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EXECUTIVE FUNCTION OF SHIFTING: FACTORIAL STRUCTURE AND RELATIONS TO PERSONALITY AND INTELLIGENCE DOMAINS

Danka Purić
Department of Psychology, University of Belgrade
Čika Ljubina 18-20, 11000 Belgrade, Serbia
dpuric@f.bg.ac.rs

Maša Pavlović
Department of Psychology, University of Belgrade
Čika Ljubina 18-20, 11000 Belgrade, Serbia
masha.pavlovic@gmail.com

Abstract

This study explores the executive function of shifting and its relation to intelligence and personality constructs. We administered four different cognitive tasks that are presumed to be markers of shifting. The exploratory factor analysis yielded a one factor solution underlying these tasks. Significant correlations between this factor and measures of intelligence were found. In addition, the shifting factor showed a significant relation to neuroticism trait and the direction of this relation implied that greater neuroticism corresponded to greater shifting costs. Our findings are in contrast with the early conceptions of executive functions as completely unrelated to intelligence and also some contemporary research showing that shifting factor is unrelated to intelligence measures, but support the findings that shifting ability is correlated with Gf. More importantly results of our study shed new light on the nature of the trait neuroticism, implying that executive functions might play a significant role in determining people's general emotional vulnerability.

Key words: executive functions, shifting, intelligence, neuroticism

Executive Functions

Executive functions are usually defined as general purpose mechanisms that modulate the operation of various cognitive subprocesses and thereby regulate the

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dynamics of human cognition (Miyake, Friedman, Emerson, Witzki, Howerter & Wager, 2000). These are the functions that control and regulate thought and action (Friedman, Miyake, Corley, Young, DeFries & Hewitt, 2006). Executive functions have been studied within the Allan Baddeley's model of working memory (1986) in which they were identified with the central executive component responsible for the control and regulation of cognitive processes. Additionally, the Supervisory Attentional System (SAS), proposed by Norman and Shallice (1986), which is responsible for endogenous control of action sets or schemas, has also been equated with executive functioning (e.g. Mayr & Kliegl, 2000; Miyake et al., 2000).

Research on executive functions started with the neuropsychological studies of patients with frontal lobe damage who had problems in the control and regulation of everyday behavior (e.g. Phineas Gage). Later on, it was shown that these types of patients also demonstrated impairments on complex executive tasks such as the Wisconsin Card Sorting Test (WCST) or Tower of Hanoi (TOH) (e.g. Milner, 1963; Shallice, 1982). Although being widely used in clinical research on executive functioning, these traditional executive tests (i.e. WCST, TOH) are considered to be problematic measures of executive functions by many authors today (Friedman et al., 2006; Miyake et al., 2000). Generally, the authors claim that these tests lack construct validity, that they often demonstrate poor reliability and contain a good share of variance unrelated to executive functioning. Due to these problems, contemporary approach to studying executive functions has focused on the use of concrete, simple and well defined cognitive tasks. Some of these tasks are assumed to tap separable executive functions and it is believed that they involve cognitive requirements that are better understood and analyzed in the literature than those in complex neuropsychological tasks (Friedman et al., 2006).

One of the most frequently postulated executive mechanisms is the executive function of shifting. The present research represents an attempt to reassess the factorial structure of the shifting function and to reinvestigate its relation to intelligence constructs. Most importantly, this study is an endeavor to explore and establish the relationship between executive functions and different personality traits.

Shifting Ability

The *Shifting function* represents the ability to efficiently shift back and forth between multiple tasks, operations or mental sets (Miyake, Emerson, Padilla & Ahn, 2004). Cognitive tasks that tend to tap into the shifting ability are typically composed of two pure-task blocks (which require participants to perform only one task per block) and one alternating-task block (where participants need to alternate between two different tasks from trial to trial). The difference between the average completion time of the alternating task block and average completion time for the pure-task blocks is defined as a shift cost and represents a measure of the shifting ability (Miyake et al., 2000).

