PRIMENJENA PSIHOLOGIJA

No4, 2023

Contents

Primenjena psihologija
Vol. 16, No. 4, pp. 437-445, 2023

Editorial

DOI: 10.19090/pp.v16i4.2512

Promoting Open Science Principles and Primenjena psihologija (Applied Psychology)

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The benefits of open science

At its heart, "open science" is a simple matter of sharing key parts of the research process that are traditionally not shared. These include detailed methods, protocols, and other materials needed to conduct the work: detailed analytical steps or code used for data analysis, the raw data collected during an investigation, and preliminary drafts of the manuscript.

A default towards not sharing may be for many reasons, but for many years, the largest one is that it was simply not possible to share raw data before online publication became the standard. That status quo became embedded in lab culture, and simply changing the status quo in a community as decentralized as the scientific community is always going to be a slow process. The fact that sharing more details about the process of scientific research represents a possible risk for the researcher, in a system where only statistically significant findings are publishable (Dickersin 1990; Komukai, Sugita, and Fujimoto 2023) and where others are not required to share their materials, making it all the more challenging to move beyond the current state.

However, this process is necessary for several reasons. Lack of access to primary research materials makes confirming or building upon earlier findings too challenging, as demonstrated by the fact that too many empirical research

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papers cannot be replicated. This issue has been well documented in the psychological sciences through projects such as the *Reproducibility Project: Psychology* (Nosek et. al., 2015) and the various *Many Labs* projects (Ebersole et al., 2016; Klein et al., 2014, 2018), but is also seen in pre-clinical cancer biology (Errington et. al. 2021, Begley & Ellis, 2012), experimental philosophy (Cova et. al., 2021), and other fields. This inability to replicate research findings wastes money (Freedman et. al., 2015) and time.

There are several key benefits that these practices have on the process of science and on the individual researcher. First, it is more efficient and practical to keep materials associated with their papers for individual researcher ease. It makes managing a lab more efficient and practical and allows for easier conduct as students come and go. Second, it increases trust in the process of science (Funk et al., 2019). Third, it increases the impact and citations for individual researchers (Christensen et al., 2019; Colavizza et al., 2019; Dorch, 2012; Henneken et al., 2011; Piwowar & Vision, 2007; Piwowar et al., 2013). These benefits should be widely known and shared, as they speak to individual rewards that align and support collective well-being, instead of individual sacrifice for the collective well-being, which can be a tough sell!

Opening science: Experiences from the Center for Open Science

Addressing the problems with embracing open science principles requires a thorough and holistic approach. Too often, solutions are too simple, too authoritarian, or too naive to be successful. Therefore, it is important to make new behaviors involved in open science supported in multiple ways. This philosophy is the cornerstone of the activities of the *Center for Open Science (COS)* (Nosek et al., 2015). Below is a summary of this plan, with links to key resources or examples of it being implemented.

This plan outlines five important steps for culture change. First, open science practices have to be possible. If we are to advocate for practices such as data sharing or preregistration, there has to be a means to do so. COS builds and maintains the open-source platform for sharing data, registering studies,

posting preprints, and managing research projects, the *Open Science Framework (OSF)*. Building a registry and project management tool enables the behaviors to happen, but unless they are easy to use, then only the most devoted users would adopt them. Considerable effort has been put into making the OSF more user friendly, so that practices such as posting a dataset or registering a study are much easier to accomplish. This work on improving user experience is the second step, "Making it Easy." This also includes comprehensive user-guides and documentation, which is included in the help section.

Once open science practices are possible and relatively easy to accomplish, they must become normalized. This process is perhaps the most important, as researchers simply learn from each other what is expected behavior. But it is also perhaps one of the most difficult to implement. There is no shortcut to normalizing new practices, it takes time and experience to learn from peers and to see more and more examples of such practices taking place. One way to make these practices more visible is through *Open Science Badges*, which recognize when behaviors take place. Such visibility is associated with increased adoption of new behaviors (Kidwell et al., 2016), but importantly this process takes time- simply offering a badge is not sufficient to incentivize new behaviors (Rowhani-Farid, 2019), they have to be visible for a period of time in order to normalize the practice.

Fourth, it is important to reward ideal behaviors with specific actions. *Registered Reports* is a publishing model that directly rewards open science practices through the promise to publish final results if the preregistered and pre-approved plan is conducted as specified. This publishing model moves peer review to before the study is conducted and incentivizes open science practices such as data sharing, conducting replications, and preregistration by granting in-principle acceptance for articles based on that early peer review.

Finally, open science behaviors can and should eventually be required. There is a guide for doing so in the *Transparency and Openness Promotion (TOP) Guidelines* (Nosek et al. 2015), which provides specific policy recommendations for journals and funders implementing open science practices. Importantly, TOP

is both modular (covering eight policies that can be independently implemented) and tiered (with levels 1-3). These features enable adoption of specific practices when a community is ready, while also enabling progressive policies to exist while some other policies are being tried out. For example, a level 1 policy for data transparency simply requires disclosure of whether or not datasets are available. This encourages adoption, as specifying "no" to that should become less and less desirable over time. Other polices may be level 2 (for example, requiring analytic code sharing) or even level 3 (requiring computational reproducibility checks). This format also enables comparison of journals on the degree to which they have been implemented. This results in a journal's *TOP Factor* and is an easy way for journals to compare policies and to adopt more stringent policies when it is reasonable to do so.

As a takeaway, below are a few primers and resources to encourage adoption of some or all of these practices.

Data Sharing

- How to make a data dictionary: https://help.osf.io/article/217-how-to-make-a-data-dictionary This guide gives some simple best practices for a data dictionary or codebook that will help future readers (even yourself!) understand the meanings behind each variable.
- Practical Tips for Ethical Data Sharing (Meyer, 2018). This tutorial provides practical steps for sharing data.
- Data Sharing: a Primer from UKRN (Towse, et al., 2020). This includes considerations of human data, consent, anonymisation, and protected access.
- Recommended language for informed consent with data sharing in mind (https://osf.io/g4jfv/wiki/Consent%20Forms/).

Data Analysis and Coding

- Good enough practices in scientific computing (Wilson et al., 2017). In this paper, the authors provide a basic set of best practices for storing data and conducting basic analyses that are useful for many researchers.
- Open Code and Software: a Primer from UKRN (Turner et al., 2020)

- Getting Started with Git (https://towardsdatascience.com/getting-started-with-git-and-github-6fcd0f2d4ac6) GitHub is a great way to work on version controlled code or projects in a way that lets you keep track of issues as they arise.

Online Courses for Statistical Tools

- Improving your statistical inferences (Coursera, Lakens: https://www.coursera.org/learn/statistical-inferences)
- Statistics with R Specialization (Coursera, Duke: https://www.coursera.org/specializations/statistics)
- Data Scientist with R (Datacamp: https://www.datacamp.com/tracks/data-scientist-with-r)
- Statistics and R (Harvard: https://pll.harvard.edu/course/statistics-and-r)
- Learn R (CodeAcademy: https://www.codecademy.com/learn/learn-r)

Preregistration and Registered Reports

- The Preregistration Revolution (Nosek et al., 2018). An introduction to preregistration along with examples of how and when to preregister.
- The UK Reproducibility Network's (UKRN) primer on pre-registration and registered reports (Stewart et al., 2020).
- Practical considerations for navigating Registered Reports (Kiyonaga & Sciemca, 2019) (with accompanying OA materials here: https://osf.io/5gazv/wiki/home/).

About this special issue

We entitled this special issue "Promoting Open Science Principles in Psychology". Our intention was to promote the principles of open science and encourage psychologists to implement these principles in their research. The first three articles in the issue are excellent examples of various open science practices. In the first, Milovanović, Sadiković, Krstić, and Stojadinović have demonstrated benefits of using citizen science approach in psychological research. A total of 26 citizens were engaged in collecting data and

disseminating results on family transmission of executive functions deficits (working memory and inhibitory control) from parents to children. In the second, Čolović, Bojanić, Žunić, and de Souza Peres have explored personality structure based on the contents of data from the open-access „Tweet-sr" Serbian Twitter linguistic corpus. The third article, authored by Radević, Milošević, Milosavljević, and Dinić, illustrates the use of open methodology approach to research. The authors have analyzed the structure an correlates of 12 freely available instruments aimed at measuring the newly emerged concept of coronaphobia. Finally, the two last articles are more conceptual in its nature and offer a wider perspective of open science research practice. Pajić, Babić, and Jevremov explored the structure, dynamics, and impact of open access articles in personality research, while Smederevac and Stojanović offered a comprehensive overview of the open science landscape in the Western Balkan Countries, providing insights into existing open science policies, infrastructure, and practices in Albania, Bosnia and Herzegovina, Montenegro, North Macedonia, and Serbia.

This special issue also marks the end of the current editorial boards' tenure. In the past three years, we put significant efforts into further improving the quality and outreach of research published in *Primenjena psihologija*, building upon the achievements of previous editorial boards. We have adopted several policies related to open science and ethics in research, encouraging authors who publish in our journal to deposit their papers in institutional repositories, share primary datasets, preregister their research designs, and submit preregistered studies. *Primenjena psihologija* became indexed in the Directory of Open Access Journals (DOAJ), signifying our commitment to open access and scholarly excellence. It also officially received Impact Factor for the first time. Instead of farewell, we appeal to our successors to further improve the impact of articles published in our journal and, more importantly, to boost the OSF's Top Factor score for Primenjena psihologija. We also appeal to our readers and fellow researchers to embrace the open science practice and use the examples provided in this issue as a guidance for their future scientific endeavors.

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Primenjena psihologija
Vol. 16, No. 4, pp.447-474, 2023

Research Article

Family Transmission of Executive Functions: Mix of Traditional and Citizen Science Research Approach

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ABSTRACT

The aim of this study was to examine the family transmission of executive functions deficits (working memory and inhibitory control) from parents to children, using a combination of traditional and citizen science research approaches. The final sample consisted of 110 families with two children (440 participants; 110 pairs of children, 110 fathers and 110 mothers). Children were preadolescent (6 to 10 years old; 24 pairs) or adolescent (11 to 15 years old; 86 pairs) siblings. The research results indicated that the inhibitory control of the mother is related to the inhibitory control of the younger child, and that the inhibitory control of the father is related to the inhibitory control of the older child in the family, regardless of developmental period. In the father-child relationship, it was revealed that there is a strong connection between parental and child working memory. On the other hand, there are significant interaction of mothers' working memory and age of children in the second-born child. Potential mechanisms of transmission were discussed, bearing in mind the specifics of mother's and father's involvement in raising children, as well as the potential direction of this research question towards the sphere of behavioral genetics and parenting styles.

Key words: citizen science, executive functions, family transmission, inhibition, working memory

UDK: 159.9.072
DOI: 10.19090/pp.v16i4.2509
Received: 20.06.2023.
Revised: 15.11.2023.
Accepted: 11.12.2023.

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Executive Functions: Definition, Structure and Life-Span Perspective

Executive functions (EFs) represent a comprehensive concept that refers to the neurocognitive processes involved in the performance of conscious, purposeful and goal-directed behavior (Miyake et al., 2000). This domain of cognition has a self-regulatory and controlling role in the individual's behavior, and it enables focusing attention on specific tasks, successful problem solving and planning of future activities in everyday life. Contemporary research is consistent in conceptualizing EFs as a hierarchical construct, operationalized by a series of lower-order executive functions (Andreson 2008; Miyake et al., 2000), and the diversity of EFs was primarily confirmed in a large number of studies conducted on adult sample (for a review, see e.g., Borella et al., 2008; Jurado & Rosselli, 2007). Despite some inconsistencies (e.g., Roebers et al., 2012), previous research most often confirms the multifactorial structure of EFs in children and adolescents (Huizinga et al., 2006; Van der Sluis et al., 2007). Certain inconsistencies in determining the number of factors arise from the use of different instruments for measuring EFs (e.g., Espy et al., 2004; Van der Sluis et al., 2007) and due to their development that does not end during the childhood and adolescence (Andreson, 2002; Huizinga et al., 2006).

Studies of children and adolescents, most often indicate their two-factor or three-factor structure (Lee et al., 2011; Van der Ven et al., 2012). In psychological research, the most common result is the separation of working memory and inhibitory control as the primary EFs during these developmental stages (Brocki & Bohlin, 2004; Lehto et al., 2003), and also across the adult life-span (Borella et al., 2008). Working memory, according to Barkley (Barkley, 1997), is a memory domain in charge of holding information while also allowing for its simultaneous manipulation. On the other hand, inhibitory control implies the ability to suppress, ignore, or eliminate distractors, as well as irrelevant content and automatic responses, in order to fully focus attention on the goal (Miyake et al., 2000). Both of these EF types significantly contribute to the general

cognitive functioning of both children and adults, but in slightly different manner.

Research shows that EFs, especially working memory and inhibition, are age-dependent, and that, starting from early childhood, they change during adolescence, adulthood and old age, through linear and/or quadratic development (Borrela et al., 2008; Ferguson et al., 2021; Leon-Carrion et al., 2004; McAuley & White, 2010). There still seems to be no consensus regarding whether EFs develop gradually (linearly) or abruptly (quadratically), depending on the age of the child, and comparing preadolescents with adolescents can potentially answer this question. The slight decline of working memory and inhibitory control begins during middle adulthood, and continues into an old age (Ferguson et al., 2021), as part of the natural aging process (Salthouse, 2010). Having in mind that the development of EFs does not end during the childhood and adolescence (e.g., Huizinga et al., 2006; Spencer et al., 2020), it seems crucial, but also chalenging, to focus research on the discrepancy between children's EF' incompleted development and their parents' EF' slight drop in performance.

Family Transmission of Executive Functions: Parent-Child Dyads and Birth Order

Family transmission, broadly known as intergenerational transmission, refers to the process by which certain characteristics, behaviors, values, beliefs, and traits are passed down from one generation within a family to the next. It encompasses the transfer of various aspects of culture, socialization, and identity from parents or older family members to children or younger family members (Schönpflug, 2009). Family transmission can involve both genetic and environmental factors, and it plays a significant role in shaping individuals' development and identity (Deater-Deckard, 2014).

The results of contemporary research indicate that EFs are also subject to family transmission (e.g., Kim et al., 2021; Korucu et al., 2019; Tomlinson et al., 2022), and that this process is evident both at the youngest age (Cuevas et al., 2014; Kim et al., 2017), as well as in middle childhood and adolescence (Brieant et al., 2017; Kim et al., 2021; Korucu et al., 2019). These results were documented

in research with neurocognitive tests (e.g., Cuevas et al., 2014; Jester et al., 2009; Kim et al., 2017; Kim et al., 2021), but also through questionnaire assessments (Korucu et al., 2019; Li et al., 2023). Brieant et al. (2017) pointed to family transmission of working memory and inhibitory control from parents to adolescents, explaining this relationship through household chaos. Their results indicated that lower parent EFs predicted lower adolescent EFs, but only in the context of high-level chaos (Brieant et al., 2017). The importance of the influence of microenvironmental factors was also suggested by other studies, which dealt with the role of parenting styles in childhood and adolescence (Bernier et al., 2012; Li et al., 2023), and some researchers have pointed out the importance of genetic factors (Tomlinson et al., 2022). On the other hand, some studies emphasize the effects of the macroenvironmental factors, such as immigration status, exposion to traummatic events, or significant risk and socioeconomic adversity (Chen et al., 2020; Kim et al., 2017). No matter the age group, nor the methods used to measure and operationalize EFs, all of the aforementioned research found that better/worse parental EFs is associated with improved/compromised child EFs, which is in line with transactional model of self-regulation development (Sameroff, 2010).

