless, the recent Dual-Process Theory of Human Intelligence (Kaufman, 2011) integrates dual-process theories of human cognition (Epstein, 2009; Evans, 2003; Kahneman, 2011) with the traditional approach to intelligence. It is argued that spontaneous and implicit cognition (related to intuition) is independent of, but complementary to, explicit cognitive ability or IQ (Danner, Hagemann, Schankin, Hager, & Funke, 2011; Kaufman, 2011; Nosal, 2011). Depending on task requirements, these two forms of cognitive abilities – explicit and implicit – dynamically interact, giving rise to intellectual functioning. Moreover, flexible switching between these two modes of cognition is likely to result in adaptive and optimal behavior.

Indeed, empirical studies have revealed that implicit learning is largely independent of general intelligence showing no, or very low, relationships between AGL and SRT tasks performance and scores on standard tests of general intelligence: the Wechsler Adult Intelligence Scale, Raven's Progressive Matrices and the Culture Fair Intelligence Test (Danner et al., 2011; Danner & Funke, 2017; Kaufman et al., 2010; Reber, Walkenfeld, & Hernstadt, 1991; Salthouse et al., 1999). Interestingly, Gebauer and Mackintosh (2007) found that under explicit, but not implicit, instruction, relationships between intelligence (fluid, crystalized, and memory) and implicit learning were significant.

On the other hand, implicit processes associated with insight seem to be more highly related to IQ. For example, previous studies have shown performance on the RAT to be moderately correlated with both nonverbal and verbal intelligence measures (Akbari Chermahini, Hickendorff, & Hommel, 2012; Barr et al., 2015; Lee, Huggins, & Therriault, 2014). These results are consistent with findings suggesting that moderate to high intelligence is a necessary condition for creativity (Jauk, Benedek, Dunst, & Neubauer, 2013; Karwowski et al., 2016). However, intelligence is not sufficient and other factors, such as Openness to Experience, also play a significant role, especially among people with higher IQs.

1.4. Relationships between intuitive abilities and Openness to Experience

Openness to Experience is one of the Big Five personality traits (McCrae & Costa, 1987). It consists of broad aspects such as intellectual curiosity, creativity, imagination and aesthetic interests, and is therefore the most likely trait among the Big Five to exhibit a relationship with intuition.

Indeed, previous research has demonstrated positive correlations between Openness and different self-report scales measuring intuition. However, the strength of these relationships depends on the scale used. Specifically, moderate to high relationships have been observed for the MBTI Intuition scale (Furnham, Dissou, Sloan, & Chamorro-Premuzic, 2007; Langan-Fox & Shirley, 2003; McCrae & Costa, 1989), moderate relationships for the Holistic-Abstract and Inferential measures (Pretz et al., 2014), low relationships for the REI Experiential measure (Witteman, van den Bercken, Claes, & Godoy, 2009) and non-significant relationships for the Affective and Holistic-Big Picture measures (Pretz et al., 2014).

Nevertheless, Openness to Experience is not a unitary construct (sometimes it is divided into two, four or six facets/factors) and relationships with intuition might depend upon the nature of any particular Openness component. For instance, Kaufman (2013) found that both the MBTI Intuition and REI Experiential measures loaded on the same factor as all the Openness to Experience subscales except Openness to Ideas, which was linked to more analytical and reflective measures.

Similar results have also been found in the case of implicit learning (Kaufman et al., 2010). Here, SRT performance was predicted by an Openness factor consisting of MBTI Intuition and all the Openness to Experience subscales except Openness to Ideas. However, in this study, correlation coefficients for SRT performance were only significant for Openness to Fantasy and Aesthetics (and both were very low). On the other hand, Norman et al. (Norman, Price, & Duff, 2006; Norman, Price, Duff, & Mentzoni, 2007) has found that another subscale – Openness to Feelings – predicts metacognitive fringe feelings related to implicit learning and awareness of a rule.

Interestingly, Langan-Fox and Shirley (2003) and Lee et al. (2014) found no significant correlations between either RAT and ACT performance and general Openness. However, people scoring high in Openness: Ideas (who are more intellectually curious) have been shown to correctly solve more triads in the RAT (Aitken Harris, 2004). In summary, Openness to Experience as a personality trait seems to be associated with intuition, but relationships are more pronounced for self-report scales. Results are mixed for cognitive tasks, and depend upon the specific aspects of Openness measured by subscales.

1.5. Research problem and hypotheses

This study aimed to investigate the structure of intuitive abilities. Based both on the mechanisms and processes described in the previous sections and the results of an exploratory study (Sobkow, 2014; Study 1), we expected to find a three-factor structure of intuitive abilities: 1. *Coherence & Insight*; 2. *Implicit Learning*; 3. *Subjective Intuitive Abilities*. The first factor (*Coherence & Insight*) should be associated with an ability to subconsciously combine information stored in long-term memory to make correct judgments based on fragmentary cues. In this case, the process of finding a solution is largely subconscious and uncontrolled. However, a correct solution can suddenly and surprisingly appear in consciousness in the form of an insight ('I know something, however I do not know the source of this knowledge'). The second factor (*Implicit Learning*) should be associated with the ability to spontaneously learn and detect cognitive patterns. In this case, both the process and its result could be present below the level of consciousness ('I do not know that I know something'). The third factor (*Subjective Intuitive Abilities*) refers to metacognitive feelings associated with intuitive abilities ('I think that I know something') and a preference for using intuition.