The plus-minus task (Jersild, 1927), the number-letter task (Rogers & Monsell, 1995), the local-global task (Miyake et al., 2000), the color-shape task (Miyake et al., 2004) and the category-switch task (Mayr & Kliegl, 2000) are some of the most frequently used cognitive tasks in studying the shifting function. It has been shown that shifting costs across different combinations of such tasks seem to share a substantial common component implying the underlying existence of the distinctive shifting ability (Kray & Lindenberger, 2000; Friedman et al., 2006; Miyake et al., 2000). Rogers and Monsell (1995) showed that shifting cost measure does not depend on the difficulty of subtasks that define these diverse cognitive tasks.

Regarding the theoretical basis of the shifting ability, few potential explanations exist. One of them implies that the shifting function is based on endogenous control that resolves the competition between different subtasks which is elicited by automatically activated schemas upon stimuli encounter (Mayr & Kliegl, 2000; Miyake et al., 2000). This means that the shifting function involves disengagement of an irrelevant task set and the subsequent active engagement of a relevant task set. Another potential explanation of the shifting function implies that shifting may not be a simple reflection of the ability to engage and disengage appropriate task sets, but may instead involve the ability to perform a new operation in the face of proactive interference or negative priming (Allport & Wylie, 2000). Finally, Mayr and Kliegl (2000) suggest that long term memory retrieval of the subtask rules and goal (i.e. what needs to be done in the forthcoming trial) represents a crucial component of the shifting function.

Correlates of the Shifting Ability

It has been shown that many patients with frontal lobe damage and corresponding deficits in executive functioning show normal intelligence as measured by traditional psychometric tests such as the Wechsler Adult Intelligence Scale (WAIS) (e.g. Brazzelli, Colombo, Della Sala & Spinnler, 1994; Damasio & Anderson, 1993). At the same time, it is deficits in planning, decision making and generally regulating everyday behavior which are considered hallmarks of intelligence (e.g. Sternberg, 1988). To resolve this paradox, Duncan, Burgess and Emslie (1995) proposed that frontal patients show deficits in fluid intelligence (Gf), but not in crystallized intelligence (Gc). However, Friedman et al. (2006) demonstrated that different measures of intelligence (more precisely Gf, Gc and WAIS IQ) show similar patterns of relations to different executive functions, suggesting that Gf may not necessarily be more associated with executive functions than other measures. Interestingly, shifting ability did not show a relation to any of the three constructs – crystallized, fluid or general intelligence (Friedman et al., 2006). The authors suggested that not all executive functions were related to the psychometric construct of intelligence and that traditional measures of intelligence were missing some fundamental supervisory functions. However, Salthouse found a high correlation between shifting and

Gf in aging adults (Salthouse, Fristoe, McGuthry & Hambrick, 1998). Several studies also demonstrated a significant relation between performance on WCST which according to Miyake et al. (2000) taps shifting, and WAIS IQ (Ardila, Pineda & Rosselli, 2000; Arffa, 2007). Inconsistency in these findings encouraged us to re-examine the relationship between the shifting ability and intelligence.

Very few studies have dealt with personality correlates of executive functions. One study, using the Big Five as a personality model, showed Openness to be correlated with Fluency and Extraversion to Vigilance (Unsworth, Miller, Lakey, Young, Meeks, Campbell & Goodie, 2010), while another study demonstrated that a composite measure of executive functions was related to Openness, Agreeableness and Neuroticism (Williams, Suchy & Kraybill, 2010). To our knowledge, the executive function of shifting has not yet been connected with any personality measures. However, a number of psychopathological states, such as ADHD, OCD, autism, schizophrenia and personality disorders, were demonstrated to be accompanied by executive impairment (Coolidge, Thede & Jang, 2004; Gibbs, 1996; Hutton, Puri, Duncan, Robbins, Barnes & Joyce, 1998; Pennington & Ozonoff, 1996) and personality variables presumably moderate these relationships.

Some authors suggest that a single factor underlies various types of psychological disorders (Knežević, Savić, Kutlešić, Jović. Opačić i Šaula, 2012). The factor is best conceptualized as a continuum of maladjustment in the general population, that is, as a broad personality trait of psychosis-proneness or Disintegration. We presumed that Disintegration, as a compound measure of different aspects of problematic cognitive functioning would have a positive correlation with the shifting costs.