However, some research indicate that there may be a gender-based relationship between parental EFs, and children's EFs (e.g., Jester et al., 2009; Meuvissen & Carlson, 2015; Ribner et al., 2022). According to Jester et al. (2009), mothers contributed more variance to adolescents' EFs than fathers, although concrete measures of working memory and inhibitory control were not used in this studiy, rather EFs were viewed as one general measure. The same results are obtained on pre-school children (Li et al., 2023), but slightly different on toddlers (Ribner et al., 2022). These somewhat conflicting findings have demonstrated that the pathways of transmission from paternal or maternal EFs to a child's EFs may vary depending on the child's developmental stage, and recommended that additional attention should be dedicated to enhancing mothers' capacity for self-regulation. In contrary, Ribner et al. (2022) found an additive role of fathers' EFs, similar in magnitude to the role of mothers' EFs, but in toddler stage. It is also not unusual for studies to include only one parent, primarily the mother

(e.g., Distefano et al., 2018; Kim et al., 2021), or to include only one parent regardless of their gender (e.g., Brieant et al., 2017; Chen et al., 2020). These studies also indicate the same process of family transmission of the EFs. Given that mothers have proven to be a more important factor in the family transmission of EFs, previous explanations have primarily focused on the fact that mothers are more involved in the care of the child, that they devote themselves more to children education and development compared to the father (Li et al., 2023), and that fathers more involve themselves in the entire process of caring for the child at the earliest age (Ribner et al., 2022).

A common finding in psychological research is that laterborn children perform less well on cognitive tests compared to first-born children and also have weaker life-work performances (e.g., Belmont & Marolla, 1973; Zajonc, 2001), although contemporary studies partially challenge these conclusions (e.g., Damian & Roberts, 2015; Damian & Spengler, 2020; Rohrer et al., 2015). Some, but not all, research results support the absence of differences in EFs between firsborn and laterborn siblings in preschool and elementary school age (Morgan et al., 2019; Park et al., 2018). On the other hand, there are results which indicate the existence of differences on EFs tests in favor of first-born child (Rochat et al., 2016; Mileva-Seitz et al., 2015), or that the number of children in the family (i.e. single child will have the most developed cognitive abilities because all the parents' attention is focused exclusively on them) is a much more important predictor of EFs than birth order (e.g., Rolan et al., 2018). Although we cannot strictly draw conclusions about how the connection of child and parent EFs are related to birth order, consulting a wider range of literature we can draw some assumptions. First-borns prioritize their families, accordingly identify more with their parents, and try to imitate them more than laterborn children (Pollet & Nettle, 2007; Rohde, 2003). Due to such a situation, it is expected that the identification of first-born children with their parents also takes place in the domain of EFs, and that the differences are maintained even in adult and old age (Holmgren et al., 2006). Latterborn children actually make up for the lack of skills with wider social support in order to attain/reach better adaptation (Salmon et al., 2016). In general, it seems that the similarity of first-born children's

traits, and thus probably EF, with parental traits, is affected by their greater orientation towards the family and achievement (family-achievement adjusted), unlike the latterborn children, who are more oriented towards the wider social environment (socialy adjusted). However, these conclusions are drawn indirectly and require additional empirical verification.

Mixed Approach of Current Study

By reviewing the literature, it can be established that the body of research dealing with this topic is not extensive, and demands additional attention for at least three reasons: 1) the role of the father in the context of the family transmission of executive functions is mostly omitted in research; 2) there are different patterns of connection between parental EFs and child EFs depending on the child developmental stage; 3) unclear role of birth order in parent EFs and child EFs relations. Therefore, the aim of this study was to answer the question of the transmission of EFs from parents to children, depending on the developmental stage (child/adolescent), gender of parents (father/mother) and order of birth (first/second child). We assumed that mother's EFs will be more strongly related to children's EFs, with a certain amount of doubt when it comes to younger respondents where the father's active role was also expected, then that first-born children will have more pronounced EFs than second-born children, and that adolescent sample will have more pronounced EFs from children sample.

We tried to answer these questions by applying a specific approach to data collection that involves a traditional and a citizen science approach. The European Citizen Science Association's (2016) guiding principles for citizen science emphasize the importance of involving the general public in research projects that advance scientific understanding of significant phenomena. Like traditional research strategy, citizen science has flaws and biases that need to be managed (Kosmala et al., 2016). To the contrary, citizen science offers the chance for more public involvement and the democratization of science. Considering that the basis of our work is the potential improvement of children's upbringing and education, our strategy aimed to include citizen scientists-

volunteers, primarily people who are interested in social issues, as well as the parents. According to Haklay (2013) citizen science activities may vary, depending on motivation, from conceptualizing the research to simplified collecting the data. Considering that the author's project activities cover a wide range of psychological related variables, we expected that the topics we are already examining will be the primary focus of people who will apply to participate in the project in the role of scientist-volunteers. Upbringing is a life domain for which the public has already shown some kind of interest in some countries (e.g., Dolgaya, 2016; Yuldashev, 2022). Therefore, we expected that the data collected through the traditional method would be supplemented by the data collected through the citizen science approach.

Method

Sample

During two iterations of sample recruitment, a total of 153 families with two children applied for the research. After reviewing the consent of the participants and after treatment of missing data, the final sample consisted of 110 families (440 participants) from Serbia. We include families that had two children with an age difference of no more than 4 years, in order to keep the time interval between the children births at least partially under control, given that the conditions in which children grow up can differ and shape children's characteristics. Taking into account applied statistical analyses, the required effect size was set to $\eta 2 = 0.15$, with a statistical power of 0.95, and it was calculated that a sample size of 107 families may be appropriate for this research (Faul et al., 2009). The sample of children and their family members (6-10 years) consisted of 24 pairs ($\Sigma 48$) of siblings and their parents (24 mothers and 24 fathers). Mean age for older child was 9.78 years ($SD = 1.25$), and for younger was 8.33 years ($SD = 1.39$). Mean age for mothers was 32.5 years, and for fathers was 35 years. The sample of adolescents and their family members (11-15 years) consisted of 86 pairs ($\Sigma 172$) of siblings and their parents (86 mothers and 86 fathers). Mean age for older child was 13.03 years ($SD = 1.43$), and for younger was 10.84 years ($SD = 1.87$). Mean age for mothers was 35 years, and for fathers

was 40.5 years. A significant difference in the representation of the two age groups (children vs. adolescents) was detected, $\chi^2(1) = 28.51$, $p < .01$. In total sample, there were 24.1% male-male sibling diads, 23.3% female-female sibling diads (Σ47.4% same sex dyads), and 52.6% female-male sibling diads.

Instruments

In this research, three parallel age-related forms of inventories were used to assess EF depending on the development stage of the participants:

Childhood Executive Functioning Inventory (CHEXI)

CHEXI (Thorell & Nyberg, 2008) is intended to measure problems in executive functioning in children of early elementary school age (6-10 years old) through assessment by parents. Answers are given on a five-point Likert scale (from 1 - *definitely not true* to 5 - *definitely true*), allowing parents to assess the extent to which the given statements are true for child. For the purposes of this research, both subscales were used: Inhibition (11 items, e.g., *Has a tendency to do things without first thinking about what could happen*, $\alpha = .68$) and Working Memory (13 items, e.g., *Has difficulty remembering lengthy instructions;* $\alpha = .72$) deficits. CHEXI has already been used in research in Serbian sample of children (Milovanović, 2021), where it showed satisfactory reliability. Answers to this questionnaire were provided by the parents of the child participants who were younger than 10 years.

Teenage Executive Functioning Inventory (TEXI)

TEXI (Thorell et al., 2020) uses a 5-point likert scale ranging from 1 ("*definitely not true*") to 5 ("*definitely true*") also in order to assess the Inhibition (11 items, e.g., *I am putting things off until the last minute;* $\alpha = .71$) and Working Memory (9 items, e.g., *Sometimes I am having difficulties remembering what I need to do in the middle of an activity;* $\alpha = .78$) deficits in teenagers (10-19 years), by self-report. TEXI is already successfully validated in Serbian sample of teenagers (Thorell et al., 2020).

Adult Executive Functioning Inventory (ADEXI)

The 14 items on the self-administered ADEXI scale (Holst & Thorell, 2018) also assess two EF domains. The Working Memory deficits measure consists of 9 items (e.g., *I have difficulty thinking ahead or learning from experience;* $\alpha = .79$), while the inhibition deficits measure consists of 5 items (e.g., *I have a tendency to do things without first thinking about what could happen;* $\alpha = .70$). ADEXI has already been used in Serbian sample of adults in pervious research (Nikolašević et al., 2022), where it showed satisfactory reliability.

Data Collecting

Data collection was carried out in two ways. The traditional method was primarily used to collect primary data, during the project activities in which the authors of this paper were engaged (Smederevac et al., 2019). This involved examining the families that were in the database of registered respondents through an online platform, where family members filled in questionnaires, each for themselves, except for children under 10 years old, who were assessed by parent reports. Part of the sample was also collected by psychology students for which they received a certain number of points on Eduational Psychology course. The second method of data collection involved a citizen science approach, which is now not uncommon approach on the Serbian research scene (e.g., Sadiković et al., 2020; Bila Dubaić et al., 2021). During 2021 and 2022, the authors organized webinars on psychological related topics that were considered to be of interest to citizens. A total of 26 citizens showed interest in this research topic and took active part in the project activities that entailed collecting data and dissemination of the results on social networks, promoting the research, motivating the families to complete the questionnaires, and, at the end, promoting the results through social networks. Final webinar was dedicated to topics that citizens-volunteers presented to a wider audience through online participation. During the entire process citizen scientists were mentored by and collaborated with the authors of this paper. The research was approved by the ethics committee of the author's institution (submission ID: 202010291658_SyRk). There is a list of the citizen scientists who contributed to

the study in the acknowledgement. Final data set and data instructions are deposited in the OSF (https://osf.io/jgxz8/). About 10% of the sample were collected through the citizen science approach.

Results

Descriptive Statistics

Descriptive parameters are shown in Table 1. It can be seen that the children have more pronounced EFs deficits than both parents, and that the mother has slightly higher scores on the ADEXI than the father. All variables are normally distributed, according to the Tabachnick and Fidell (2016) criteria: -1.00 < *Sk* and *Ku* < 1.00. Considering the significantly different representation of children and adolescents in the sample, comparisons between family members were made using non-parametric statistical methods.

Table 1

Descriptive parameters of used measures

	Working Memory deficits				Inhibition deficits			
	M	SD	Sk	Ku	M	SD	Sk	Ku
First-born sibling	2.38	0.92	0.51	-0.43	2.86	0.82	0.29	-0.30
Second-born sibling	2.30	0.88	0.61	-0.22	2.87	0.79	0.17	0.17
Mother	2.12	0.80	0.75	0.49	2.52	0.83	0.83	-0.07
Father	2.03	0.80	0.81	0.35	2.48	0.91	0.91	-0.46

Differences between Groups of Participants and Pairwise Comparisons

According to the results of Friedman ANOVA test, due to the dependence of measures among family members (Tabachnick & Fidell, 2013), there is a statistically significant overall difference on the measure of Inhibition deficits between children and parents, $\chi^2 = 15.68$, $p < .01$. Pairwise comparisons

suggested that there is no difference between first-born and second-born children measures, $p = .95$, nor between mother and father measures, $p = .40$. In the sample of children it can be seen that differences between siblings on the Inhibition problems measure do not exist in both: children, $p = .50$, and adolescents, $p = .75$. However, there is significant differences between children and parents Inhibition deficit measures. First-born, $MR = 2.73$, $p < .01$, and second-born, $MR = 2.74$, $p < .01$, children have significantly higher Inhibition deficits in comparisson to mothers' ($MR = 2.35$). The same case is evident in comparisson of the first-born, $p < .01$, and second-born, $p < .01$, child with the fathers' measure of Inhibition deficits ($MR = 2.19$). There is also a statistically significant overall difference on the measure of Working Memory deficits between children and parents, $\chi^2 = 14.59$, $p < .01$. Pairwise comparisons suggested that there is no difference between children measures, $p = .42$, nor between mothers' and fathers' measures, $p = .11$. If the sample of children is viewed by age subgroups, it can be seen that differences between first- and second-born siblings on the Working Memory measure do not exist in both children, $p = .69$, and adolescents, $p = .39$. However, there are significant differences between children and parents working memory deficits measures. First-born, $MR = 2.72$, $p < .05$, and second-born, $MR = 2.69$, $p < .05$, children have significant higher deficits in Working Memory in comparisson to mothers' ($MR = 2.45$). The same case is evident in comparisson of the first-born, $p < .01$, and second-born, $p < .01$, children with the fathers' measure of Working Memory problems ($MR = 2.14$). A significant difference was also observed between children ($MR = 41.43$) and adolescents ($MR = 60.08$) on the working memory deficits measure (M-W U = 780.5, $p < .05$) in favor of adolescents, but that differences do not exist on inhibitory control deficits (M-W U = 945.0, $p = .28$).

Effects of Parental EF on Child EF

Due to positive and mild-to-strong intraclass correlation (Cohen, 1988) of EFs between children and parental measures (Table 2), we first tested the interaction effects of parental EFs on child EFs using MANOVA. We didn't get

interaction effect in the case of Inhibiton deficits, $\lambda = .99$, $F = 0.32$, $p = .72$, $\eta^2 = .01$, nor in the case of Working memory deficits, $\lambda = .99$, $F = 0.41$, $p = .67$, $\eta^2 = .01$.

Table 2

Intraclass correlations between siblings and parents

	INH_s1	INH_s2	WM_s1	WM_s2	INH_m	INH_f	WM_m	WM_f
INH_s1	-	.43**	.78**	.43**	.32**	.37**	.22*	.45**
INH_s2	.02	-	.35**	.74**	.43**	.26*	.22*	.29**
WM_s1	.53**	-.06	-	.53**	.29**	.40**	.28**	.51**
WM_s2	-.12	.41*	.29	-	.49**	.34**	.35**	.45**
INH_m	.06	.26	.28	-.03	-	.53**	.61**	.54**
INH_f	.27	.26	-.13	-.18	-.01	-	.35**	.63**
WM_m	.41*	-.31	.36*	-.32	.21	.12	-	.54**
WM_f	.16	-.01	.24	-.03	-.15	.43*	.30	-

Notes. INH – inhibition deficits, WM – working memory deficits, s1/2 – first-born/second-born sibling, m – mother, f – father. Coefficients below diagonal refers to preadolescents, and abowe to adolescents. * $p < .05$. ** $p < .01$.

Due to that, we tested the effects of parental EFs on child EFs, with two sets of hierarchical regression analyses, with parental EFs as independent predictors. In the first step, age group of the child was included as a predictor variable, while we added EFs in the second step of the analysis. Criterion in both cases was one of the EF. The results in the context of Inhibition deficits are presented in Table 3.

Table 3

Hierarchical regression analysis: Inhibition deficits

	First-born sibling						Second-born sibling					
	Step 1			Step 2			Step 1			Step 2		
	β	*t*	*p*	β	*t*	*p*	β	*t*	*p*	β	*t*	*p*
Age group	.12	1.23	.22	.12	1.32	.19	.06	0.59	.56	.07	0.74	.46
M. Inhibition				.14	1.41	.16				.35	3.61	.00
F. Inhibition				.29	2.88	.01				.11	1.13	.26

Note. M – mother, F – father.

The results have shown that mothers' inhibition is significant predictor for the second-born child, while fathers' inhibition for the first-born. Age group (children – 1, adolescents – 2) did not play a significant role in determining the degree of inhibition in children and adolescents. By analyzing the interactions of children age group and father/mother inhibition in cotribution of children inhibition, it was obtained that there is no significant interactive effect in the case of inhibition neither in the first-born (fathers' inhibition – β = .01, *t* = .02, *p* = .99; mothers' inhibition – β = .18, *t* = .40, *p* = .69) nor in the second-born (fathers' inhibition – β = -.35, *t* = -.79, *p* = .43; M. mothers' inhibition – β = .33, *t* = .74, *p* = .46) child. The obtained results indicate that greater problems in the father's inhibitory control contribute to the manifestation of the same problems in older sibling, while in the case of mothers, this happens when we talk about younger sibling. The results in the context of Working Memory deficits are presented in Table 4.

Table 4

Hierarchical regression analysis: Working Memory deficits

	First-born sibling						Second-born sibling					
	Step 1			Step 2			Step 1			Step 2		
	β	*t*	*p*	β	*t*	*p*	β	*t*	*p*	β	*t*	*p*
Age group	.21	2.25	.03	.20	2.39	.02	.23	2.48	.02	.22	2.42	.02
M. WM				.10	0.98	.33				.08	.79	.43
F. WM				.40	4.10	.00				.31	3.05	.00

Note. M – mother, F – father; WM – Working Memory problems.