We also expected that different patterns of relationships between IQ and components of Openness to Experience would be observed. For example, intelligence (especially verbal intelligence) should be a major predictor of *Coherence and Insight*, but not *Subjective Intuitive Abilities*. On the other hand, rather than being related to aspects of IQ, *Subjective Intuitive Abilities* should be mainly predicted by different components of Openness to Experience. Finally, we hypothesized that, most correlations with *Implicit Learning* would be very low or even non-significant. Such a pattern of results would be important argument regarding the heterogeneity of intuitive abilities.

2. Method

2.1. Participants

Two hundred and six volunteers (140 females, M_{age} = 25.1 years, SD_{age} = 7.6, 68% students) participated in the study.[1] Participants were recruited via an announcement posted on an internet website and invited to a computer lab. All participants gave informed consent before the study, and received a financial reward (15 PLN = approximately 5 USD) as well as feedback regarding their results. The study was approved by the departmental Ethical Board at SWPS University of Social Sciences and Humanities. Data for two participants were excluded from analysis: one person participated twice, and one was a non-native Polish speaker.

2.2. Procedure

The experimental procedure was administrated in the computer lab and lasted approximately 90 min. Participants solved a set of tasks measuring different aspects of intuitive processing (the Remote Associ-

[1] Some of the data reported in this manuscript were previously used in an article focusing on the construction of a Polish version of the Remote Associates Test (Sobkow et al., 2016).

ates Test, the Serial Reaction Time task, the Artificial Grammar Learning task and Westcott's Test of Intuitive Abilities), explicit cognitive ability (Raven's Progressive Matrices and Verbal Analogies), and completed three questionnaires: the Myers–Briggs Type Indicator, the Sense of Intuition Scale, and the six NEO-PI-R Openness to Experience subscales.

2.2.1. *The Artificial Grammar Learning task (AGL)*

The AGL is one of the most commonly used tests of implicit learning. It consists of training and test phases. During the training phase participants were shown 18 letter strings in random order. Each string contained from 5 to 9 letters (e.g., VVTRVM) and appeared on a computer screen for 5 s. After each string, participants were immediately asked to recall that string. Letter strings were the exemplars of a complex grammar (Grammar A, from Dienes & Scott, 2005). After this phase, participants were informed about the existence of a rule and asked to assess (by pressing the A or K key on a computer keyboard within 7 s) if a new string was or was not an exemplar of the grammar. Half the strings ($N = 30$) fitted Grammar A (learned in the previous stage) and half fitted another rule (Grammar B, from Dienes & Scott, 2005) that was generated from the same letters but had a different structure.

2.2.2. *The Serial Reaction Time task (SRT)*

The SRT task was chosen as the second measure of implicit learning. This was taken from the Kaufman et al. (2010) study. In each trial, a black dot appeared on a computer screen in one of four possible locations. Participants were instructed to press a key corresponding to the location of the dot as quickly as possible. They were not informed about a rule whereby in 85% of trials the dot appeared in locations corresponding to Sequence A (1–2–1–4–3–2–4–1–3–4–2–3; where the numbers are labels for specific locations on the screen), and in 15% of trials the dot appeared in locations corresponding to Sequence B (3–2–3–4–1–2–4–3–1–4–2–1). The task was divided into nine blocks. In the first block (training), both sequences appeared with equal probabilities. In the following eight blocks, Sequence A appeared in 85%, and B in 15%, of trials. Each block contained 120 trials (960 trials in total). After each block, participants received feedback about their percentage of correct responses, and were informed that if it was lower than 92% they should try to increase their accuracy in the following blocks.

2.2.3. *The Remote Associates Test (RAT)*

The RAT is widely used in creativity and insight research. Because associations are strongly related to culture and language, we were unable to directly translate the original test triads proposed by Bowers et al. (1990). Instead, we used a Polish version of the test (RAT-PL; Sobkow, Polec, & Nosal, 2016). This consists of 17 trials whereby three words (triads) are each remotely associated with a solution (a fourth word). The triads appeared in the center of a computer screen for 30 s (or until a response was made), and participants were asked to type the solution or the phrase, “don't know”.

2.2.4. *Westcott's Test of Intuitive Abilities (WTIA)*

Westcott defined intuition as a process of reaching correct conclusions based on little information (Westcott, 1968a; Westcott & Ranzoni, 1963). Building on his ideas and research, a new perceptual inference task was designed (this task was tested in Study 1 of Sobkow, 2014). Ten photographs of people and buildings were selected that were highly recognizable by people in the population under study (i.e., Adolf Hitler, Marilyn Monroe, Albert Einstein, Nicolaus Copernicus, Pope John Paul II, Elvis Presley, Lech Walesa, the Statue of Liberty, Sydney Opera House, and the Pyramids of Giza and the Sphinx). Each of these pictures was covered by 64 black squares (an 8 × 8 matrix). After pressing a key, a random square disappeared revealing a fragment of the picture. Participants decided if they knew the answer or needed more cues. Similarly to Westcott's tasks, two indicators of intuitive processing were used: Recognition success and Information demand. Recognition success was defined as the percentage of correctly recognized pictures. Information demand was related to the mean number of revealed cues for each picture. However, it was recoded in such a way that a higher score corresponded to fewer cues, and hence the higher intuition.