Overview of Aims

One of the purposes of the present study was to assess the factorial structure of four different tasks that are presumed to be markers of shifting. We believed that a unique shifting mechanism underlies the different tasks that were selected to cover as many stimuli domains as possible. Additionally, we wanted to retest the hypothesis of lack of correlation between the shifting ability and intelligence. Finally and most importantly, we wanted to explore and establish a hypothesis of interrelations between executive function of shifting and Big Six (Big Five+Disintegration) personality traits. To our knowledge, there are still no published studies dealing with this question.

METHOD

Participants

A total of 62 undergraduate psychology students from the University of Belgrade, Serbia participated in the study in exchange for partial course credits.

Materials, Design and Procedure

Shifting measures. All participants completed four tasks that were presumed to tap the shifting executive function. Task administration was computerized, with stimuli appearing on the computer screen and participants giving answers through the keyboard. The following tasks were used:

Plus-minus task. This task was adapted from Miyake et al. (2000) and it required participants to solve simple mathematical equations. In the first block, participants were required to add number three to one of the randomly preselected two-digit numbers. They answered by choosing the correct answer between two offered solutions presented simultaneously with the equation on the computer screen. In the second block they subtracted number three from the target numbers. Each of the two blocks had 24 trials. In the third, crucial block, participants were randomly presented with 48 addition and subtraction equations, which demanded constant shifting between these two operations. The trials in this block were pre-randomized so that half of them required shifting between these two mathematical operations and half did not. Participants gave their answers via the keyboard and the next stimulus was presented after an interstimulus interval (ISI) of 150ms.

Number-letter task. The number-letter task was taken from Miyake et al. (2000) with minor adaptations. A number-letter pair (e.g. 4F) was presented to participants in one of the four quadrants of the computer screen (the numbers and letters used were: 2, 3, 4, 5, 6, 7, 8, 9 and A, E, F, G, I, K, R, U). The participants' task was to indicate whether the number was odd or even if the number-letter pair was presented in the upper quadrants, and whether the letter was a consonant or a vowel if the number-letter pair was presented in the bottom quadrants of the screen. In the first block of 32 trials, the pairs only appeared in the top two quadrants, and in the second block of 32 trials only in the bottom quadrants. In the third block, 128 pairs appeared in all quadrants in a clockwise rotation sequence, so that half of the trials required participants to switch between mental sets and half did not require this switch. Participants gave their answers via the keyboard and the next stimulus was presented after an ISI of 150ms.

Local-global task. The local-global task was adapted from Miyake et al. (2000). In this task the participants were presented with a geometrical figure in which the lines of the "global" figure were made out of smaller, "local" figures (e.g. a "global" triangle is composed of "local" circles; see Figure 1). Depending on the color of the figure (black or red), the participants needed to indicate the number of lines (one for a circle, two for an X, three for a triangle and four for a square) of the "global" (black) or the "local" (red) figure. In the first block of 24 trials, only "global" figures were presented and in the second block of 24 trials there were only "local" figures. In the third block, 48 trials were pre-randomized so that half the trials required shifting between mental sets. Participants gave their answers through the keyboard and the next stimulus was presented 500ms after participants' response.

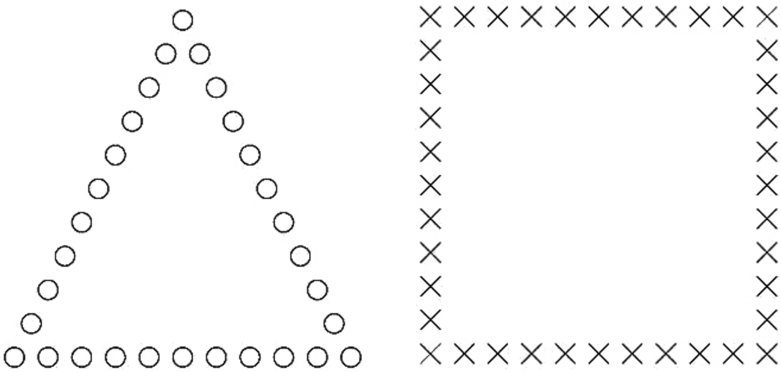

Figure 1. Two examples of Navon figures used as stimuli in the local-global task. On the left side the global figure is a triangle, while the local figures are circles; on the right side the global figure is a square, while the local figures are Xs.