The results have shown that the measure of fathers' working memory problems is significant predictor for the both siblings, first-born and second-born, and that this counts more for adolescents than for children. The obtained results indicate that greater problems in the father's working memory contribute to the manifestation of the same problems in both children, and that it is more typical for the period of adolescence than for childhood. Mother's working memory deficits did not play a significant role in shaping children's working memory problems in any age groups. By analyzing the interactions of children age group and father/mother working memory in cotribution of children working memory, it was obtained that there is no significant interactive effect in the case of working memory in the first-born (fathers' working memory – β = 0.60, t = 1.45, p = .15; M. Working memory – β = -0.66, t = -1.46, p = .15) child. However, there is a significant contribution of interaction in the second-born child in case of mothers (β = 0.78, t = 2.11, p = .04), but not in case of fathers (β = 0.51, t = 1.19, p = .24). By introducing the interaction, the unique contribution of the father's working memory drops significantly in case of second-born child (β = -0.20, t = -0.48, p = .63). In general, it seems that the mother's working memory is a significant factor of working memory in the adolescent second-born child.

Discussion

The purpose of this study was to provide a response to the question of whether executive functions (EFs) are transmitted from parents to children depending on the developmental stage, the gender of the parent, and the child's or adolescent's birth order using the mixed traditional-citizen science approach. We assumed that the mother's EF will be more strongly related to the children's EFs in comparisson to father's EFs, that first-born children will have a more pronounced EF than second-born children, and that the adolescent sample will have a more pronounced EFs from the children sample. This study did partially confirm our assumptions, and provided new insight into the consideration of the relationship between parental and child EFs.

The findings of this study indicate that adolescents, compared to children, have more deficits in working memory, but not in inhibitory control. Suggested by some applied psychological research (e.g., Huizinga et al., 2006; Spencer, 2020), adolescents, who have a higher working memory capacity than children, use more sophisticated problem-solving techniques, filter out inappropriate stimuli beforehand, and quickly access the information they need from long-term memory. On the other hand, children, who have a lower working memory capacity, may use simpler task-solving techniques, do not filter out inappropriate responses beforehand, take longer to recall the information they need from long-term memory, and do not operate with more complex problem-solving techniques. Due to their increased use of additional, but redundant cognitive processes in daily life, adolescents with higher working memory capacities may be more susceptible to compromising the information processing, due to ovreloaded working memory. Children, with their lower working memory capacity, use mostly necessary and less demanding cognitive processes, and there are less chances of overloading the working memory with additional stimuli that could cause deficits in functioning. The absence of differences on inhibition deficits, as well as the existence of differences on working memory deficits that were obtained in this research, still leave the question of the development of executive functions (linear vs. quadratic) open for future researchers (Borrela et al., 2008; Leon-Carrion et al., 2004; McAuley &

White, 2010), who would conceptualize a longitudinal type design of this kind of research.

The absence of differences on EF deficit measures between first-born and second-born children can also be explained by the issue of (non)linear development of EF. Bearing in mind that the average age difference between siblings in our study was less than 2 years (1.82), this appears to be too small age difference in order to detect an increase or decrease in EFs, which is consistent with the results of some earlier studies (Morgan et al., 2019; Park et al., 2018). Other studies (Damian & Roberts, 2015; Damian & Spengler, 2020; Rohrer et al., 2015) suggest that minor birth order effects are obtained on cognitive, but primarily intelligence tests. Rohner et al. (2015) suggested that differences could be obtained in siblings with an age difference of less than five, but they add that those differences can be expected rather on some personality dimensions, due to potential competitiveness between siblings, than on cognitive measures. Additionally, differences have thus far been found more often on neuropsychological tests measuring EF than on self-reported or peer-rated measures.

Our assumptions about a stronger association of mothers' EFs with children's EFs were partially confirmed. We found that father's working memory deficits are associated with children's working memory deficits, especially in adolescence, regardless of birth order. However, after introducing the interaction with the age group of children into the model, the father's contribution is lost and only the mother's working memory effect prevails in the second-born sibling, and this case can be considered the most specific transmission. Mothers favor lastborn child over other children in the family, and they participate more in the educational process in children (Waizenhofer et al., 2004), which potentially contributes to the development of working memory through one of the mechanisms of transmission. However, for specific models of transmissionmit is necessary to conduct a lognitudinal research, and to include some of the moderator or mediator variables that are not included in this research (e.g., parenting). On the other hand, mother's inhibition deficits were more strongly associated with younger sibling's inhibition deficits, and

father's with older sibling's inhibition deficits. At this point, it should be noted that a nuclear family twin design could probably provide a more complete answer for these results, given that it is evident that genes, shared and non-shared environment could shape children's EFs (Tomlinson et al., 2022). Some other studies outside the field of behavioral genetics offer other explanations. According to Gold et al. (2020) children may be more conscious of their fathers' participation in adolescence and middle childhood than in early childhood in the context of upbringing, and they may develop relationships based on common interests. The fact that effect sizes in this research were large suggests that adolescence may be a stage of life where the fathers' time investments may have a bigger impact in comparisson to mothers' (Gold et al., 2020). These conclusions could be explained by assumption that in adolescence a greater closeness is formed between the interests of fathers and children through some home-based or outdoor activities which can accelerate the process of identification and working memory development (Gold et al., 2020). Adolescents, for instance, may have important life concerns in a way that appeals to fathers who are starting to sense their own developing role. This convergence of developmental requirements might provide a dynamic environment for the father, who is motivated to become more involved with the adolescent child because he is able to have a more companionable connection with, than is achievable with a children in the middle childhood (Bruce & Fox, 1999). According to Flouri and Buchanan (2003), and Su et al. (2017) fathers' involvement in childhood is linked to less internalizing and externalizing problems in adolescence, which, among other, could also includes deficits in working memory and itd consequences. Therefore, another recommendation is to conduct longitudinal research, which would check the assumptions that joint father-child activities in adolescence can be carried out in earlier childhood, which could improve the EFs of children. When considering the results related to inhibition, the role of fathers is present only in older sibling, and role of mother in younger sibling, regardless of the age period. According to Hetherington & Stanley-Hagan (1999), fathers are more likely to be involved with older children than with younger ones in the family. Some studies indicate that fathers actually favor first-born child, and mother favor lastborn child over other

children in the family, and that they show greater (dys)functional participation in their upbringing (e.g., Salmon et al., 2016). Moreover, according to Deater-Deckard et al. (2010, 2012), parents with weak inhibitory abilities are more likely to lose their temper, and struggle to restrain their own impulsive thoughts and emotions, which maybe creates a harsh parenting and unstable environment for the development of child inhibition. Although there is a lack of empirical studies specifically exploring how parenting practices affect the transmission of EFs (Li et al., 2023), it seems that the development of a child's inhibitory control may be negatively impacted by these parents' propensity for negative or harsh parenting (e.g., Cuevas et al., 2014), which could arose as a consequence of weak inhibitory control. So, the parenting style should unquestionably be included as a significant factor in future studies, as well as some personal characteristics of children and parents such as intelligence or personality traits.

Limitations and Future Directions

Our study provides new and more precise insights into the specificity of familial transmission of EF in relation to developmental period, gender of parents and birth order through within-family design. Moreover, this is the first study in Serbia that mixes traditional and citizen science research approaches. Still, there are certain limitations of the study. First of all, number of children and adolescents was not even across two groups, and the gender of the children was not included in the analysis. Although some of the previous research indicates that there are no gender differences in the EF transmission patterns (e.g., Li et al., 2023), the absence of the child gender in this study is caused by the fact that several groups of siblings should be made: same-sex male, same-sex female, mixed-sex in which the brother is older than the sister, and mixed-sex in which the sister is older than the brother. We could not apply this approach due to a relatively small sample in general, and especially in combination with the developmental period (childhood vs adolescence). Therefore, future research should include a larger number of respondents, incorporation of complex analyses of nested data, so that these groups could

be formed and potential more specific forms of transmission of EF from parents to children could be seen.

Additionally, although citizens scientists showed interest in participating in the study, it seems that the percentage of citizen participants could be higher or at least the promotion of the results could be more visible to a wider audience, given that only about 10% of the respondents were gathered through the citizen science approach. When citizen scientists are actively involved in multiple levels of the research design, they therefore feel the research project is more their own and, relating more to the research project, and there is a greater motivation for participation. In future research, it would be highly valuable to include citizen scientists in the conceptualization of the research problem, setting of research questions, processing and analysis of research data, as Haklay (2013) suggested through the various stages of citizen participation. Nevertheless, this preliminary study indicates that the quality of data collected by citizen science methods does not lag behind the quality of data collected by the classical method, which speaks in favour of the fact that the citizen science approach is a valid and proven approach to the organization of scientific studies.

Finaly, it seems that self-reported measures need to be supplemented with measures from neuropsychological tests, given that they do not suffer from social desirability problem. At the end, our results indicated that there are still at least three directions of development in this field: 1) direction towards behavioral genetics, i.e. twin and adoptive studies, and 2) inclusion of other variables in the process of family transmission of EF, such as family size, personality traits, parenting styles and intelligence, and 3) longitudinal design of study.

Acknowledgement

The authors would like to thank all citizen scientists for their great help in all stages of our study: Aleksandra Kostić, Andrej Skokić, Andrea Mihajlović, Luka Vučićević, Anja Stojković, Aleksandra Vojvodić, Anđela Joksimović, Luka Tašković, Diana Jankov, Viktoria Francuski, Dragana Arsenić, Anja Aleksić, Irena Maksimović, Matija Vidović, Jasmina Pajić, Aleksandra Vranac, Jelena Nikolov,

Nikola Adamov, Jovana Đurđević, Isidora Stojanović, Katarina Stanić, Jovana Taleski, Sofija Pavlović, Johana Tot, Tamara Filipović, and Željana Đokić.

Funding

This research was supported by the Science Fund of the Republic of Serbia (#7744418, Genetic and environmental influences on psychological adaptation of children and adults GENIUS).

Ethics Statement

The studies involving human participants were reviewed and approved by the ethical committee of the author's institution (submission ID: 202010291658_SyRk). Participants provided their informed consent to participate in this study.

Conflict of interest

We have no conflict of interest to disclose.

Data Availability Statement

The supporting materials and data supporting the conclusions of this manuscript are available on the OSF data repository (https://osf.io/jgxz8/).

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Primenjena psihologija
Vol. 16, No. 4, pp. 475-519, 2023

Research Article

Personality Adjectives in Serbian Tweets: An Opening

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ABSTRACT

There has been a great interest in investigating relations between personality and language use on the web or social media. Most of the recent studies are based on mining the users' information available online and then using machine learning algorithms to predict their personality characteristics. On the other hand, a few studies relied on the traditional lexical hypothesis when exploring personality under the assumption that personality-related attributes could be obtained from dictionaries. However, little is known about personality structure from Twitter/X - do data strictly reflect personality structure as represented by personality models, or as unique personality semantic patterns. The aim of the study was to assess and interpret the personality adjective-based structure contained in tweets. The data were collected from an open-access „Tweet-sr" Serbian Twitter linguistic corpus (Ljubešić & Klubička, 2014). Latent Dirichlet Allocation, a topic modeling technique, was conducted to extract topics and cosine similarity was used as a measure to determine topic similarities, as well as similarities between the topics and personality dimensions. The results showed that the optimal solution comprised four non-overlapping topics reflecting specific semantic structures. Topics did not replicate trait constructs but were modestly related to them. The largest similarities were found with Extraversion and Agreeableness, pointing out the conceptual importance of these traits when describing interpersonal behavior. Also, no inter-topic differences in word category distributions were found, with the evaluation

terms being the second most frequent in three topics. Although tweets are short-form text messages, they have the potential to communicate socially relevant information through personality descriptors.

Keywords: personality structure, personality descriptors, topic modeling, Twitter.

UDC: 159.923:316.472.4(497.11)
DOI: 10.19090/pp.v16i4.2514
Received: 12.10.2023.
Revised: 07.12.2023.
Accepted: 12.12.2023.

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Introduction

In recent years, particularly in the last decade, a growing body of literature has highlighted the importance of exploring relations between natural language and various social, behavioral, and psychological phenomena (Boyd & Pennebaker, 2017; Kosinski et al., 2013; Pennebaker et al., 2003). One of the benefits of using language-based measures in personality research is that data available on the web or social media channels reflect a more realistic representation of personality characteristics from the language people use on a daily basis, compared to self-report measures (Boyd & Pennebaker, 2017). Therefore, how people use words and express themselves online has initiated researchers' interest in finding linguistic phenomena (words and word patterns, such as sentiments and topics) as correlates or functions of personality attributes (i.e., personality traits). This approach is primarily based on mining the users' information gathered on social media platforms and using machine learning algorithms to predict their personalities (i.e., personality prediction framework).

Twitter, personality, and lexical hypothesis

Personality has been a consistent point of interest in natural language processing (NLP) and Twitter-related studies. Personality information has been chiefly derived from the web and social media platforms (e.g., Facebook, Twitter- currently rebranded as X) by employing text-mining techniques (Carducci et al., 2018; Golbeck et al., 2011; Qiu et al., 2012; Quercia et al., 2011; Schwartz et al., 2013; Yarkoni, 2010; Zhao et al., 2020). Personality studies on social media platforms have primarily been based on mining the users' information using machine learning algorithms to predict their personality features. On the other hand, little is known about personality structure within the social media context without relying solely on the predictive modeling paradigm.

Few studies have addressed the issue of personality cues in social media from the perspective of the traditional lexical hypothesis. Assuming that

personality-related attributes (i.e., personality traits) are embedded within natural language and extractable from dictionaries (De Raad & Mlačić, 2020; Goldberg, 1981, 1990, this paradigm has yielded several methodological strategies for gathering personality-relevant words. Influential personality models have stemmed from psycholexical studies, such as the Big Five (Hofstee et al., 1992), Big Six / HEXACO (Lee & Ashton, 2004), Big Seven (Almagor et al., 1995; Benet-Martínez & Waller, 2002), and Cattell's Sixteen personality factors (Cattell & Kline, 1977). The informally termed „Dutch" and „German" methodological frameworks are usually considered „classic approaches" in the field. Both focus primarily on adjectives, though nouns and verbs are steadily gaining more attention from researchers (De Raad et al., 1988; De Raad & Ostendorf, 1996; Henss, 1995; Paulsen, 2011; Saucier, 2003). Both advocate using comprehensive word lists extracted from dictionaries (instead of using descriptor samples). The „Dutch" methodology assumes that a personality descriptor is relevant if it fits in the phrase „I am…" (or „She/he is…", „They are…") and does not pose any additional restrictions regarding word category or function (Hofstee, 1990). German studies were focused on thirteen word categories, based on Warren Norman's English descriptors' fifteen-category classification (Angleitner et al., 1990; Norman, 1967). In the third Serbian psycholexical study (De Raad et al., 2018), nine descriptor categories appeared: temperament and character traits; abilities, talents, or their absence; emotions, moods, and cognitions; states and activities; roles and relationships; social effects – reactions of others; pure evaluation; social status, and value orientations. The first two categories fall into the broader class termed „dispositions, " the following two into „temporary conditions, " and the next four into „social and reputational aspects." The third prominent methodology, proposed by Tellegen and Waller (Almagor et al., 1995), suggests sampling personality-relevant words from dictionaries, imposing no restrictions, and not relying on comprehensive descriptors' lists. This approach has highlighted the importance of evaluative terms, which constitute two personality dimensions – positive valence and negative valence. Out of three psycholexical studies in the Serbian language, two have applied Tellegen and Waller's methodology, yielding results comparable to Big Seven dimensions (Čolović et al., 2014;

Smederevac et al., 2007) but also hinted at the possibility of Big Five replication (Colovic et al., 2005). The third study, utilizing word categories, has demonstrated that the trait descriptor structures change according to the word categories included; dispositional terms result in dimensions similar to the Big Five, while the introduction of evaluative terms leads to solutions comparable to the Big Six or HEXACO (De Raad et al., 2018). Thus the relevance of methodological factors, particularly word categories (Barelds & Raad, 2015) in lexical studies and their impact on the results have once again been demonstrated. At the same time, statistical integration of the results of three Serbian psycholexical studies (De Raad et al., 2018) pointed to five dimensions as, so far, most plausible approximations of top-tier personality dimensions in Serbian language: Agreeableness, Conscientiousness, Extraversion, Negative Valence, and a Neuroticism-related factor.