2.2.5. *Raven's Advanced Progressive Matrices (RAPM)*

RAPM is the gold-standard for testing fluid intelligence (Raven, 2000). In each trial, participants were shown a 3 × 3 matrix of drawings (elements) with one missing element. They were asked to detect the rule and identify the element required to complete the matrix from the options presented below it. A shortened version was used but, similarly to the original procedure, participants were familiarized with the task by solving three easy items, after which, without any time constraint, they solved 18 test matrices which increased in difficulty.

2.2.6. *Verbal analogies*

The Verbal Analogies were chosen as a second measure of explicit cognitive ability (Baltes, Cornelius, Spiro, Nesselroade, & Willis, 1980). A set of 25 verbal analogies was used. Each item consisted of a pair of words that were connected via some type of relationship. To illustrate, for each pair of words, e.g., “fisherman” and “fish” (relationship: a fish is caught by a fisherman), a third word was displayed below (e.g., “goalkeeper”), and then four possible answers were provided (e.g., A: “playground”, B: “ball”, C: “fishing rod”, D: “match”). The task was to find the relationship in the first pair of words, and to use this relationship to the word displayed below to choose one of the four answers.

2.2.7. *The Myers–Briggs Type Indicator (MBTI)*

The MBTI is founded on Jung's theory of psychological types (Jung, 2014; Myers et al., 1998). This theory describes four functions by which people experience the world: sensation, intuition, feeling, and thinking. Despite its critics, the inventory has been widely used in intuition research (Kaufman et al., 2010; Langan-Fox & Shirley, 2003). We focused only on the Intuition scale, which in the Jungian theory is related to a global style of information-gathering (perceiving). Items in the scale focus on preference for creative solutions and imagery.

2.2.8. *The Sense of Intuition Scale (SoIS)*

The SoIS (Sobkow et al., 2016) was used as a second self-report measure of intuition. This scale consists of 10 items addressing the symptoms and manifestations of intuitive processing. For example: “It sometimes happens that I know something, but do not know the source of this knowledge” or “Usually, I need only a few tips to make a decision or find a solution to a puzzle”. Participants responded using a 4-point scale (1 - Strongly disagree, 4 - Strongly agree).

2.2.9. *The NEO-PI-R*

The six NEO-PI-R Openness to Experience subscales (Costa & McCrae, 2008) were used: Fantasy, Aesthetics, Feelings, Actions, Ideas and Values. Items from these subscales were interspersed with those from the SoIS and a 4-point unified response scale was used.

3. Results

3.1. Data pre-processing

3.1.1. The AGL task

Participants correctly classified 62% of letter strings, which was significantly higher than the 50% chance level, $t(203) = 15.801$, $p < 0.001$. Based on the proportion of hits and false alarms, *d'* (from signal detection theory, Wickens, 2001) was calculated. Descriptive statistics for the AGL *d'* measure are presented along with statistics for all other intuition measures in Table 1. The *d'* indicator was used as a measure of AGL task performance in all further analyses.

3.1.2. The SRT

The analysis procedure developed by Kaufman et al. (2010) was used. In the first step, all trials with incorrect responses (3.3%) or with reaction times longer than 3 *SDs* (1.7%) were removed for each participant. Next, we tested whether reaction times for trials compatible with Sequence A were significantly shorter than those for Sequence B. The results were binary coded (0 – no, 1 – yes) for each block separately. Indicators from Blocks 0 (training), 1 and 2 were not taken into account (implicit learning of a sequence was still in progress in these blocks). The sum of binary codes from Blocks 3 to 8 was the final measure of implicit learning for this task (see Table 1 for descriptive statistics).

3.2. Relationships between measures of intuition

Correlations among measures of intuition were rather weak (see Table 2), but many of them were statistically significant. For example, the number of correctly solved triads in the RAT correlated with both of the WTIA measures, as well as with the self-report measures of intuition. However, both the SoIS and MBTI Intuition scores correlated with WTIA Information demand, but not Recognition success. Interestingly, there was also a significant correlation between the two measures of implicit learning (the AGL and SRT tasks).

3.3. The structure of intuition

Based on an exploratory factor analysis performed in a previous study with similar measures of intuition (Sobkow, 2014, Study 1), three models of intuition were tested using confirmatory factor analysis: one, two and three factor models (see Table 3 for a model comparison). All measures of intuition were standardized and entered into structural models. Missing data were imputed using the full-information maximum likelihood approach in the laavan() package (Rosseel, 2012) run in the R statistical environment (R Core Team, 2014).

A comparison of fit indices revealed that the three factor structural model, with *Coherence & Insight*, *Implicit Learning* and *Subjective Intuitive Abilities,* exhibited the best fit to the data, $\chi 2$ (11) = 10.744, $p = 0.465$; CFI = 1.000; TLI = 1.009; AIC = 3995.174; BIC = 4074.809; RMSEA (*pclose*) < 0.001 ($p = 0.807$); SRMR = 0.038. What is more, in case of this model, all path coefficients were significant (or marginally significant: $p = 0.06$ for *d'* AGL). Interestingly, *Subjective Intuitive Abilities* was significantly related to the *Coherence & Insight* factor, but not the *Implicit Learning* factor (see Fig. 1 for more details).