Lower case-capital letters task. The lower case-capital letter task was created by the authors for this research. We wanted to include and construct an additional task in order to cover as diverse stimuli type and operations performed in pure task block as possible. Additionally, we were interested in testing the validity of this new task as a marker of shifting ability. In this task, participants were presented with letter sequences of nine randomly chosen letters, half of which contained a target letter. Depending on the size of the letter sequences (lower case or capital letters), participants needed to indicate whether the letter **c** (lower case letters) or **D** (capital letters) was present in the sequence. In the first block of 24 trials, only lower case letter sequences were presented, and in the second block of 24 trials only capital letter sequences were presented. In the third block, 48 trials were pre-randomized so that half of them required shifting between these two target searches. Of course, in the third block only one of the target letters was present in any of the sequences. Participants gave their answers by pressing the keyboard, and the next stimulus was presented 500ms after participants' response.

The testing took place in one session that lasted approximately 45 minutes. The order of the tasks was fixed for all participants (plus-minus task, number-letter task, local-global task and lower case-capital letter task). All tasks had an example and a few practice trials. Shifting costs were computed as the difference between average RTs for the mixed task trials and the average RTs for the two pure task trials (Miyake et al., 2000).

Personality measures. For some of the participants, personality and intelligence measures were available, being that, in order to gain course credit, the students have filled in a number of personality inventories and a battery of intelligence tests. The personality measures used in this research included the Big Five personality traits (measured by the Revised NEO Personality Inventory in Serbian language, Knežević, Džamonja-Ignjatović & Đurić-Jočić, 2004) and a measure of Disintegration, a general predisposition for psychotic-like behavior and many aspects of human maladjustment and psychopathology (measured by Delta Personality inventory, Knežević i sur., 2012).

Intelligence measures. The intelligence battery given to participants was the KOG9 battery, created within the Cybernetic model of cognitive functioning and intended for a precise and comprehensive assessment of intellectual capacities in adults (Lazarević & Knežević, 2008). It comprises nine tests, three for each of the three proposed factors:

Perceptive processing. This is a factor of perceptive identification and discrimination; tests used to assess it are the object matching test IT1, the hidden figure test CF2 and the form matching test GT7.

Serial processing. This is a factor of identification of denotative meaning of verbal symbols; tests used to assess this factor are the synonym - antonym test AL4, the analogy test AL7 and the synonym test GSN.

Parallel processing. This factor refers to the eduction of spatial relations, and the tests used to tap it are the visual spatialisation test S1, the three-dimensional space relations test IT2 and the non-verbal relation eduction test D48 originally intended as a general intelligence test.

RESULTS

Transformations and Outlier Analysis

For all of the tasks, only correct trials longer than 200ms were analyzed. Further, a double (between and within subjects) trimming procedure was performed. Based on overall between-subjects mean values and standard deviations for each task and subtask, critical values were determined and all outliers were replaced with these critical values (400ms and 3500ms for the plus-minus task, 200ms and 3000ms for the number-letter task, 300ms and 3500ms for the local-global task and 300ms and 3000ms for the lower case-capital letter task). Within subjects trimming procedure included replacing, for each participant and for each subtask, any RTs that were more than three SDs away from that participant's mean RT for the given subtask with the three SDs value.

Descriptive Statistics

A summary of descriptive statistics for all of the used measures is presented in Table 1. Shifting cost measures generally had satisfactory skewness and kurtosis.

Table 1. Descriptive statistics for shifting costs (in ms), intelligence and personality measures