At the same time, traditional psycholexical studies' have so far almost exclusively utilized the data gathered by self-report or peer-report questionnaires, with a few exceptions across several decades (Cutler & Condon, 2022; Čolović & Filipović Đurđević, 2019; Fischer et al., 2020; Passakos & De Raad, 2009; Oljača et al., 2018; Peres, 2018; Roivainen, 2015b, 2015a). One may argue that the Twitter format is a challenge for personality researchers due to its specific features: brevity, extensive use of colloquial terms and slang, vast diversity of topics, frequent dialogue or polylogue form, richness of production, and others. Due to all these idiosyncracies, one may wonder whether the Twitter form reflects the „known" personality trait structures, as represented by models of personality, or personality-related semantic patterns that we know little of.

Recognizing Twitter as a valuable source of personality information, Peres (2018) has conducted a study on Brazilian Portuguese self-reporting tweets, applying the methodology adherent to traditional lexical hypothesis and using Latent Dirichlet Allocation (LDA, a topic modeling technique) as the primary analytic tool. Brazilian Portuguese adjective list was assembled and used along the descriptors embedded in the Big Five, HEXACO and Cattell's models. Despite the semantic coherence of seven- and fourteen-topic solutions, their contents did not substantially overlap with Big Five, Big Six, or Cattell's model.

Within the seven-topic solution, which was deemed to be one of the two most plausible, three topics were predominantly related to Agreeableness.

Investigating Openness to Experience adjective descriptors as modifiers of person-related nouns in Google Books and Tweets, Roivainen (2015a) pointed to smaller linguistic diversity in Tweets than in books, whereby a small set of terms dominated the Twitter discourse. The same author (Roivainen, 2015b), in a similarly designed but more comprehensive study, emphasized the lack of replicability of established personality models but demonstrated substantial positive correlations regarding the use of personality modifiers of the nouns „man" and „woman" in English and French languages.

Current study

According to the results obtained so far, apparently there is a substantial amount of semantically coherent personality information on Twitter, but it does not appear to straightforwardly represent the structure of personality dimensions from lexically-derived personality models (Peres, 2018; Roivainen, 2015a, 2015b). In a study of the frequencies of Openness adjective markers, Roivainen (2015b) pointed to flawedness in laypersons' personality assessment skills. On the other hand, the prediction of participants' Big Five traits based on Tweets has yielded successful results (Christian et al., 2021; Jaimes Moreno et al., 2019; Kern et al., 2019; Mavis et al., 2021). Hence the crucial question arises: if tweets carry conceptually relevant personality information, whereby it does not seem to reflect lexical personality models directly, how can we assess and interpret the personality descriptor structure contained in them?

We opted to apply traditional psycholexical study methods to self-referencing tweets, adopting elements of both Dutch and German approaches (Angleitner et al., 1990; Hofstee, 1990), as they have been used in the third psycholexical study in the Serbian language (De Raad et al., 2018). An analogous methodological strategy was first employed by Peres (2018), though without using adjective categorization, which did not exist in Brazilian Portuguese at the time. Hence, in a sense, one may regard this study as a tentative replication of the pioneer work in the field (Peres, 2018), though in a different language and

cultural context. We adopted Latent Dirichlet Allocation technique of topic modeling as the analysis applied in the referential study (Peres, 2018), whereby its advantages have been outlined in prediction research (Jaimes Moreno et al., 2019).

Projecting the traditional personality psychology procedure on specific social media output, based on the results of previous studies, our tentative hypotheses may be as follows. Namely, we expect to find a substantial presence of personality descriptive adjectives in Serbian Tweets, though we expect the set of terms to be smaller than in psycholexical studies, as suggested by Roivainen (2015a). Secondly, we expect the topics extracted to contain semantically coherent adjective combinations, but we expect modest or moderate similarities to established trait structures such as Goldberg's personality adjectives (Goldberg, 1981, 1990) and the overall five-factor structure based on the merged results of three Serbian psycholexical studies (De Raad et al., 2018). This assumption is based on the results of previous studies, particularly Peres (2018). As for adjective categories, we expect all of them to appear in Serbian tweets.

However, the assumptions regarding categories' structure and distribution across topics are more challenging to articulate, since so far, they have not been used in Twitter-related studies. However, the implications of two possible outcomes can be provisionally outlined. If the results show no deviations of the word categories' distributions in Tweets from the distributions in lexical studies, one could assume that lexical word categories may be valid across discourses, and not only applicable to questionnaire-gathered data. If the deviations are found, it would suggest that Twitter discourse may be specific regarding the use of personality descriptor categories.

An additional incentive for this study regards the data sources used in previous studies. Most of the studies cited in this paper, including the referential ones, did not utilize fully open-access data sources. This state of affairs may be due to the limited accessibility of the sources such as Twitter/X and GoogleBooks. In the current study, we have chosen to capitalize on the open accessibility of the Serbian Twitter data collected between 2008 and 2014,

assembled in the *Tweet-sr* linguistic corpus (Ljubešić & Klubička, 2014) available in *noSketch* and *KonText* services. We believe that the use of an open, fully tagged linguistic corpus as a source of Twitter/X archival data will both contribute to the understanding of Serbian Tweeter discourse and encourage future replication studies in Serbian and other languages contained in similar corpora accessible in previously mentioned locations.

Method

Procedure

The methodological procedure we used in this study to extract and process the Twitter data was based on the methodology described in Peres (2018). This procedure is in line with the core methodological principles of the classical approaches in psycholexical studies, as described in Hofstee, whereby descriptor categorization was included as described in Angleitner et al. (1990) and applied in the third Serbian psycholexical study (De Raad et al., 2018). The procedure included the following steps:

Open data extraction:

1. Using an open-access linguistic repository, „Tweet-sr (Serbian Tweets)" (Ljubešić & Klubička, 2014) (containing 174,235,555 words), tweets in Serbian language were extracted containing the phrase „I am". Only Tweets in Latin alphabet were used. The tweets were extracted in the lemmatized form provided in the repository.
2. Tweets containing at least one adjective from the Serbian 383 personality-descriptive adjectives list (De Raad et al., 2018) were retained for further analysis. 2a. A total of 268 Serbian descriptors were found in 109759 Tweets containing the phrase "I am".
3. The retained adjectives' category was determined using the categorization from the third Serbian psycholexical study and described in detail in De Raad et al. (2018).
4. A document-feature matrix (Benoit et al., 2018), was formed using tweets as documents and the retained adjectives as features.

5. For validation purposes, steps 2 and 4 were applied using Goldberg's list of 100 personality-descriptive adjectives (Goldberg, 1981). We intended to use these results to estimate similarities between Serbian topics' contents and the Big Five personality traits. Word categorization was not available for Goldberg's adjective list and thus was not applied. To control for possible translation effects on results, two versions of Goldberg's 100 were used: the original English one, and the Serbian translated by the authors. We kept the version containing original Serbian and translated Goldberg terms, since it contains the original Serbian adjective descriptors and provides a more conservative estimation of topic similarities.

Data processing

6. Latent Dirichlet Allocation as a method of topic modeling was applied separately on Serbian adjectives and Goldberg descriptive adjectives. For both sets of terms, the analytic procedure included the following:

a. Determining the optimal number of topics, based on four coefficients and visual inspection of the topics' distances, explained in more detail in the Data analysis section.

b. Terms with the largest term-topic probabilities, i.e., the terms with the highest likelihoods of belonging to a particular topic and simultaneously the smallest likelihoods of belonging to other topics, were extracted as optimal topic descriptors. To obtain the broadest range of topic indicators and ensure optimum reliability, we decided to impose the maximum upper limit of the number of indicators per topic, i.e., indicator number divided by topic number, as enabled by the software used (Watanabe et al., 2023).

c. Topic content similarities were calculated using the document similarity function as implemented in the *quanteda* package (Benoit et al., 2018) This step was conducted for:

d. Serbian Twitter topics and topics based on Goldberg's Big Five descriptor list;

ii. Serbian 383-based topics and five overall factors from the third psycholexical study, as outlined in De Raad et al. (2018);
iii. Goldberg 100 adjectives-based topics and the contents of the five original Goldberg scales, measuring the lexical Big Five dimensions (Emotional stability, Extraversion, Intellect, Agreeableness, and Conscientiousness) (Goldberg, 1981).

7. For the Serbian 383 adjectives-based topics, frequencies of word categories were calculated. The relative frequencies of the categories appearing in tweet topics were compared to those in the third Serbian psycholexical study (De Raad et al., 2018). Categories' frequencies across topics were presented as a contingency table.

Data analysis

Latent Dirichlet Allocation (LDA) (Blei et al., 2003) is an unsupervised algorithm that groups the documents with respect to the topics (i.e., a topic modeling technique). The high-level idea of LDA is that each document is described with a set of topics. Whereas, each topic is represented with a group of words, more specifically a probability distribution of words is given for each topic. Within this work each personality trait is described with a set of adjectives, therefore the words we are interested in among the topics are the adjectives themselves. In order to see how the adjectives that belong to certain personality traits are distributed among the topics we performed LDA.

For LDA the most important parameter that needs to be defined is the number of topics N. If the number of topics is set to a small value the model will be focused around general topics, whereas if the number of topics is set to a large value, the model will create topics that overlap. LDA was conducted in R (Ponweiser, 2012; R Core Team, 2023) by using the packages *ldatuning* for LDA (Nikita, 2020) and *seededlda* for topics' term extraction (Watanabe et al., 2023). To determine the optimal number of topics for the LDA model we used four metrics from the *ldatuning* package (Nikita, 2020). The optimal number of topics show low values for CaoJuan and Arun metrics (Arun et al., 2010; Cao et al., 2009), and high values for Griffiths and Deveaud metrics (Deveaud et al., 2014; Griffiths

& Steyvers, 2004). Two smoothing hyperparameters, *alpha* and *beta*, whose combination determines the distributional features (Celard et al., 2020), were set to the values of one. We made this decision given that the hyperparameters' zero values would imply the smoothest distribution of words across topics, while the values of one would allow for the most scattered distribution. To enable the full range of possible distributional features, and not exclusively the smoothest one, we opted for the latter.

Similarly to Peres (2018) and according to the default parameters contained in the software solution we used (Nikita, 2020), we conducted the initial analyses including two to fifteen-topics solutions, among which we selected the one with the best coefficients' values. To complement the values of the raw coefficients, we calculated the standardized differences between the maximum- and minimum-values aimed coefficients and thus attempted to determine the optimum solution. Simultaneously, we plotted the initial fifteen-topic solution using multidimensional scaling based on topics' Euclidean distances, to visually asses topic overlap and choose the least-overlapping solution.

Topic similarities, as well as topic-personality dimensions' similarities, were calculated using cosine similarity between the sets of terms constituting each topic, as implemented in the *quanteda* package in R (Benoit et al., 2018). In LDA cosine similarity is a measure used for calculating a distance between two term frequency vectors with values ranging from 0 to 1, and larger values indicating higher similarity (Sidorov et al., 2014), while values closer to zero indicate orthogonality.

Results

Approximately 69.97% of the Serbian personality adjectives lexicon described in De Raad et al. (2018) were found in our study. The frequencies of the retained adjectives within the dataset used in this study are shown in Supplementary materials, Table 1.

To complement the information regarding word frequency, we have compared word frequencies of the retained 268 adjectives and the remaining

115 adjectives from the reduced Serbian list (De Raad et al, 2018). We used two data sources for the comparison: the Tweet-sr corpus as described previously in this paper, and the srWAC corpus of Serbian language, assembled using the available web resources and accessible within the NoSketch resources (Ljubešić & Klubička, 2016). The results show that the retained terms are significantly more frequent than the omitted ones both in Tweet-sr ($M_{retained}$ = 2276.429 (5592.151), $M_{omitted}$ = 51.243 (66.867), t (381) = -4.264, p < .001, Mann-Whitney = 2145.00, p <.001) and srWAC ($M_{retained}$ = 10506.332 (23437.028), $M_{omitted}$ = 630.835 (787.135), t (381) = -4.514, p < .001, Mann-Whitney = 5929.00, p <.001).

Determining topic numbers

Topic number: Serbian 383 adjectives–based topics

The results of four metrics for 2-15 topics are plotted in Figure 1. Topics' positions for the 2-15 solutions are shown in Figure 2. The positions were determined using multidimensional scaling (MDS) space based on topic Euclidean distances. Four topics-solution was chosen as optimal due to topical parsimony, as shown in Figure 3. Additional measures of topics' standardized differences are shown in Supplementary materials, Table 2.

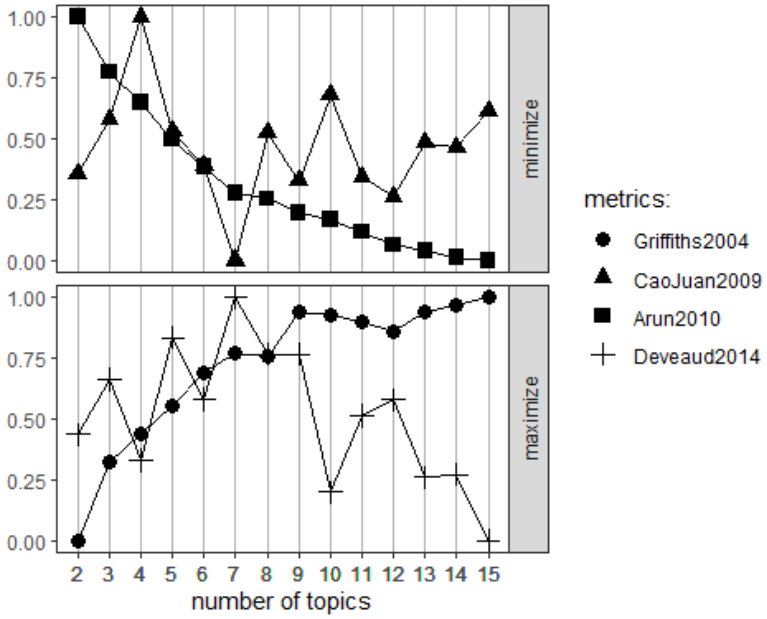

Figure 1. Fifteen topics based on Serbian 383 adjectives: coefficients

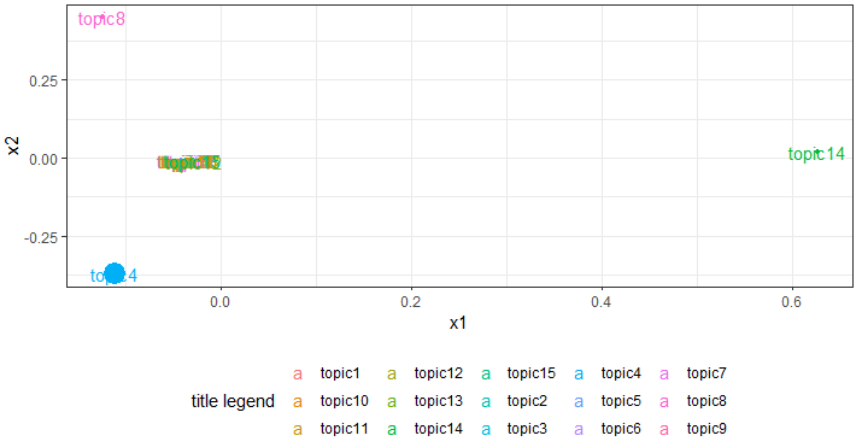

Figure 2. Fifteen topics based on Serbian 383 adjectives: Topic overlap (MSA)

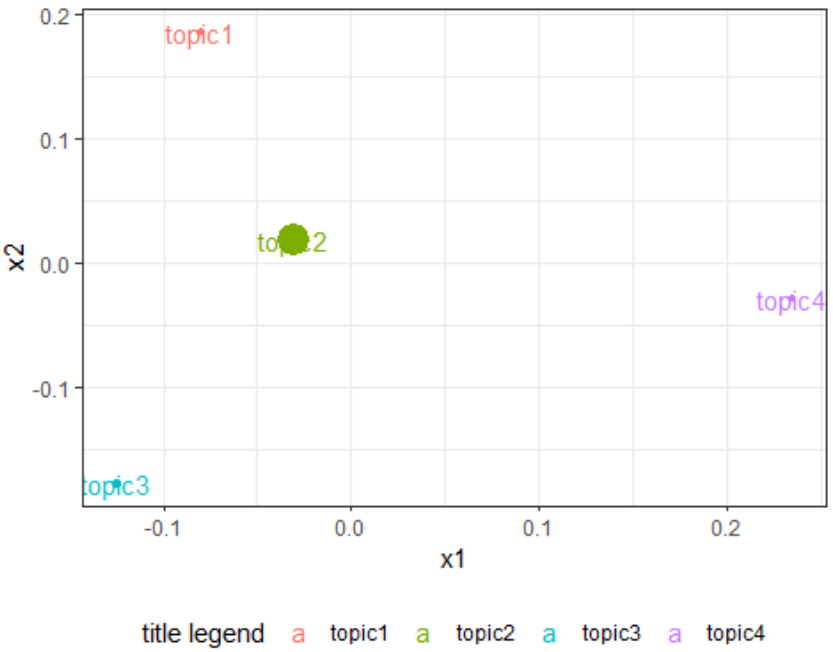

Figure 3. Four topics based on Serbian 383 adjectives: overlap

Topic number: Goldberg's 100 adjectives-based topics

The steps described in the previous section were also followed when the LDA model is based on Goldberg's 100 adjectives. According to the results of four metrics depicted in Figure 4, and the MDS - estimated topic positions (Figure 5) four topics were chosen as the optimal solution, with no visible overlaps among the four topics (Figure 6). Standardized differences based on minimum- and maximum-value aimed coefficients are shown in Supplementary materials, Table 3.