3.4. Relationships between intuition and intelligence

To explore relationships between the intuitive ability factors and intelligence, a structural model (Fig. 2) with intelligence as a latent variable (defined by Raven's Progressive Matrices and Verbal Analogies) was tested. This model fitted the data well: $\chi 2$ (21) = 18.334, $p = 0.628$; CFI = 1.000; TLI = 1.027; AIC = 5045.976; BIC = 5155.474; RMSEA (*pclose*) < 0.001 ($p = 0.946$); SRMR = 0.039. Intelligence was significantly related to *Coherence & Insight* (0.77, $p < 0.001$), and *Implicit Learning* (0.54, $p < 0.01$), but not *Subjective Intuitive Abilities* (0.14, $p = 0.340$).

Additionally, to gain a deeper understanding of the relationships between intuition and intelligence, we estimated a model including the two latent variables (*Coherence & Insight* and *Implicit Learning*) that exhibited significant relationships with intelligence in the previous analysis. The measures of intelligence (Raven's Matrices and Verbal Analogies) were introduced as predictors in regressions explaining factors of intuition (see Fig. 3 for more details). This model was well fitted to data $\chi 2$ (10) = 4.187, $p = 0.938$; CFI = 1.000; TLI = 1.088; AIC = 3906.107; BIC = 3989.06; RMSEA(*pclose*) < 0.001 ($p = 0.989$); SRMR = 0.021. *Coherence & Insight* was significantly predicted by both Verbal Analogies ($b_3 = 0.43$, $p < 0.001$) and Raven's Matrices ($b_1 = 0.28$, $p < 0.01$). On the other hand, *Implicit Learning* was significantly predicted by Raven's Matrices ($b_2 = 0.39$, $p < 0.05$) but not Verbal Analogies ($b_4 = 0.15$, $p = 0.329$). However, Wald tests directly comparing these coefficients revealed no significant differences among coefficients b_1, b_2, b_3 and b_4 (all *ps* > 0.05) suggesting that in this study both Raven's Matrices and Verbal Analogies are likely to contribute equally to both intuitive ability factors.

3.5. Relationships between intuition, intelligence and Openness to Experience

To explore relationships between the intuitive ability factors and Openness to Experience, we tested a structural model with Openness as a latent variable (defined by Openness: Fantasy, Aesthetics, Feelings, Action, Ideas and Values) similarly to the model including Intelligence as a latent variable (Section 3.4). However, this model exhibited a poor fit to the data: $\chi 2$ (59) = 127.575, $p < 0.001$; CFI = 0.859; TLI = 0.814; AIC = 7132.299; BIC = 7281.614; RMSEA (*pclose*) = 0.075 ($p = 0.012$); SRMR = 0.062.

We decided to estimate the relationships between openness facets and intuition independently for each intuitive ability factor. Standard-

Table 1
Descriptive statistics for measures of intuition used in the study.

	N	Minimum	Maximum	Mean	*SD*	Cronbach's α
RAT- PL	204	0	17	6.90	3.90	0.791
WTIA recognition success	202	0.6	1	0.92	0.10	0.483
WTIA information demand	198	41.38	60.56	53.19	3.45	0.763
d' AGL	204	− 0.61	3.12	0.86	0.66	0.697
SRT	200	0	6	2.06	1.50	0.506
MBTI: intuition	204	2	25	13.55	5.19	0.818
SoIS	204	21	48	37.45	4.55	0.711

Note: RAT – Remote Associates Test, WTIA – Westcott's Test of Intuitive Abilities, AGL – Artificial Grammar Learning task, SRT – Serial Reaction Time task, MBTI – Myers-Briggs Type Indicator, SoIS – Sense of Intuition Scale.

Table 2
Pearson correlation matrix for relationships between all measures used in the study.

		1	2	3	4	5	6	7	8	9	10	11	12	13
1	RAT-PL	–												
2	WTIA recognition success	0.295***	–											
3	WTIA information demand	0.140*	0.122*	–										
4	*d'* AGL	0.090	0.046	0.093	–									
5	SRT	0.054	0.028	0.067	0.163*	–								
6	MBTI: intuition	0.142*	0.048	0.183**	0.004	− 0.026	–							
7	SoIS	0.172*	0.045	0.161*	− 0.016	− 0.152*	0.305***	–						
8	RAPM	0.370***	0.165**	0.100	0.173**	0.208**	0.071	0.011	–					
9	Verbal analogies	0.395***	0.229***	0.190**	0.137*	0.148*	0.171**	0.033	0.517***	–				
10	Openness: fantasy	0.092	− 0.02	0.262***	0.011	0.078	0.633***	0.460***	0.049	0.111	–			
11	Openness: aesthetics	0.101	0.125*	0.235***	0.037	0.079	0.401***	0.319***	− 0.048	0.016	0.413***	–		
12	Openness: feelings	0.028	− 0.063	0.100	− 0.063	− 0.124*	0.321***	0.270***	− 0.176**	− 0.056	0.476***	0.435***	–	
13	Openness: actions	0.090	0.023	0.105	− 0.032	− 0.064	0.375***	0.411***	− 0.015	0.059	0.273***	0.305***	0.260***	–
14	Openness: ideas	0.261***	0.165**	0.156*	− 0.044	0.095	0.386***	0.469***	0.194**	0.297***	0.426***	0.354***	0.173**	0.255***
15	Openness: values	0.212**	0.094	− 0.014	− 0.021	0.066	0.226***	0.219***	0.140*	0.305***	0.192**	0.193**	0.146*	0.291***