Measure	*N*	Mean (SD)	Skewness (SE Skewness)	Kurtosis (SE Kurtosis)
Plus-minus shifting cost	62	151(144)	-0.04(0.30)	-0.03(0.60)
Number-letter shifting cost	62	417(230)	0.32(0.30)	0.30(0.60)
Local-global shifting cost	62	707(227)	1.00(0.30)	2.01(0.60)
Lower case-capital letter shifting cost	62	244(150)	0.53(0.30)	0.21(0.60)
Neuroticism	49	99.73(20.50)	0.76(0.34)	2.45(0.67)
Extraversion	49	118.57(21.66)	1.55(0.34)	3.92(0.67)
Openness	49	123.37(28.44)	0.94(0.34)	0.14(0.67)
Agreeableness	49	114.65(22.94)	0.49(0.34)	0.90(0.67)
Conscientiousness	49	122.47(26.97)	1.55(0.34)	2.90(0.67)
Disintegration	40	2.00(0.42)	0.09(0.37)	-0.91(0.73)
Antonym test AL4	49	23.25(8.77)	0.93(0.34)	-0.29(0.67)
Synonym test GSN	49	26.10(4.31)	-0.99(0.34)	2.37(0.67)
Object matching test IT1	49	26.41(7.98)	-2.28(0.34)	5.63(0.67)
Form matching test GT7	48	40.29(12.10)	-1.45(0.34)	3.39(0.67)
Visual spatialisation test S1	49	24.69(5.19)	-2.46(0.34)	9.87(0.67)
Three-dimensional space relation test IT2	49	26.86(5.73)	-0.54(0.34)	-0.26(0.67)
Non-verbal relation eduction test D48	49	27.16(5.34)	-0.82(0.34)	1.22(0.67)
Hidden figure test CF2	48	50.73(15.40)	-1.50(0.34)	3.68(0.67)
Analogy test ALF7	49	24.10(3.84)	-1.30(0.34)	1.83(0.67)

Mean RTs for each task as a whole were also computed and used to determine the relative difficulty of each task. The most difficult task as a whole was plus-minus, followed by local-global, lower case-capital letter and finally number-letter task. Mean RTs for each task's shifting block gave a somewhat different picture, with the most difficult task being local-global, followed by number-letter, small-capital letter and plus-minus task. Both these RTs were rank-order correlated with the ordinal number of the task within the testing situation. No significant correlation was found, which gives support to the claim that no significant learning or fatigue effects were present during the testing session.

Factor Analyses

The criteria for exploratory factor analysis were met since the number of participants (62) was more than 10 times larger than the number of analyzed variables (MacCallum, Widaman, Zhang & Hong, 1999). The correlations between shifting cost variables are presented in Table 2. Maximum likelihood method of extraction

Table 2. Intercorrelations between different shifting tasks

Measure	1	2	3	4
1. Plus-minus task	–			
2. Number-letter task	0.197	–		
3. Local-global task	**0.381****	**0.374****	–	
4. Lower case-capital letter task	0.193	0.242	**0.261***	–

Note. Significant correlations are in bold face; * p < 0.05, ** p < 0.01.

Table 3. Shifting costs factor loadings

Shifting costs	Shifting cost factor
Plus-minus task	**0.486**
Number-letter task	**0.495**
Local-global task	**0.753**
Lower case-capital letter task	0.379

Note: Factor loadings above 0.04 are in bold face

of factors was used and a one-factor solution fitted the data very well (χ^2 = 0.606, *p* = 0.739). The shifting cost factor explained 29.789% of the variance of its variables. The loadings of specific tasks' shifting costs on this factor can be seen in Table 3.

Relation of Personality and Intelligence to Shifting Ability

Considering the relation of shifting costs to personality and intelligence measures, it was shown that shifting cost factor correlate significantly and positively with neuroticism (r = 0.326, p < 0.05) and the direction of this correlation implies that more neurotic participants suffer greater shifting costs (need more time in the shifting task situation as opposed to the pure task situation) compared to their less neurotic peers. The relevance of this finding should be stressed, since it is the first found correlation between the specific executive function of shifting and neuroticism as defined by the Big Five personality model. Contrary to most of the previous research, we found large negative correlations between intelligence measures and shifting cost factor, ranging from -0.346 to -0.529 (see Table 4), meaning that more intelligent participants suffered fewer shifting costs than their less intelligent peers. Having the possible restriction of range for both intelligence and shifting cost scores in mind (see Limitations of the study section), general population correlations are expected to be even higher.

Since a significant correlation between neuroticism and AL4 intelligence test was observed (r = 0.346, p < 0.05), correlations of these two measures with shift-

Table 4. Intercorrelations between shifting factor and intelligence measures

Intelligence measures	Shifting factor
Perceptive processing	
Object matching test IT1	-0.090
Hidden figure test CF2	-0.176
Form matching test GT7	-0.151
Serial processing	
Antonym test AL4	-0.039
Analogy test AL7	-0.480**
Synonym test GSN	-0.529**
Parallel processing	
Visual spatialisation test S1	-0.346*
Three-dimensional space relation test IT2	-0.173
Non-verbal relation eduction test D48	0.027

Note: Significant correlations are in bold face; * $p < 0.05$, ** $p < 0.01$

ing cost factor were recalculated, partialling out the other variable. Neuroticism remained significantly correlated with shifting cost factor ($r = 0.408$, $p < 0.05$, respectively), while AL4 remained non-correlated with this factor.