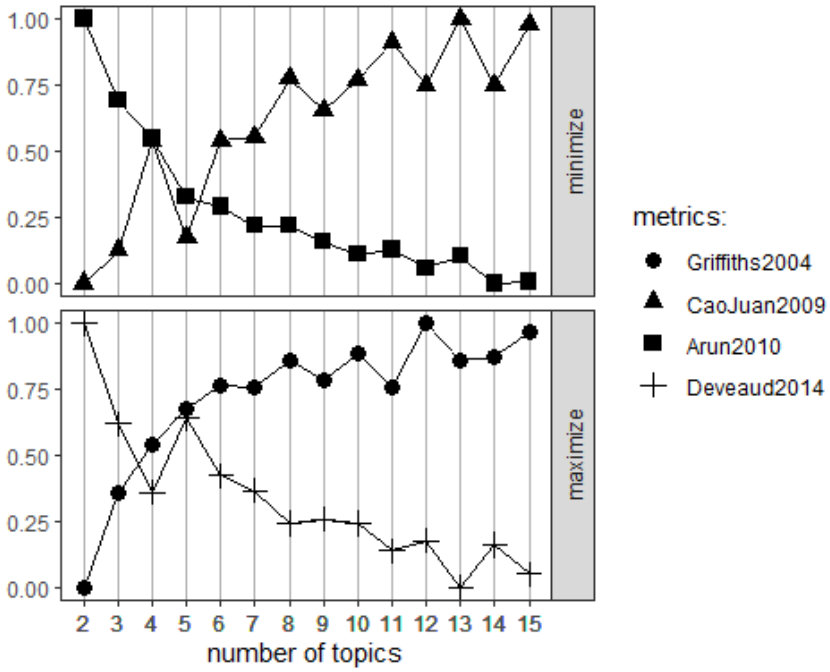

Figure 4. Fifteen topics based on Goldberg's 100 adjectives: coefficients

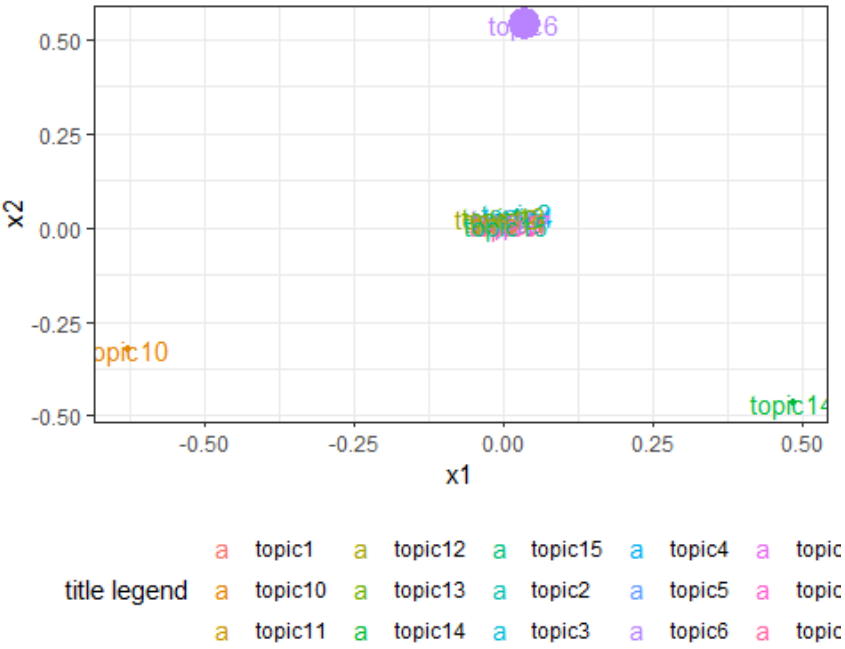

Figure 5. Fifteen topics based on Goldberg's 100 adjectives: Topic overlap (MSA)

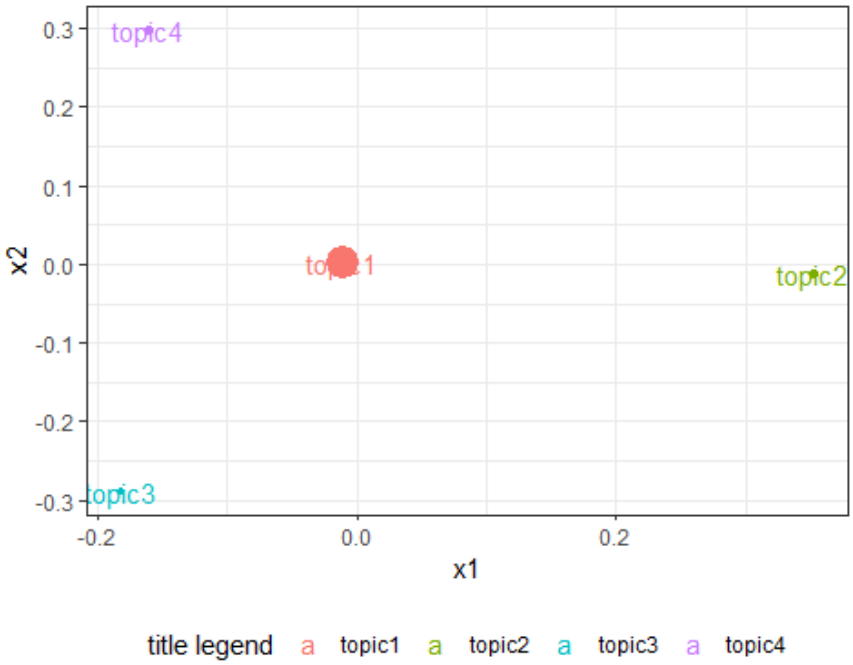

Figure 6. Four topics based on Goldberg's 100 adjectives: overlap

Topics contents

Serbian 383 adjectives–based topics

Table 1 outlines the 20 most frequent terms (adjectives) per every topic for Serbian adjectives and Goldberg adjective descriptors. The topics, both in Serbian Tweets' adjectives and in Goldberg adjective descriptors, are heterogeneous regarding the markers of personality traits that constitute their content. Given that topics are blends of personality trait markers, we opt to offer a more detailed interpretation at the end of this section, through a summary of the topics' similarity to personality traits and category distributions within topics.

Table 1

Serbian and Goldberg topics: Distribution of top 20 terms across each topic

Serbian topic 1	Serbian topic 2	Serbian topic 3	Serbian topic 4	Goldberg topic 1	Goldberg topic 2	Goldberg topic 3	Goldberg topic 4
crazy	satisfied	guilty	normal	nervous	cold	agreeable	jealous
mellow	interesting	boring	frank	deep	emotional	creative	relaxed
nervous	sad	modest	ordinary	kind	quiet	anxious	simple
proud	beloved	realistic	pert	unexcitable	pleasant	touchy	active
jealous	cold	hardworking	witty	careful	shy	helpful	artistic
important	cultured	weak	brilliant	selfish	uninquisitive	shallow	reserved
emotional	natural	weird	simple	organized	fretful	disorganized	conscientious
stubborn	depressive	romantic	lonely	envious	rude	intellectual	demanding
honest	naive	slow	capable	insecure	withdrawn	complex	generous
amusing	complicated	well-mannered	dependent	warm	introverted	neat	uncharitable
furious	quiet	smiling	creative	practical	harsh	distrustful	daring
responsible	captive	pleasant	active	efficient	unemotional	unrestrained	considerate
perverse	different	original	busy	thorough	inhibited	negligent	undemanding
powerful	crooked	concerned	unhappy	unintelligent	nervous	quiet	innovative
intriguing	shy	tolerant	decorous	untalkative	warm	imaginative	steady
self-supporting	intelligent	brutal	successful	vigorous	sloppy	haphazard	bright
contemporary	susceptible	insensitive	moral	bright	uncharitable	undependable	helpful
stupid	desperate	rugged	kind	unadventurous	helpful	talkative	uninquisitive
wise	advanced	careful	aggressive	temperamental	neat	trustful	imaginative
violent	subtle	spontaneous	dark	uncreative	distrustful	imperturbable	practical

Similarities

Serbian topics and Serbian lexically-derived personality dimensions

When examining similarities between Serbian topics and lexical markers of higher-order traits from De Raad et al. (2018), results show lower to average cosine similarities values (Figure 7). For the Serbian topic one, the maximum similarity was found for Extraversion, (theta = 0.16), while minimum cosine distance was found for Negative Valence , (theta = 0.03). For topic two, the similarities ranged from (theta = 0.03) for Neuroticism-related to (theta = 0.26) for Extraversion. Topic three was most similar to Agreeableness (theta = 0.21), and least similar to Negative Valence (theta = 0.08). Topic four showed the largest cosine similarity to Extraversion (theta = 0.18), and the smallest to Neuroticism-related (theta = 0).

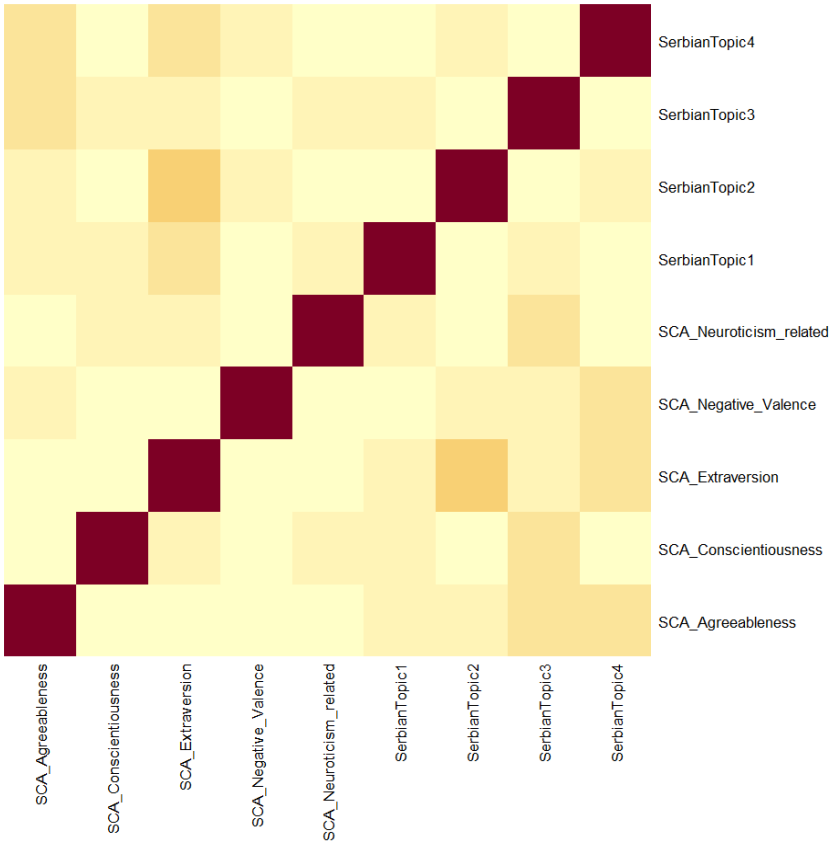

Figure 7. Four topics based on Serbian 383 adjectives: Word - topic probabilities

Note. SCA Agreeableness – SCA Neuroticism-related: personality dimensions subsuming the findings of the three Serbian psycholexical studies (De Raad et. al, 2018); SerbianTopic1 – Serbian Topic4: topics extracted in Serbian tweets gathered from the "Tweet-sr" corpus. Darker colors indicate larger cosine similarities.

Serbian topics and Big Five dimensions (Goldberg)

Topic one extracted from Serbian Tweets (Figure 8) is most similar to Emotional Stability (theta = 0.11) and least similar to Agreeableness (theta = 0.03). Topic two cosine similarities span from theta = 0 for Intellect to theta = 0.11 for Agreeableness. Topic three is most similar to Conscientiousness (theta = 0.08) and least similar to Agreeableness (theta = 0.03). Topic four has the largest

cosine similarity to Intellect (theta = 0.08) and the smallest to Agreeableness (theta = 0.03).

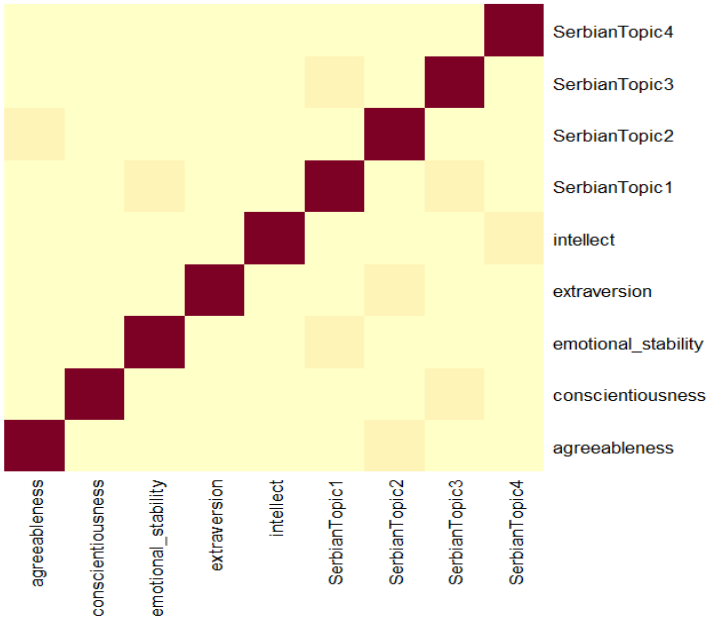

Figure 8. Serbian topics (original) and Big Five (Goldberg) dimensions (translated to Serbian) - cosine similarities

Note. Serbian Topic 1 – Serbian Topic 4: topics extracted in Serbian tweets gathered from the "Tweet-sr" corpus; intellect, extraversion, emotional stability, conscientiousness, agreeableness – Big Five dimensions measured using Goldberg's set of personality-descriptive adjectives (Goldberg, 1981; Goldberg, 1990). Darker colors indicate larger cosine similarities.

Serbian and Big Five-based (Goldberg) topics

Results point out lower to average similarities between topics based on Serbian 383 adjectives and topics based on Goldberg's 100 adjectives (Figure 9).

Serbian topic one is most similar to Goldberg Topic 2, (theta = 0.1) and least similar to Goldberg Topic 3, (theta = 0.02). For the second topic, the largest

similarity was with Goldberg Topic 2, (theta = 0.15) and the smallest with Goldberg Topic 3, (theta = 0.02). The largest cosine distance for Serbian topic three was with Goldberg Topic 2, (theta = 0.07) and the smallest with Goldberg Topic 1, (theta = 0.05). Cosine similarities for topic four spanned from theta = 0.05 for Goldberg Topic 1, to theta = 0.05 for Goldberg Topic 1.