Note: RAT—PL – Remote Associates Test, WTIA – Westcott's Test of Intuitive Abilities, AGL – Artificial Grammar Learning task, SRT – Serial Reaction Time task, MBTI – Myers-Briggs Type Indicator, SoIS – Sense of Intuition Scale, RAPM- Raven's Advanced Progressive Matrices.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

Table 3
Summary of fit indices for the three structural models of intuitive abilities.

	One factor	Two factors	Three factors
	• WTIA information demand • WTIA recognition success • RAT–PL • *d'* AGL • SRT • MBTI intuition • SoIS	*Cognitive tests:* • WTIA information demand • WTIA recognition success • RAT–PL • *d'* AGL • SRT *Self-reports:* • MBTI intuition • SoIS	*Coherence & Insight:* • WTIA information demand • WTIA recognition success • RAT–PL *Implicit Learning:* • *d'* AGL • SRT *Subjective Intuitive Abilities:* • MBTI intuition • SoIS
χ^2	χ^2 (14) = 29.993; p = 0.008	χ^2 (13) = 19.520; p = 0.108	χ^2 (11) = 10.744; p = 0.465
CFI	0.704	0.879	1.000
TLI	0.556	0.805	1.009
AIC	4008.424	3999.950	3995.174
BIC	4078.104	4072.949	4074.809
RMSEA	0.075	0.050	< 0.001
(*pclose*)	(p = 0.124)	(p = 0.460)	(p = 0.807)
SRMR	0.060	0.052	0.038

ized measures of intuitive processing were summed according to the factor analysis: *Coherence & Insight* (RAT—PL, WTIA Recognition success, WTIA Information demand), *Implicit Learning* (*d'* AGL, SRT), *Subjective Intuitive Abilities* (SoIS, MBTI Intuition). Three independent hierarchical regression analyses were performed with the three intuition factors as dependent variables (see Table 4). Because the measures of intelligence and openness were significantly related (Table 2), the influence of intelligence was controlled by entering Raven's Matrices and Verbal Analogies as predictors in the first step of these analyses. In the next step, the six Openness to Experience subscales were entered into the models. This procedure significantly increased explained variances, but only for *Coherence & Insight* and *Subjective Intuitive Abilities*. *Coherence & Insight* was predicted by Openness: Aesthetics, however *Subjective Intuitive Abilities* was predicted by Openness: Fantasy, Action and Ideas.

4. Discussion

The present study demonstrated that intuitive ability is not a unitary construct, and we confirmed the existence of at least three types of intuitive ability: *Coherence & Insight*, *Implicit Learning* and *Subjective Intuitive Abilities*.

4.1. Coherence & Insight

People obtaining higher scores on the *Coherence & Insight* factor found more correct solutions on the RAT and WTIA, so they were more able to make correct judgments based on fragmentary cues, activate broad semantic networks and experience insight. Further, they also needed fewer cues to find solutions. We argue that this type of processing could be related to both Holistic and Inferential intuitions (Pretz et al., 2014). On the one hand, these tasks probably demanded the activation of very broad associations and the taking of a 'Big Picture' view of a situation that could help coherently synthesize cues/information into a whole. On the other hand, in the case of WTIA, participants are also likely to have used the 'intuitive leaps' that are characteristic of Inferential intuition and expertise. However, these assumptions need further empirical investigation, preferably using The Types of Intuition Scale (Pretz et al., 2014).

Also, *Coherence & Insight* performance was predicted by measures of explicit cognitive ability (especially Verbal Analogies) and Openness: Aesthetics. It is worth noting that in both tasks – the RAT and WTIA – participants should use previous knowledge and experience to find correct solutions. Because of this, a broader vocabulary (related to Verbal Analogies) and greater interest in music or architecture (related to the Openness: Aesthetics facet) might have made this task easier and a correct solution more easily available. We tried to minimize these effects by using objects that were highly recognizable in the studied population, however, future studies should try to construct tasks measuring coherence and insight mechanisms with novel and abstract objects. We expect that in such cases relationships with explicit cognitive ability and openness would be even weaker and probably non-significant.

4.2. Implicit Learning

The second factor obtained in the study was related to the ability to spontaneously acquire complex patterns – *Implicit Learning*. This type of intuitive ability consists of two tasks: Artificial Grammar Learning (verbal) and the Serial Reaction Time task (nonverbal), that weakly but significantly correlated with each other. This factor was not significantly related to either *Coherence & Insight*[2] or *Subjective Intuitive Abilities*. Moreover, performance on implicit learning tasks was predicted by intelligence (especially by Raven's Matrices), although this effect was weak.