DISCUSSION

Factorial analysis yielded a one factor solution confirming the hypothesis that a unique and general shifting mechanism underlies the administered tasks regardless of their differences in stimuli type and operations performed in pure task blocks. All tasks' loadings on this shifting factor were positive and higher than 0.3, and the local-global task had the highest loading (above 0.7) suggesting that this task taps the shifting ability in its purest form.

Since the ability to shift mental sets, tasks or operations hadn't previously been connected with any personality measures, we had no clear expectations as to which personality factors might be associated with shifting ability. We assumed that Disintegration, as a compound measure of different aspects of problematic cognitive functioning would have a positive correlation with shifting costs. This correlation, however, was not obtained, which does not seem to be a consequence of a generally low disintegration level in psychology students (since the disintegration distribution is normal in our sample) but would rather indicate that such a global measure of psychotic proneness may not be sufficiently sensitive to specific executive function impairment. Interestingly, it was only neuroticism that showed significant correlations with shifting ability and the direction of this relation implied that greater neuroticism corresponded to greater shifting costs. Taking into account the nature of trait neuroticism as a general vulnerability factor, one possible explanation of this correlation is that more neurotic participants felt more threatened by the demands of the shifting tasks than their less neurotic peers. This anxiety might at least partly be due to the fact that participants, within the shifting sub-task, do not know whether the next trial would demand shifting from the previously performed operation or not. Evidently, this type of uncertainty would place greater pressure on more neurotic participants, rendering them less able to quickly shift from one task to another. Of course, the requirement to rapidly shift between mental operations might in itself be anxiety provoking, especially for more neurotic participants.

Shifting cost factor had a significant negative correlation with two serial processing or verbal tests – the analogy test AL7 and the synonym test GSN, one parallel processing or nonverbal test – the visual spatialisation test S1 and no perceptive processing i.e. perceptive speed tests. It would seem that the shifting cost factor is related to general intelligence, although slightly more to its verbal components and not so much to the aspects of cognitive speed. However, the battery KOG9 may, by its nature, be more similar to executive function tests than some other intelligence batteries, as it is based on a cybernetic model that places emphasis on information processing ant it predominantly includes simple cognitive tasks, with six out of nine being speed tests (only S1, IT2 and D48 are power tests).

Still, we believe that cognitive speed as one of the proposed intelligence factors (Horn, 1997) could not be responsible (at least not solely) for the high correlations between shifting ability and intelligence (which would imply that more intelligent people perform shifting tasks quicker simply due to their greater general cognitive speed), primarily because of lack of correlation of shifting cost factor with any of the processing speed tasks used in our research. It is, however, possible that more intelligent participants adopted a more efficient strategy within the shifting tasks which enabled them to better deal with their demands. This explanation would need further investigation, since participants were not asked about their strategies. Executive functions, including shifting ability, might represent essential aspects of intelligence – "the aggregate or global capacity of the individual to act purposefully, to think rationally and to deal effectively with his environment" (Wechsler, 1944, p. 3) – which has so far been neglected in the research on intelligence. However, the explanation that we find most likely is that executive functions are the mechanism by which intelligent behaviour is accomplished and are perhaps the necessary prerequisite.

Our findings are in contrast with conceptions of executive functions as completely unrelated to intelligence (e.g. Brazzelli et al., 1994; Damasio & Anderson, 1993), and also some contemporary research showing that the shifting factor is unrelated to intelligence measures (Friedman et al., 2006), but support the findings that shifting ability is correlated with Gf (Salthouse et al., 1998). Evidently, the subject is in need of further research.