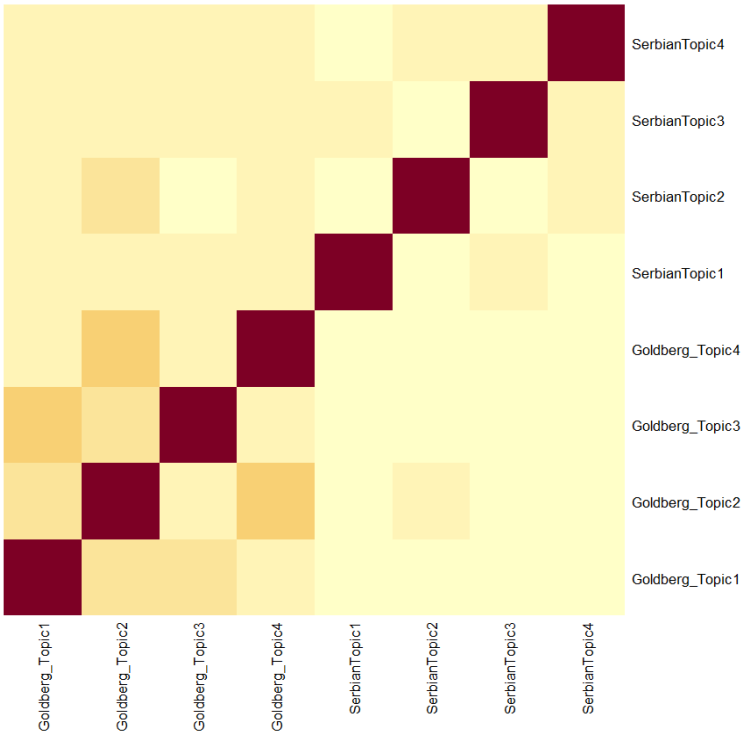

Figure 9. Serbian topics and Goldberg topics - cosine similarities

Note. SerbianTopic1 – Serbian Topic 4: topics extracted in Serbian tweets gathered from the "Tweet-sr" corpus; Goldberg Topic 1 – Goldberg Topic 4: topics extracted in Serbian tweets based on the Big Five dimensions' markers as conceptualized by Goldberg (Goldberg, 1981; Goldberg, 1990). Darker colors indicate larger cosine similarities.

Serbian topics - word categories

Supplementary materials, Table 4 displays word categories frequencies for Serbian 383 adjectives-based topics.

Word categories' frequencies in Serbian Tweets (Supplementary materials, Table 5) were compared to category proportions in the third Serbian psycholexical study (De Raad et al., 2018). The results showed no differences $\chi 2$ (8) = 7.79; p =0.45 in category distributions. Tweets' categories' distributions across topics (Supplementary materials, Table 5) did not reveal substantial differences in category patterns within topics $\chi 2$ (24) = 29.99; p =0.19.

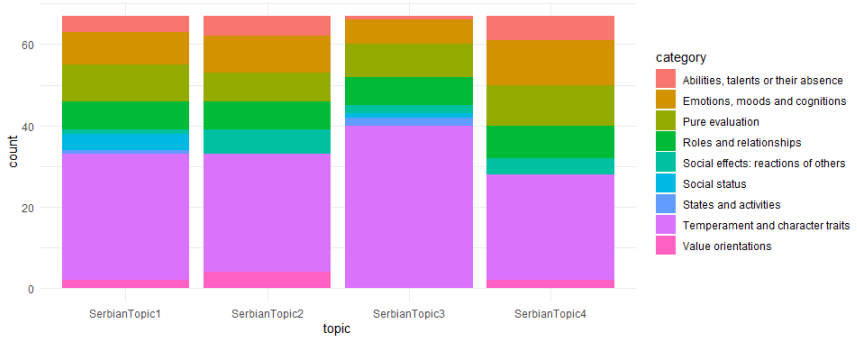

Figure 10. Distribution of word categories across Serbian topics

Note. Serbian Topic 1 – Serbian Topic 4: topics extracted in Serbian tweets gathered from the "Tweet-sr" corpus; categories – adjective categories as presented in the third Serbian psycholexical study (De Raad et al., 2018)

A summary of the topics' features is shown in Table 2. Three of four Serbian Twitter topics show most pronounced, though modest, cosine similarities to Serbian top-tier Extraversion dimension, while one is most similar to Agreeableness. Negative Valence and Neuroticism are the dimensions to which most of the topic vectors are orthogonal. Among all topics, markers of Temperament and character traits category are most frequent, with Pure evaluation in the second place for the first three topics, and Emotions, moods and cognitions for the fourth. Among the Big Five (Goldberg) dimensions, similarity of Twitter topics is more diverse, with extraversion not being among the most similar dimensions for any of the topics. However, one should bear in

mind the differences in conceptualizations of broad personality traits between Goldberg's and Serbian "emic" studies. Additionally, the similarities with Serbian traits are substantially larger than with Goldberg's, which could emphasize the relevance of language issues and cultural context.

A tentative interpretation of the topics' contents could suggest that all of them involve mostly self-descriptions of stable traits, with pure evaluation and emotions/moods as secondary saturators. Provisionally, only by referring to the twenty highest-loading indicators, topic one appears to contain descriptions pointing to social dominance and overt representation, the second one to emotional aspects of social presentation, the third points to activities and socially desirable behaviors, while the fourth appears to capture the terms that would constitute representations of one as ordinary and non-exceptional. If we approached the topics from the viewpoint of self-representation biases as conceptualized by Paulhus and John (1998), we could argue that topics one and four are more in line with "egoistic biases", while two and three are more in line with "moralistic biases" (Paulhus & John, 1998; Pedović, 2021).

Table 2

Serbian topic profiles based on similarities and category frequencies

Serbian topic	Goldberg - most similar	Goldberg - least similar	Serbian lexical - most similar	Serbian lexical - least similar	Descriptor category (minus stable) - most frequent	Descriptor category (minus stable) - least frequent
Serbian Topic 1	Emotional Stability	Agreeableness	Extraversion	Negative Valence	Pure evaluation	Social effects: reactions of others
Serbian Topic 2	Agreeableness	Intellect	Extraversion	Neuroticism-related	Pure evaluation	Social effects: reactions of others
Serbian Topic 3	Conscientiousness	Agreeableness	Agreeableness	Negative Valence	Pure evaluation	Value orientations
Serbian Topic 4	Intellect	Agreeableness	Extraversion	Neuroticism-related	Emotions, moods and cognitions	Social status

Discussion

In this study, we attempted to gain insight into the semantic structure of self-referent Tweets in Serbian language. To accomplish that, we approached the Twitter material using a methodological procedure applied in classic psycholexical studies, combined with a widely applied NLP technique (LDA topic modeling), and building on a single contemporary study conducted on Twitter material so far in a similar fashion. Despite its roots in classic and current studies, we tend to see this study as an exploratory one, primarily because it is, to our knowledge, the first personality study using Tweets in Serbian language. The results provide answers to the questions we posed, but, perhaps more importantly, open new ones to be addressed in future studies.

The number of extracted terms revealed that approximately 70% of the Serbian trait lexicon appeared in Tweets. This result is congruent with Roivainen (2015a) and speaks in favor of the findings suggesting that Twitter personality vocabulary is "smaller" than the one comprised in standard language. One possible account for this result could take into account the Tweets' brevity i.e., the pre-imposed restriction on a maximum number of words allowed. Shorter messages probably involve semantically condensed terms of specific connotation, which is an issue that should be addressed in future studies. The adjectives found within the Tweet-sr corpus and consequently analyzed are substantially more frequent than the remaining one hundred and fifteen adjectives that were not found in Tweets. This result is in line with the expectations that a communication "device" such as Twitter would rely on more common words. Nevertheless, it poses a more specific question of the impact of personality descriptors' frequencies on their use in various contexts. Such a question has recently been addressed by Condon et al (2022) and Condon & McDougald, (2022), and in Serbian language by Čolović et al. (2012). However, we believe that, due to its complexity, it should be a highly relevant topic for future studies in a range of languages.
We extracted four distinct topics in Serbian Tweets, which appear to reflect specific semantic structures.

This result is also in line with previous studies' results, which did not find conclusive links between Tweet topics and personality traits (Peres, 2018). Although topics do not replicate trait constructs, they are modestly related to them. Focusing on Serbian topics, we found the largest similarities (though still modest to moderate, according to standard interpretation) with Extraversion and Agreeableness. According to well-established conceptions in personality psychology, such as the Interpersonal circumplex (Gurtman, 2009), Extraversion and Agreeableness are perceived as the traits most relevant for interpersonal behavior. Hence the explanation of their similarity to Tweet topics may have sound conceptual foundations. As means of informal, brief written communication, Tweets are intuitively expected to convey socially relevant information that can best be carried through personality markers from the dimensions mentioned above. Hence we believe that, in future studies, more attention should be given to interpersonal circumplex concepts and their structure within the Twitter discourse. Topic categories are equally distributed across topics, and their distribution is equal to the distribution described in the third Serbian psycholexical study. This may be taken as a result in favor of the validity and applicability of personality adjectives' categories in Twitter discourse. However, there are no substantial inter-topic differences in category distributions. While this result can also be seen as a tentative confirmation of topic categories' validity, it limits the possibilities for topic distinction. Nevertheless, when stable trait terms are excluded, the less frequent categories' distributions apparently, though not largely, differ among topics. Pure evaluation is present as the second most frequent category in three topics, while in one of them emotions are most frequent. While evaluative personality dimensions are virtually orthogonal to topics' vectors, evaluation is still present within the predominantly socially themed topics. That may mean that, when communicating socially relevant self-referent information, Serbian Tweeters may be using evaluatively profiled (desirable or undesirable) terms either to facilitate the comprehensibility of communication or to establish more transparent impressions of themselves with their co-communicators. At the same time, communicating situation-specific emotions and moods may be one

of the most important functions of self-talk in Tweets and, as such, deserves more careful consideration in future studies.

Limitations and future directions

One major conceptual (no less methodological) limitation of this study is the exclusive use of adjectives as personality descriptors. We made this decision to ensure compliance with previous psycholexical studies, where adjectives have been the most frequently used word type. However, given the idiosyncrasies of Twitter discourse (or slang), one may wonder whether nouns (as more efficient "type" descriptors) and verbs (as more accurate regarding behavioral cues) should be included. The use of adjectives in self-describing tweets may have overlooked the effect of other word types, and even syntactic variables (tweet length, sentence length, etc.) and hence obscured their relevance for the current results. Including other word types is certainly one of the crucially important tasks for future studies.

Methodologically, we have made several decisions whose implications could be termed as either overly liberal or overly conservative. Having no prior knowledge of words' distributions within the Serbian Tweets, we opted for the least restrictive setting for topic formation, allowing for any distributional features in the final outcome (i.e., topics.) This way we obtained maximally distinctive topics, having no information on the implications of such distinctiveness. Additionally, we have used the tweets in a single (Serbian) language, which limits the possibility of full validation. Open accessibility of Twitter resources in similar (Croatian, Bosnian) and less similar languages (English, Japanese) can enable a good starting point for the validation of these results and possible replication of the current study in different language settings. Finally, self-themed Tweets are only one piece of the personality-tweeting puzzle. Addressing the issues of tweeting about others may greatly help us understand the structure and specific features of tweet topics.

To conclude, in this study we have applied classic psycholexical methodology to study self-referencing tweets. While the results show that personality trait content is present in the extracted topics, it suggests that

personality adjectives or adjective-based traits are most likely not sufficient to provide the full account on personality descriptors' use in this specific medium. Hence future studies are warranted to address the issues of word types, syntactic features, self-talk or talk of others, and other important and still open questions.

Conflicts of Interest

The authors declare no conflicts of interest with respect to the authorship or the publication of this article.

Data availability statement

Primary data used in this study are available upon a reasonable request.

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Supplementary materials

Word frequencies

Table 1

Serbian personality-descriptive adjectives frequencies

feature	frequency	rank	docfreq	group
normalan	1,419.82389	1	612	all
kriv	1,283.12564	2	500	all
lud	1,119.85462	3	439	all
zadovoljan	680.86449	4	258	all
zanimljiv	623.26385	5	232	all
tužan	616.56779	6	211	all
dosadan	596.20580	7	214	all
drag	549.19478	8	197	all
blag	543.70284	9	197	all
nervozan	525.44637	10	176	all
ponosan	517.14859	11	182	all
ljubomoran	515.25601	12	180	all
iskren	466.22339	13	164	all
realan	419.90874	14	146	all
slab	388.54598	15	125	all
hladan	380.44458	16	130	all
emotivan	350.72601	17	117	all
skroman	322.61937	18	106	all
običan	301.87219	19	98	all
vredan	291.39467	20	94	all
važan	267.98983	21	84	all
bezobrazan	246.00805	22	77	all
kulturan	245.57095	23	78	all
prirodan	244.63803	24	73	all
duhovit	243.73417	25	75	all
depresivan	233.71615	26	69	all
genijalan	224.11137	27	69	all
tvrdoglav	191.86669	28	54	all
naivan	190.06670	29	58	all

feature	frequency	rank	docfreq	group
jednostavan	190.06670	29	58	all
pošten	187.22022	31	57	all
usamljen	183.30785	32	51	all
komplikovan	181.94255	33	54	all
čudan	179.51959	34	52	all
zabavan	175.75671	35	53	all
sposoban	172.87071	36	52	all
besan	169.97637	37	51	all
tih	161.24155	38	48	all
romantičan	156.26142	39	44	all
kreativan	149.46745	40	44	all
zavisan	146.49978	41	43	all
vaspitan	140.53391	42	41	all
spor	140.53391	42	41	all
nasmejan	140.53391	42	41	all
odgovoran	138.42626	45	38	all
zatvoren	131.94506	46	37	all
prijatan	131.50495	47	38	all
inteligentan	119.74549	48	33	all
različit	119.74549	49	33	all
pokvaren	119.30468	50	34	all
stidljiv	117.11959	51	31	all
zabrinut	116.66458	52	32	all
originalan	114.02620	53	30	all
aktivan	113.57051	54	31	all
osetljiv	113.12929	55	32	all
uspešan	113.12929	55	32	all
zauzet	113.12929	55	32	all
nesrećan	110.91931	58	29	all
pristojan	110.02143	59	31	all
perverzan	107.34126	60	29	all
tolerantan	106.89957	61	30	all
moralan	103.76322	62	29	all
moćan	103.76322	62	29	all
očajan	101.05414	64	27	all

feature	frequency	rank	docfreq	group
ljubazan	97.44506	65	27	all
brutalan	91.06250	66	25	all
napredan	84.61038	67	23	all
agresivan	81.35638	68	22	all
samostalan	78.99542	69	19	all
interesantan	78.52761	70	20	all
bezosećajan	78.08264	71	21	all
bahat	74.78820	72	20	all
mračan	74.78820	72	20	all
savremen	74.78820	72	20	all
suptilan	71.47204	75	19	all
mudar	68.57984	76	17	all
dubokouman	68.13302	77	18	all
glupav	68.13302	77	18	all
sebičan	68.13302	77	18	all
spontan	68.13302	77	18	all
nestrpljiv	64.76985	81	17	all
površan	64.76985	81	17	all
pažljiv	60.60660	83	10	all
talentovan	57.96523	84	15	all
opterećen	54.97096	85	13	all
nasilan	54.52037	86	14	all
miroljubiv	51.04446	87	13	all
ironičan	47.53511	88	12	all
vulgaran	47.53511	88	12	all
aseksualan	47.53511	88	12	all
napet	43.98952	91	11	all
ambiciozan	43.98952	91	11	all
grub	43.98952	91	11	all
okrutan	40.40440	94	10	all
tradicionalan	40.40440	94	10	all
nesiguran	40.40440	94	10	all
optimističan	40.40440	94	10	all
nežan	36.77578	98	9	all
dominantan	36.77578	98	9	all

feature	frequency	rank	docfreq	group
rezervisan	36.77578	98	9	all
komunikativan	36.77578	98	9	all
samouveren	36.77578	98	9	all
baksuzan	36.77578	98	9	all
ljigav	33.09880	104	8	all
hladnokrvan	33.09880	104	8	all
savestan	33.09880	104	8	all
primitivan	33.09880	104	8	all
posesivan	33.09880	104	8	all
skeptičan	33.09880	104	8	all
vedar	33.09880	104	8	all
neuredan	33.09880	104	8	all
stabilan	33.09880	104	8	all
ravnodušan	33.09880	104	8	all
sujeveran	33.09880	104	8	all
umeren	33.09880	104	8	all
racionalan	33.09880	104	8	all
ubedljiv	33.09880	104	8	all
umiljat	33.09880	104	8	all
sentimentalan	33.09880	104	8	all
srčan	29.36739	120	7	all
svestran	29.36739	120	7	all
intelektualan	29.36739	120	7	all
poštovan	29.36739	120	7	all
ranjiv	29.36739	120	7	all
ogorčen	29.36739	120	7	all
zloban	29.36739	120	7	all
plemenit	25.57373	127	6	all
operativan	25.57373	127	6	all
poslušan	25.57373	127	6	all
povučen	25.57373	127	6	all
sirov	25.57373	127	6	all
istrajan	25.57373	127	6	all
radostan	25.57373	127	6	all
sujetan	25.57373	127	6	all