At first glance the last mentioned effect might appear unsatisfactory, however, it is consistent with previous research showing low and unstable relationships between implicit learning and measures of explicit cognitive ability (Danner et al., 2011; Danner & Funke, 2017; Gebauer & Mackintosh, 2007; Kaufman et al., 2010; Pretz et al., 2010; Reber, 1993; Reber et al., 1991; Salthouse et al., 1999; Woolhouse & Bayne, 2000; Xie, Gao, & King, 2013). This might be a consequence of the low reliability of the implicit learning tasks. However, although the reliability coefficients were not yet satisfactory (α_{AGL} = 0.697, α_{SRT} = 0.506), they were comparable to, or even higher than, those reported in other studies for both AGL and SRT tasks (Danner & Funke, 2017; Kaufman et al., 2010; Reber et al., 1991; Salthouse et al., 1999). Moreover, Reber et al. (1991) suggested that, because it is evolutionarily old, implicit learning '*ought to display tighter distributions in the population when compared with explicit systems; fewer individual differences and smaller population variances*' (p. 888).

Nevertheless, how might the present positive relationship between *Implicit Learning* and explicit cognitive ability as measured by Raven's Progressive Matrices be explained? We argue that this test of nonverbal fluid intelligence measures two types of processing: sequential (analytical and analogical) and gestalt-like (perceptual) processing, both of which play a significant role in solving matrices (Hunt, 1974; Mackintosh & Bennett, 2005). The gestalt-like component might be associated with the spontaneous complex pattern recognition processes which are related to intuitive abilities. However, this positive relationship was very weak and it can be concluded that *Implicit Learning* is

[2] However, the Pearson's correlation between the *Implicit Learning* and *Coherence & Insight* used in the regression analyses described in Section 3.5 (standardized measures of intuitive processing summed according to the factor analytic results) approached significance, r = 0.114, p = 0.106 (two-tailed), suggesting that this relationship might become significant in studies with larger samples.

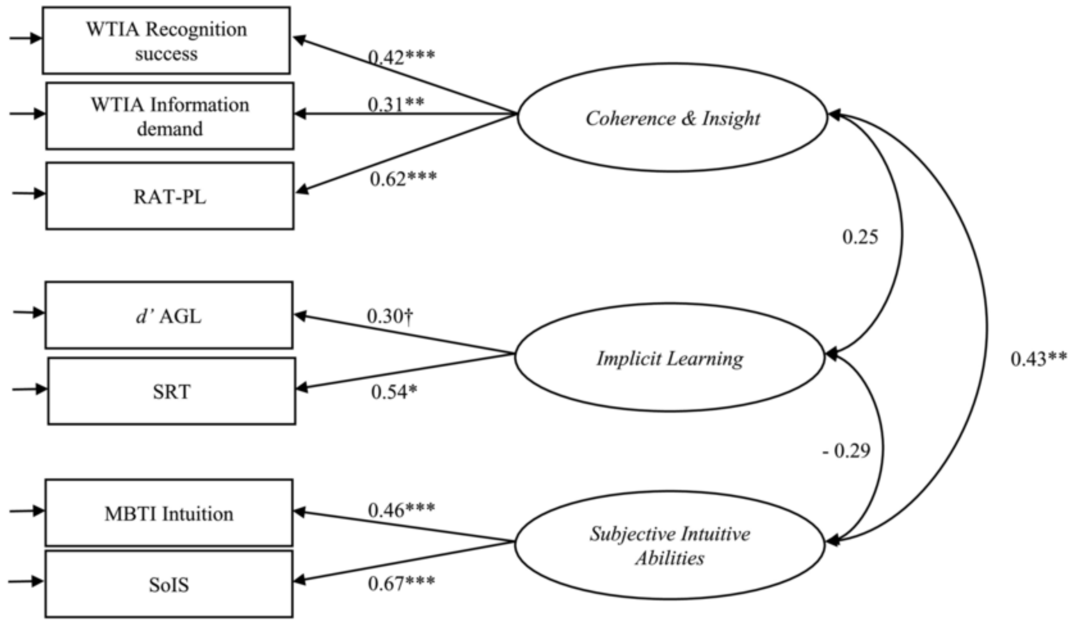

Fig. 1. The three factor structure of intuitive abilities.*Note:* Standardized path coefficients. †p = 0.06, *p < 0.05, **p < 0.01, ***p < 0.001; χ^2 (11) = 10.744, p = 0.465; CFI = 1.000; TLI = 1.009; AIC = 3995.174; BIC = 4074.809; RMSEA (*pclose*) < 0.001 (p = 0.807); SRMR = 0.038.