Limitations of the study

One of the main limitations of our study refers to a fact that we conducted our study on a relatively small sample. Furthermore, our sample consisted of psychology students who are a highly selected group regarding cognitive abilities, for in order to be admitted to the academic program they must have good high school grades and do well on the admission tests of psychology knowledge and general knowledge. Both educational achievement and general knowledge have been demonstrated to have a moderate to strong correlation with general intelligence (Deary, Strand, Smith, & Fernandes, 2007; Furnham & Chamorro-Premuzic, 2006; Furnham & Monsen, 2009). Therefore, it is expected that the range and variability of intelligence and potentially shifting costs are lower for this group than they would be for the general population. A lack of normative data on either of these measures makes it impossible to directly test this presumption. Finally, the decision to use battery KOG9 as a measure of intelligence might have yielded a specific pattern of results, because by its nature this battery is more similar to executive function tests than some other intelligence batteries. All these facts call for replications of our findings on larger and more diverse samples, as well as additional research on the relation between the shifting ability and different measures of intelligence.

Final Conclusion and Directions for Future Research

The main findings of our study can be summarized as follows: (1) It is possible to extract one general shifting factor from four different shifting tasks; (2) This general shifting ability correlates significantly with general intelligence as measured by KOG9 intelligence battery; (3) Among personality traits, only neuroticism shows significant correlations with shifting ability in the direction that greater neuroticism corresponds to greater shifting costs.

Our results suggest that shifting is related to general intelligence, supporting the findings of Salthouse and his associates (1998) and contrasting those of Friedman et al. (2006) who did not report such a relation. New studies stressing the role of moderators of this relationship could provide answers about the reasons behind such a contradiction. It is possible that certain, for instance methodological moderators like construct width, could account for the inconsistencies in current findings. Additionally, an interesting question about what mediates the relationship between executive functions and intelligence should be addressed more directly in the future. One potential mediator could be the cognitive strategies which more intelligent people employ when performing shifting tasks. Alternatively, general cognitive speed could be responsible for certain aspects of both intelligent behavior and the shifting ability. Finally, shifting ability could directly represent essential aspects of intelligence – "the aggregate or global capacity of the individual to act purposefully, to think rationally and to deal effectively with his environment" (Wechsler, 1944, p. 3). Future research employing pure measures of cognitive speed and measures of cognitive strategies could help us move forward in addressing this question.

Most importantly, results of our study open up a new and exciting line of research regarding the role of executive functioning in shaping at least certain (i.e.

neuroticism) personality traits. They raise the possibility that the general vulnerability of neurotic people stems at least partially from the fact that they are usually not capable of shifting their attention which might be the reason why they are prone to rumination and do not easily recover from stressful events. On the other hand, maybe the uncertainty of the forthcoming operation within the shifting block could have led to greater pressure on more neurotic participants, rendering them less able to quickly shift from one task to another. Future studies employing alternative task paradigms and cognitive tasks that tap into executive functions other than shifting could help us further investigate these questions.

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IZVRŠNA FUNKCIJA IZMJENJIVANJA PAŽNJE: FAKTORSKA STRUKTURA I POVEZANOST S DOMENAMA LIČNOSTI I INTELIGENCIJE

Sažetak

Istraživanje se bavilo izvršnom funkcijom izmjenjivanja pažnje te povezanošću s inteligencijom i faktorima ličnosti. Primijenili smo četiri različita kognitivna zadatka koji se smatraju markerima izmjenjivanja pažnje. Inicijalna faktorska analiza pokazala je jedan zajednički faktor tih zadataka. Utvrđene su značajne korelacije između ovog faktora i mjera inteligencije. Faktor izmjenjivanja pažnje također je značajno povezan s neuroticizmom, a smjer tog odnosa pokazuje da povišen neuroticizam odgovara većem izmjenjivanju pažnje. Naši su nalazi suprotni ranijim koncepcijama izvršnih funkcija kao nepovezanim s inteligencijom te nekim suvremenim istraživanjima koja pokazuju da izmjenjivanje pažnje nije povezano s mjerama inteligencije, ali potvrđuju nalaz da je sposobnost izmjenjivanja pažnje u korelaciji s Gf-om. Još važnije, rezultati našeg istraživanja otkrivaju prirodu neuroticizma, sugerirajući da izvršne funkcije imaju značajnu ulogu u određivanju opće emocionalne osjetljivosti.

Ključne riječi: izvršne funkcije, izmjenjivanje pažnje, inteligencija, neuroticizam

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