feature	frequency	rank	docfreq	group
beskoristan	25.57373	127	6	all
borben	25.57373	127	6	all
zaljubljiv	25.57373	127	6	all
pitom	22.19190	138	4	all
preosetljiv	21.70735	139	5	all
temeljan	21.70735	139	5	all
srdačan	21.70735	139	5	all
nedokazan	21.70735	139	5	all
uvredljiv	21.70735	139	5	all
veseo	21.70735	139	5	all
atraktivan	21.70735	139	5	all
pristrasan	21.70735	139	5	all
mio	21.70735	139	5	all
promašen	21.70735	139	5	all
diskretan	21.70735	139	5	all
anksiozan	21.70735	139	5	all
živčan	18.95764	151	2	all
dostojanstven	17.75352	152	4	all
bezgrešan	17.75352	152	4	all
druželjubiv	17.75352	152	4	all
zamišljen	17.75352	152	4	all
elokventan	17.75352	152	4	all
nerazuman	17.75352	152	4	all
prilagodljiv	17.75352	152	4	all
religiozan	17.75352	152	4	all
zaostao	17.75352	152	4	all
vickast	17.75352	152	4	all
konzervativan	17.75352	152	4	all
žestok	17.75352	152	4	all
luckast	14.21823	164	2	all
čedan	13.68996	165	3	all
superioran	13.68996	165	3	all
slatkorečiv	13.68996	165	3	all
pedantan	13.68996	165	3	all
strog	13.68996	165	3	all

feature	frequency	rank	docfreq	group
impulsivan	13.68996	165	3	all
umišljen	13.68996	165	3	all
setan	13.68996	165	3	all
nepoverljiv	13.68996	165	3	all
snažan	13.68996	165	3	all
bespomoćan	13.68996	165	3	all
izopačen	13.68996	165	3	all
apolitičan	13.68996	165	3	all
frustriran	13.68996	165	3	all
načitan	13.68996	165	3	all
slobodouman	13.68996	165	3	all
lažljiv	13.68996	165	3	all
prefinjen	13.68996	165	3	all
bezazlen	13.68996	165	3	all
velikodušan	13.68996	165	3	all
besraman	13.68996	165	3	all
usiljen	10.08088	186	1	all
bezbrižan	9.47882	187	2	all
oprezan	9.47882	187	2	all
povodljiv	9.47882	187	2	all
problematičan	9.47882	187	2	all
samokritičan	9.47882	187	2	all
snalažljiv	9.47882	187	2	all
inertan	9.47882	187	2	all
maštovit	9.47882	187	2	all
zastrašujući	9.47882	187	2	all
izdržljiv	9.47882	187	2	all
isključiv	9.47882	187	2	all
zavodljiv	9.47882	187	2	all
gord	9.47882	187	2	all
melanholičan	9.47882	187	2	all
odlučan	9.47882	187	2	all
rasejan	9.47882	187	2	all
buntovan	9.47882	187	2	all
šarmantan	9.47882	187	2	all

feature	frequency	rank	docfreq	group
vešt	9.47882	187	2	all
odmeren	9.47882	187	2	all
ćutljiv	9.47882	187	2	all
erotičan	9.47882	187	2	all
principijelan	9.47882	187	2	all
ciničan	9.47882	187	2	all
neposredan	9.47882	187	2	all
brižan	9.47882	187	2	all
nemaran	9.47882	187	2	all
nepouzdan	9.47882	187	2	all
prevrtljiv	9.47882	187	2	all
dinamičan	9.47882	187	2	all
poletan	9.47882	187	2	all
kompetentan	9.47882	187	2	all
provokativan	9.47882	187	2	all
licemeran	9.47882	187	2	all
kolegijalan	5.04044	221	1	all
neumoljiv	5.04044	221	1	all
hirovit	5.04044	221	1	all
prevaran	5.04044	221	1	all
oštrouman	5.04044	221	1	all
šaljiv	5.04044	221	1	all
zajedljiv	5.04044	221	1	all
vragolast	5.04044	221	1	all
pristupačan	5.04044	221	1	all
pravdoljubiv	5.04044	221	1	all
divalj	5.04044	221	1	all
radoznao	5.04044	221	1	all
priprost	5.04044	221	1	all
suzdržan	5.04044	221	1	all
entuzijastičan	5.04044	221	1	all
nepromišljen	5.04044	221	1	all
ponizan	5.04044	221	1	all
privlačan	5.04044	221	1	all
sažaljiv	5.04044	221	1	all

feature	frequency	rank	docfreq	group
popustljiv	5.04044	221	1	all
bezvoljan	5.04044	221	1	all
haotičan	5.04044	221	1	all
neživljen	5.04044	221	1	all
koristoljubiv	5.04044	221	1	all
škrt	5.04044	221	1	all
prostodušan	5.04044	221	1	all
čuvaran	5.04044	221	1	all
temperamentan	5.04044	221	1	all
sumnjičav	5.04044	221	1	all
konvencionalan	5.04044	221	1	all
učtiv	5.04044	221	1	all
tanan	5.04044	221	1	all
teatralan	5.04044	221	1	all
misaon	5.04044	221	1	all
dovitljiv	5.04044	221	1	all
gramziv	5.04044	221	1	all
galantan	5.04044	221	1	all
zbunljiv	5.04044	221	1	all
svadljiv	5.04044	221	1	all
disciplinovan	5.04044	221	1	all
indiskretan	5.04044	221	1	all
zadrt	5.04044	221	1	all
nadmen	5.04044	221	1	all
ohol	5.04044	221	1	all
drzak	5.04044	221	1	all
pragmatičan	5.04044	221	1	all
zlonameran	5.04044	221	1	all
cmizdrav	5.04044	221	1	all

Table 2

Fifteen topics based on Serbian 383 adjectives: coefficients' differences

topics	Griffiths_plus_Deveaud_std	CaoJuan_plus_Arun_std	difference
15	-0.69	-0.25	-0.44
14	-0.01	-0.64	0.63
13	-0.12	-0.54	0.42
12	0.57	-1.10	1.67
11	0.49	-0.77	1.26
10	-0.33	0.28	-0.62
9	1.32	-0.65	1.98
8	0.82	0.02	0.80
7	1.53	-1.40	2.93
6	0.10	-0.08	0.18
5	0.46	0.55	-0.09
4	-1.30	2.19	-3.49
3	-0.66	1.27	-1.93
2	-2.18	1.11	-3.29

Table 3

Fifteen topics based on Goldberg's adjectives: coefficients' differences

Topics	Griffiths_plus_Deveaud_std	CaoJuan_plus_Arun_std	difference
15	-0.28	0.45	-0.73
14	-0.14	-0.94	0.81
13	-1.50	1.20	-2.70
12	0.98	-0.59	1.57
11	-1.25	0.85	-2.10
10	0.60	-0.13	0.73
9	-0.11	-0.50	0.38
8	0.37	0.60	-0.23
7	0.53	-0.70	1.23
6	1.03	-0.30	1.33
5	2.06	-2.25	4.32
4	-1.18	1.36	-2.54
3	-0.65	-0.16	-0.49
2	-0.46	1.10	-1.56

Table 4

Serbian topics and word categories: Overall category distribution per topic

Categories	Serbian Topic1	Serbian Topic2	Serbian Topic3	Serbian Topic4	Total
Abilities, talents or their absence (f)	4.00	5.00	1.00	6.00	16.00
Emotions, moods and cognitions (f)	8.00	9.00	6.00	11.00	34.00
Pure evaluation (f)	9.00	7.00	8.00	10.00	34.00
Roles and relationships (f)	7.00	7.00	7.00	8.00	29.00
Social effects: reactions of others (f)	1.00	6.00	2.00	4.00	13.00
Social status (f)	4.00	0.00	1.00	0.00	5.00
States and activities (f)	1.00	0.00	2.00	0.00	3.00
Temperament and character traits (f)	31.00	29.00	40.00	26.00	126.00
Value orientations (f)	2.00	4.00	0.00	2.00	8.00
Abilities, talents or their absence (p)	0.01	0.02	0.00	0.02	0.05
Emotions, moods and cognitions (p)	0.03	0.03	0.02	0.04	0.12
Pure evaluation (p)	0.03	0.03	0.03	0.04	0.13
Roles and relationships (p)	0.03	0.03	0.03	0.03	0.12
Social effects: reactions of others (p)	0.00	0.02	0.01	0.01	0.04
Social status (p)	0.01	0.00	0.00	0.00	0.01
States and activities (p)	0.00	0.00	0.01	0.00	0.01
Temperament and character traits (p)	0.12	0.11	0.15	0.10	0.48
Value orientations (p)	0.01	0.01	0.00	0.01	0.03

Note. (f) - frequency; (p) - proportion

Table 5

Serbian topics and word categories: Category by topic

Categories	Serbian Topic1	Serbian Topic2	Serbian Topic3	Serbian Topic4
Abilities, talents or their absence (p)	0.06	0.07	0.01	0.09
Emotions, moods and cognitions (p)	0.12	0.13	0.09	0.16
Pure evaluation (p)	0.13	0.10	0.12	0.15
Roles and relationships (p)	0.10	0.10	0.10	0.12
Social effects: reactions of others (p)	0.01	0.09	0.03	0.06
Social status (p)	0.06	0.00	0.01	0.00
States and activities (p)	0.01	0.00	0.03	0.00
Temperament and character traits (p)	0.46	0.43	0.60	0.39
Value orientations (p)	0.03	0.06	0.00	0.03

Note. (f) - frequency; (p) - proportion

Primenjena psihologija
Vol. 16, No. 4, pp. 521-552, 2023

Research Article

Coronaphobia – What Do Coronaphobia Scales Measure? An Analysis of 12 Open Instruments and their Correlates

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ABSTRACT

Previous studies confirmed the psychological, psychosomatic, and economic consequences of the COVID-19 outbreak, which lead to the introduction of a new concept of coronaphobia as a persistent and excessive fear of the novel coronavirus. With the beginning of the pandemic, the interest in coronaphobia-related measurement began and until 2021, 12 instruments were created, with a total of 28 (sub)scales. The first aim of this study was to explore the joined factor structure of these measurements. The second aim was to explore a wide range of correlates of coronaphobia (sociodemographic characteristics, general anxiety disorder, Big Five traits, knowledge about coronavirus, and political orientation). The sample included 347 participants (42.1% male) from the general population of Serbia and data were collected in April 2021. Results showed that only one component could be extracted based on 28 (sub)scales of coronaphobia, meaning that physiological, cognitive, emotional, and behavioral aspects of coronaphobia are rather intercorrelated. Furthermore, among explored correlates, general anxiety disorder had the highest contribution to the explanation of coronaphobia. Additionally, Openness showed a negative, and age showed a positive contribution to the explanation of coronaphobia. Our results suggest that coronaphobia should be understood as a syndrome that captures physiological, cognitive, behavioral, and emotional aspects, and that individuals who are already prone to anxiety disorders are more prone to coronaphobia as well.

Keywords: coronaphobia, factor structure, COVID-19, general anxiety disorder

UDK: 159.9.072: 578.834
DOI: 10.19090/pp.v16i4.2467
Received: 20.04.2023.
Revised: 15.11.2023.
Accepted: 08.12.2023.

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Introduction

In late 2019 in China, several cases of pneumonia with an unknown etiology appeared (Hui et al., 2020). Later, the new virus named severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has been identified as the cause of the illness now known as coronavirus disease 2019 (COVID-19). The World Health Organization (WHO) declared the COVID-19 outbreak a global pandemic on March 11, 2020. The infection quickly spread around the globe (Hui et al., 2020) and so far (March 19, 2023), there have been 760 million confirmed cases of the disease with nearly 6 million deaths (source: https://covid19.who.int).

In addition to physical health consequences, the outbreak of the COVID-19 pandemic also had important psychological consequences for people's lives, such as fear, moderate to severe anxiety, depression, anger, social isolation, exaggerated interpretation of minor symptoms; then psychosomatic consequences such as insomnia; and economic consequences such as job losses and scarcity due to panic buying (Asmundson & Taylor, 2020; Cao et al., 2020; Lee, 2020; Lin 2020; Liu et al., 2020; Wang et al., 2020). Such circumstances led to the coining of a new concept – coronaphobia. Arpaci et al. (2020, pp. 1) define coronaphobia as "a persistent and excessive fear of the novel coronavirus, which can be classified as a particular type of the DSM-V specific phobia", given the presence of unique triggers and fear of the unknown. The main specific characteristic of coronaphobia is that fear comes primarily from physical contact with other people (Arora et al., 2020). Another important characteristic that should be taken into account when exploring coronaphobia is that it represents a maladaptive, excessive fear that interferes with daily functioning as it is the case with all phobias (Arora et al., 2020). Based on a literature review, Arora et al. (2020, pp. 2) defined coronaphobia as "an excessive triggered response of fear of contracting the virus causing COVID-19, leading to accompanied excessive concern over physiological symptoms, significant stress about personal and occupational loss, increased reassurance and safety seeking behaviors, and avoidance of public places and situations, causing marked impairment in daily

life functioning". They further identified three main components of coronaphobia: 1) physiological, which encompasses symptoms such as palpitations, tremors, difficulty in breathing, dizziness, change in appetite, and sleep due to excessive concern and worry; 2) cognitive, which refers to the fear of coronavirus that involving preoccupation with threat-provoking cognitions and could further trigger emotional reactions (e.g., sadness, guilt, anger); 3) behavioral, which refers to avoidance behavior in order to prevent the infection (e.g., avoidance of public transportation and gathering) as well as reassurance behaviors such as constantly checking body vitals, confirming the absence of illness, self-medicating, or excessive hygiene (Arora et al., 2020). It should be noted that the emotional aspect of coronaphobia is not recognized as the main component, but rather as a response to them.

The need for a more specific concept like coronaphobia stems from the unique circumstances surrounding the COVID-19 pandemic. This includes the worldwide scope of the crisis, the extensive media coverage, rapid changes in daily life due to lockdowns and social distancing, and the prevailing uncertainty regarding the future. These factors have resulted in a distinct type of fear and anxiety that differs from generalized anxiety disorder (GAD) or other established concepts. In fact, the inclusion of coronaphobia in psychological discourse is important for accurately describing and studying the unique psychological reactions to the COVID-19 pandemic. It does not replace existing concepts but rather adds a new facet to our comprehension of anxiety and fear responses. For instance, although both generalized anxiety disorder (GAD) and coronaphobia encompass anxiety, there are notable distinctions. GAD typically manifests as a chronic and all-encompassing condition, with individuals experiencing worry across various domains of life. On the other hand, coronaphobia is more specific in nature, centering around e.g. fears associated with contracting the virus, the well-being of loved ones, and the societal consequences of the pandemic (Ahorsu et al., 2020; Schimmenti et al., 2021; Muller et al., 2021).

The first measurement instruments of coronaphobia were soon developed after its importance was recognized. Although the first instruments

were unidimensional (such as The Obsession with COVID-19 Scale from Lee, 2020; Coronavirus Anxiety Scale from Lee et al., 2020; The fear of COVID-19 scale from Ahorsu et al., 2020), subsequent instruments consisted of multiple factors. For example, there are instruments that capture the difference between somatic and nonsomatic factors (Bernardo et al., 2020), fear and somatic concern (Silva et al., 2020), while Dilbaz et al. (2020) distinguish worry, mood, reassurance seeking, and avoidance as coronaphobia dimensions. In a meta-analysis of fear of COVID-19 measures, Muller et al. (2021) identified four instruments only 10 months after the pandemic began. They found that no study validated more than one instrument and that overall study quality was generally low due to the sampling strategy. To the best of our knowledge, until 2021 we found 12 created instruments related to various aspects of coronaphobia (e.g., physiological, cognitive...). Considering a variety of coronaphobia instruments, the first aim of this study was to explore common factor structure of existing coronaphobia instruments to get a better insight into its main dimensions or aspects.