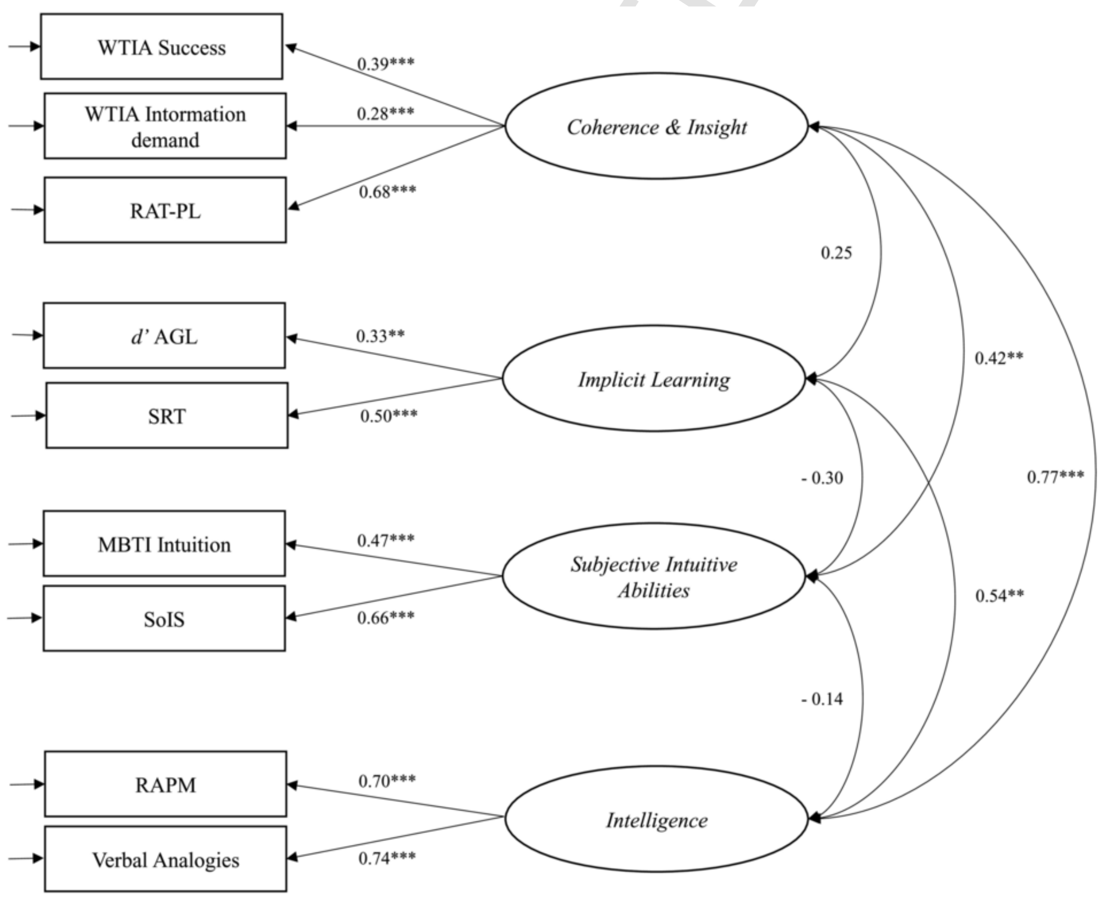

Fig. 2. The relationships among three factor structure of intuitive abilities and a latent factor of intelligence.*Note:* Standardized path coefficients. *p < 0.05, **p < 0.01, ***p < 0.001; χ^2 (21) = 18.334, p = 0.628; CFI = 1.000; TLI = 1.027; AIC = 5045.976; BIC = 5155.474; RMSEA (*pclose*) < 0.001 (p = 0.946); SRMR = 0.039.

largely independent of psychometric intelligence, which is consistent with both empirical results and the Dual-Process Theory of Human Intelligence (Kaufman, 2011).

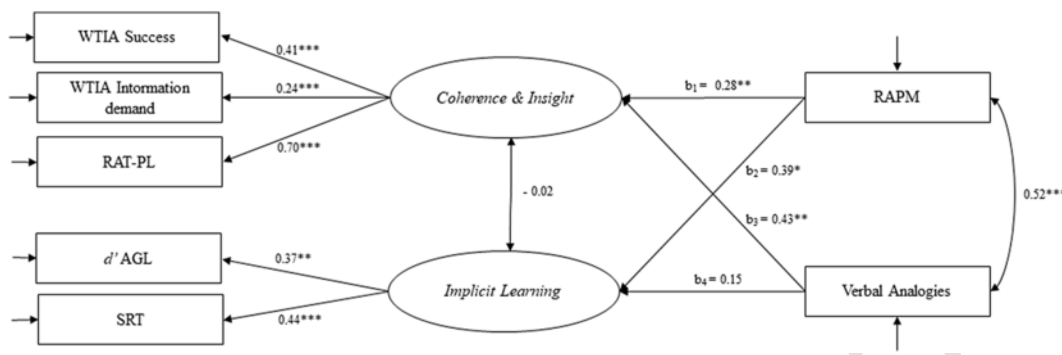

Fig. 3. Relationships between the two intuitive ability factors (*Coherence & Insight* and *Implicit Learning*) and the two measures of intelligence (Raven's Matrices and Verbal Analogies).*Note:* Standardized path coefficients. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$; χ^2 (10) = 4.187; $p = 0.938$; CFI = 1.000; TLI = 1.088; AIC = 3906.107; BIC = 3989.06; RMSEA (*pclose*) < 0.001 ($p = 0.989$); SRMR = 0.021.

4.3. Subjective Intuitive Abilities

The Subjective Intuitive Abilities consisted of two questionnaires: the Intuition Scale from Myers–Briggs Type Indicator and the Sense of Intuition Scale. Similarly to previous studies (Furnham et al., 2007; Kaufman, 2013; Langan-Fox & Shirley, 2003; McCrae & Costa, 1989; Pretz et al., 2014; Witteman et al., 2009), these self-report measures of intuition were positively related to the Openness to Experience personality trait. However, while there were significant correlations with all of the Openness to Experience subscales, only the Fantasy, Action, and Ideas subscales significantly predicted *Subjective Intuitive Abilities* when all the Openness to Experience subscales and explicit cognitive ability were included in a regression model. These results suggest that higher preferences for intuition might be observed among people who: (a) like daydreaming and have very vivid and creative mental imagery: (b) are open to new experiences such as seeking new places and eating unusual food, and; (c) are intellectually curious (e.g., enjoy puzzles and philosophical disputes). Importantly, *Subjective Intuitive Abilities* had a moderate positive relationship with *Coherence & Insight* but not with *Implicit Learning*. It can be argued that, because people have limited access to their unconscious and subconscious processes, self-report measures should not be used as a proxy for general intuitive abilities. Nevertheless, such a pattern of results – the gap between performance (e.g., cognitive tests) and self-report measures – has been observed for many psychological constructs; for example, risk preference (Frey, Pedroni, Mata, Rieskamp, & Hertwig, 2017), creativity (Gajda, Karwowski, & Beghetto, 2016; Plucker & Makel, 2016) and self-control (Duckworth & Kern, 2011).

4.4. Concluding remarks

Our study shed new light on the study of cognitive abilities. We showed that: 1) it is possible to measure individual differences in intuitive abilities; 2) intuition is not homogeneous and there are at least three types of intuitive ability; 3) intuitive abilities (especially *Implicit Learning*) are largely independent of psychometric intelligence; 4) intuitive abilities are related to the Openness to Experience, however relationships are particularly significant for self-report measures (*Subjective Intuitive Abilities*).

We argue that there are at least three types of intuitive ability. In this study, participants completed four cognitive tasks and two questionnaires relating to intuition. Further studies using different paradigms and measures, for example, the Iowa Gambling Task (Bechara et al., 2005), statistical learning (Siegelman & Frost, 2015), Diads of Triads (Bowers et al., 1990), magic tricks (Danek & Wiley, 2017), and the Types of Intuition Scale (Pretz et al., 2014) should be conducted to confirm the proposed structure of intuitive abilities.

Moreover, it is plausible that, similarly to psychometric intelligence (Cattell, 1963), intuition has two general forms: fluid and crystalized. Our study tested more basic and elementary mechanisms that could be categorized as 'fluid intuition' – a human potential that, through experience and practice might develop, into 'crystalized intuition', for example, in the form of tacit knowledge/expertise (Kahneman & Klein, 2009; Kaufman, 2011; Pretz et al., 2014) or domain-specific processes/outcomes (Gore & Sadler-Smith, 2011). We suggest that the process of gaining expertise might be faster and easier for people with higher intuitive abilities.

Finally, studies showing predictive validity are crucial to understanding the importance of individual differences in intuitive abilities. For example, similarly to Danner et al. (2011), it would be useful to investigate the degree to which intuitive abilities are able to predict superior decision making and personal/academic success independently of psychometric intelligence and personality, and how explicit and implicit cognitive ability interact in different tasks/situations (Kaufman, 2011).

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Table 4
Three independent hierarchical regression analyses with the three intuition factors (*Coherence & Insight*, *Implicit Learning*, *Subjective Intuitive Abilities*) as dependent variables.

Step		*Coherence & Insight*						*Implicit Learning*						*Subjective Intuitive Abilities*	
		b	*z*	*p*	*pr*	R^2	ΔR^2	*b*	*z*	*p*	*pr*	R^2	ΔR^2	*B*	*z*
1	RAPM	0.14	1.82	0.066	0.13			**0.21**	**2.66**	**0.008**	**0.18**			− 0.02	− 0.24
	Verbal analogies	**0.32**	**4.26**	< **0.001**	**0.30**	0.170***		0.08	0.98	0.329	0.07	0.068**		0.14	1.68
2	Openness: fantasy	0.03	0.33	0.745	0.02			0.12	1.37	0.170	0.10			**0.47**	**8.97**
	Openness: aesthetics	**0.21**	**2.79**	**0.005**	**0.19**			0.16	2.06	0.039	0.14			0.09	1.69
	Openness: feelings	− 0.05	− 0.63	0.530	− 0.05			− 0.17	− 2.14	0.032	− 0.15			− 0.01	− 0.25
	Openness: action	0.02	0.24	0.814	0.02			− 0.09	− 1.22	0.225	− 0.09			**0.27**	**5.56**
	Openness: ideas	0.10	1.37	0.172	0.10			− 0.08	− 0.98	0.325	− 0.07			**0.23**	**4.31**
	Openness: values	− 0.04	− 0.53	0.599	0.04	0.236	0.066*	− 0.01	− 0.13	0.896	− 0.01	0.108	0.04	0.03	0.59

Note: RAPM – Raven's Advanced Progressive Matrices, pr – partial correlation coefficient; **p* < 0.05, ***p* < 0.01, ****p* < 0.001.

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