Results from previous research indicate that coronaphobia aspects are related to health-responsible behaviors, i.e., to positive attitudes towards the COVID-19 vaccine (Erdem & Karaman, 2022; Turan et al., 2022) and willingness to vaccinate (Šorgo et al., 2022). The effect of coronaphobia on willingness to vaccinate has been shown to be long-term, over 14 months (Mertens et al., 2022). Thus, coronaphobia plays an important role in public health and can lead to increased vigilance and adherence to public health guidelines. On the other hand, coronaphobia clearly can lead to significant distress and impairment in daily life. Specifically, it can lead to avoidance behaviors that disrupt normal life, such as refusing to leave the house even for essential activities and can also cause significant psychological distress. Therefore, all the consequences and impacts of coronaphobia urges a better understanding of its correlates.

To predict coronaphobia and create preventive strategies, many studies focused on factors related to coronaphobia. In this study, we focused on individual characteristics as predictors of coronaphobia. The first group of

factors comprises demographic characteristics – gender, age, and education level. Regarding gender, results are not consistent across studies, with some studies showing that women are more prone to intense fear of coronavirus compared to men (e.g., Silva et al., 2020; Lippold et al., 2020), and others find no gender differences (e.g., Cao et al., 2020; Perz et al., 2022; Zhang & Ma, 2020). Similar inconsistencies are observed for age, with one group of studies showing that age does not play a significant role in fear of coronavirus (Silva et al., 2020; Evren et al., 2020; Lee, 2020), and another group showing that age is positively (Jain & Jha, 2020; Schweda et al., 2021) or negatively (Lippold et al., 2020) related to fear associated with COVID-19. Although there is limited research regarding the effect of education level, it seems to be positively related to coronaphobia (Lippold et al., 2020).

The second group of factors includes those factors that are corona-specific, such as knowledge about the coronavirus. Even in prior cases of pandemics, such as the Ebola virus outbreak, studies revealed the significant role of knowledge and its negative relation to anxiety and fear (e.g., Mishra et al., 2016). The same findings were noted in the case of the ongoing pandemic, with the knowledge about COVID-19 being negatively related to the fear of COVID-19 (Roy et al., 2020; Terzić-Šupić et al., 2021). However, in some studies, a non-significant correlation was found between knowledge about COVID-19 and fear and stress related to coronavirus (Medina Fernández et al., 2021).

The third group of factors comprises personality characteristics and we differentiate the tendency towards general anxiety disorder (GAD) from the basic personality traits. Previous research showed that coronaphobia was positively related to generalized anxiety among middle school students (Yang et al., 2023) and adults, in which it was the main correlate besides demographics, neuroticism, and health and death anxiety (Lee et al., 2020). Thus, it is expected that GAD will show a significant relation with coronaphobia. Given that GAD is highly related to neuroticism and shares a common genetic basis with it (Hettema et al., 2004), it is not surprising that neuroticism is the strongest predictor of coronaphobia among Big Five personality traits (Lippold et al., 2020; Nikčević & Spada, 2020). Additionally, some studies have identified a negative

relation between coronaphobia and extraversion and conscientiousness, suggesting that these traits might play a role as protective factors (Nikčević & Spada, 2020).

Finally, the fourth group of factors refers to political orientation. It should be noted that only few studies examined the ideological differences in response to the pandemic. Some previous research has shown that individuals who are more conservative and right-orientated tend to report lower levels of fear of COVID-19 (Winter et al., 2023) as well as less general concern about the virus (Ruisch et al., 2021). However, Lippold et al. (2020) reported contrary findings from a longitudinal study on a German sample but also stated that the effect of political orientation changes over time and it is not a stable predictor of COVID-19-related fear as personality traits (especially neuroticism) are.

The main aim of this research was to explore the structure of coronaphobia. Although there are different conceptualisations of coronaphobia, in line with the definition provided by Arora et al. (2020), we expected to detect three main dimensions - physiological, cognitive, and behavioral. For this purpose, we examined the common factor structure of existing instruments that measure all or some of coronaphobia aspects (e,g., only cognitive aspect). Up until 2021, we found 12 created instruments related to various aspects of coronaphobia, all of which were included in this study. The second aim was to explore a wide range of correlates of coronaphobia. First, predictors of coronaphobia were explored, including demographic characteristics, knowledge about the coronavirus, personality traits, and political orientation. Demographic characteristics were the most explored factors of coronaphobia (e.g., age, see Evren et al., 2020; Jain & Jha, 2020; Lee, 2020; Silva et al., 2020; Schweda et al., 2021), thus we included them in the first step of predictors, followed by corona-related predictor such as knowledge of coronavirus, and then we included more general factors that were highlighted in the previous studies (GAD, personality traits, political orientation; e.g., Lee et al., 2020; Lippold et al., 2020; Winter et al., 2023; Yang et al., 2023). In this study, the effects of all these predictions were explored in one model, which could give us better

insight into the most important predictors of coronaphobia. We expect to find strong evidence of relations between coronaphobia and GAD (e.g., Lee et al., 2020). However, considering that previous studies showed mixed results regarding the importance of other characteristics as well as the direction of relations in some characteristics (e.g., Lippold et al., 2020; Winter et al., 2023), we do not have an assumption regarding their effects. Second, we explored the relations between coronaphobia and compliance with preventive behaviors and vaccination status. We expect that coronaphobia is positively related to the practice of preventive behaviors as well as to the willingness to vaccinate as the most effective preventive measure (e.g., Mertens et al., 2022).

Method

Participants and procedure

The sample included 347 participants (42.1% male) from the general population of Serbia (aged between 19 and 54 years; $M = 29.98$, $SD = 9.42$). The majority (45%) were students or had Bachelor's or Master's degree (24.2%) or Ph.D. (1.4%), while 21.3% finished high school and 8.1% finished higher school. The inclusion criterion for the sample was that the participant was over 18 years old and the sample size was determined in accordance with similar research. The data were collected online in April of 2021 by trained psychology students for course credit. The students' task was to collect data from 5 participants in line with predetermined quotas (e.g., one male and one female aged 18-30, one male and one female older than 31 years, etc.), to distribute link to the questionnaires and to inform participants about the main objectives of the study. The study was approved by the Ethical Committee for the Psychological Research of the Department of Psychology, Faculty of Philosophy, University of Novi Sad, Serbia (No. 202103300011_f4Tx).

Measures

In this study several scales for a measure of coronaphobia aspects were adapted to Serbian (see https://osf.io/rnmqh/ for original and adapted items).

Adaptation was done by two independent translators, and then the third translator compared the translations and chose one or adapted existing ones.

Coronavirus Anxiety Scale (CASa; Evren et al., 2020)

The CAS is a 5-item measure of probable cases of dysfunctional anxiety associated with the COVID-19 crisis. The participants were asked to rate the frequency of these symptoms over the past two weeks (0 = *not at all*, 4 = *nearly every day*).

Obsession with COVID-19 Scale (OCS; Lee, 2020)

The OCS is a 4-item scale that measures persistent and disturbed thinking about COVID-19. Participants were asked to rate the frequency of the symptoms during the past two weeks (0 = *not at all*, 4 = *nearly every day*).

COVID-19 Anxiety Scale (C19AS; Chandu et al., 2020)

The C19AS is a 7-item measure of two aspects of COVID-19 anxiety: fear of social interaction (5 items) and illness anxiety (2 items). A semantic differential response scale was given. Respondents were asked to rate given items along a continuum, between two extreme evaluations (*Extremely afraid - Not at all afraid; Always - Never; Extremely worried - Not at all worried; Extremely anxious - Not at all anxious; Extremely concerned - Not at all concerned*), with 4 points in between.

COVID-19 Anxiety scale (CASb; Silva et al., 2020)

The CAS-7 is a 7-item measure (0 = *does not apply to me*, 3 = *very applicable to me*) assessing how participants felt towards the threat of the new coronavirus in the previous days.

COVID-19 Phobia Scale (C19P-S; Arpaci et al., 2020)

The C19P-S is a 20-item measure of coronaphobia as a persistent and excessive fear of the novel coronavirus and includes four subscales: social factors (5 items), psycho-somatic factors (5 items), psychological factors (6 items), and economic factors (4 items). Participants were asked to indicate their

level of agreement with the statements (1 = *strongly disagree*, 5 = *strongly agree*).

Fear of COVID-19 Scale (FCV-19S; Tzur Bitan et al., 2020)

FCV-19S is a 7-item (1 = *strongly disagree*, 5 = *strongly agree*) measure of emotional fear reactions toward the COVID-19 pandemic. Although the original scale was proposed to be unidimensional (Ahorsu et al., 2020), a recent evaluation of the instrument (Tzur Bitan et al, 2020) provided support a two-factor structure which includes emotional fear reactions (4 items) and symptomatic expressions of fear (3 items).

Fear of the Coronavirus Questionnaire (FCQ; Mertens et al., 2020)

The FCQ is an 8-item (1 = *strongly disagree*, 5 = *strongly agree*) measure of experiencing the fear of the coronavirus.

Coronavirus Disease Concern Scale (COVID-19CS; Dadfar & Lester, 2020)

The COVID-19CS is an 18-item (0 = *definitely false*, 3 = *definitely true*) measure of three distinct types of concerns over COVID-19: infection/unsafety (6 items), instability/fear of social isolation (6 items), and insecurity/death fear (5 items).

COVID Stress Scale (CSS; Taylor et al., 2020, for Serbian adaptation see Mihić et al., 2022)

This 36-item scale measures 6 distress domains related to COVID-19 (6 items per each, from 0 = *not at all* to 4 = *extremely*): danger, socio-economic consequences, xenophobia, contamination, traumatic stress symptoms, and compulsive checking and reassurance seeking.

Coronavirus Pandemic Anxiety Scale (CPAS-11; Bernardo et al., 2020)

The CPAS-11 is an 11-item measure of symptoms of anxiety related to the COVID-19 pandemic and includes two subscales: somatic symptoms (5 items) and non-somatic symptoms (6 items). Participants are asked to rate how frequent these symptoms have been for the past two weeks (*0 - never/not at all; 3 - nearly every day in the past two weeks*).

COVID-19 Pandemic Anxiety Scale (COVID-19 PAS; Kumar et al., 2020)

The COVID-19PAS is a 10-item scale (0 = *did not apply to me at all*, 3 = *applied to me very much or most of the time*) that measures anxiety related to the coronavirus pandemic. It consists of two subscales: fear - fear of going out and meeting strangers, listening to news updates, and possible death due to the coronavirus (6 items) and somatic concerns - perceived bodily concerns regarding COVID-19 (4 items).

COVID-19 Phobia Scale (Dilbaz et al., 2020)

This is a 22-item scale (1 = *strongly disagree*, 5 = *strongly agree*) that measures emotions and behaviours related to the COVID-19 pandemic, grouped into 4 domains: mood (3 items), precaution (5 items), avoidance (2 items), and worry (10 items). It's important to note that due to technical issues, two items (in the original paper labeled as 36 and 39 - "I need to talk to others after learning about coronavirus" and "I care to pay attention to healthy food" from Dilbaz et al., 2020) were omitted from the online form.

Besides coronaphobia instruments, other measures were also used:

Knowledge About the Coronavirus

This is a 12-item test (0 = *False*, 1 = *True*) that assesses knowledge about coronavirus regarding the virus, symptoms, protective behaviors, and treatment. From 12 items, 8 which were still held were used from the Teovanović et al. (2021) and 4 were added in line with new knowledge about the coronavirus announced on the WHO website.

General Anxiety Disorder-7 (GAD-7; Spitzer et al, 2006, for Serbian adaptation see Rokvić, 2019)

The GAD-7 is a 7-item measure (0 = *not at all*, 1 = *several days*, 2 = *more than half the days*, 3 = *nearly every day*) of a generalized anxiety disorder (GAD) and assesses symptom severity, describing the most prominent diagnostic features for GAD. Participants are asked if they were bothered by anxiety symptoms over the past two weeks.

Mini IPIP-6 (Goldberg, 1999, for Serbian adaptation see Međedović & Bulut, 2017)

Mini IPIP is a 20-item measure of Big Five personality traits (neuroticism, extraversion, agreeableness, conscientiousness, and openness), each per 4 items (1 = *totally disagree*, 5 = *totally agree*).

Political orientation

Political orientation was measured via one item with the description of economic left and right orientation. According to Kroh (2017), an 11-point scale produces the highest validity and this response format was used (0 = *strongly left*, 5 = *center*, 10 = *strongly right*).

The COVID-19 Protective Behaviors Scale (Dinić & Bodroža, 2021)

This is a 5-item measure of various COVID-19 protective behaviors (e.g., handwashing, physical distancing). Participants rated the frequency of each behavior (0 = *never*, 4 = *all the time*) in the last 3 months.

Vaccination status

Participants were asked whether they: 1) are not planning to be vaccinated against COVID-19 (n = 157 or 45.2%); 2) didn't apply for vaccination yet but planning to do so (n = 123 or 35.4%); 3) applied for or already vaccinated against COVID-19 (n = 67 or 19.3%).

Descriptives and alpha reliability for all instruments were presented in Table 1.

Results

Descriptives and alpha reliability

Several scales showed normality violation (> ±2 for skewness and kurtosis, see Dinić, 2019 and Table 1) and their scores were normalized by *rankit* transformation. Alpha reliability was satisfactory, except for the Mood subscale from the Phobia Scale COVID-19 and Knowledge about coronavirus.

Overall, mean scores for the majority of the scales and subscales are relatively low, which is not surprising, given that coronaphobia encompasses an excessive and maladaptive forms of fear, anxiety and other aspects related to coronavirus. Moreover, according to our results, the lowest mean scores were observed on the Anxiety of COVID Scale and the subscale of Illness Anxiety from The Covid-19 Anxiety Scale, indicating that these (sub)scales likely capture more extreme variants of coronaphobia expressions than others.

Additionally, most of these scores are also lower when compared to the scores obtained in the original studies (e.g. Arpaci et al., 2020; Chandu et al., 2020; Evren et al., 2020; Silva et al., 2020; Tzur Bitan et al., 2020). One possible explanation for this outcome could be related to the timing of our testing. Precisely, all the original papers that introduced newly developed coronaphobia scales which we subsequently used in our study were published during the first year of the pandemic. Since the data for our study was gathered in April, 2021, it could be assumed that by then people learned more about the virus and got somewhat adapted to living in new circumstances which likely resulted in lower levels of fear and anxiety in comparison to the early stage of the pandemic.

Table 1

Descriptive statistics and Cronbach's alpha for all scales

Scale	*M*	*SD*	Skewness	Kurtosis	α	Min	Max	No. items	Scale range
Anxiety of COVID Scale (CAS; Evren et al., 2020)	1.03	2.72	3.70	15.82	.93	0	20	5	0-4
Obsession with COVID-19 Scale (OCS; Lee, 2020)	1.79	2.72	2.35	6.72	.81	0	16	4	0-4
COVID-19 Anxiety Scale (C19AS; Chandu et al., 2020)	3.44	3.91	1.67	3.14	.89	0	21	7	0-3
Illness anxiety	0.76	1.05	2.02	5.29	.62	0	6	2	
Fear of social interaction	2.68	3.05	1.47	2.14	.86	0	15	5	

COVID-19 Anxiety scale (Silva et al., 2020)	3.67	4.70	1.66	2.40	.92	0	21	7	0-3
COVID-19 Phobia Scale (C19PS; Arpaci et al., 2020)	34.49	14.14	1.58	2.83	.95	20	100	20	1-5
Social factors	10.88	4.95	0.72	-0.22	.88	5	25	5	
Psycho-somatic factors	6.37	3.10	3.29	12.07	.90	5	25	5	
Psychological factors	11.75	5.62	1.10	0.60	.90	6	30	6	
Economic factors	5.49	2.61	2.50	7.30	.85	4	20	4	
Fear of COVID-19 Scale, (FCV-19S; Tzur Bitan et al., 2020)	9.94	4.69	2.67	8.59	.90	7	35	7	1-5
Emotional fear reaction	6.31	3.23	1.88	3.70	.85	4	20	4	
Symptomatic expression of fear	3.63	1.76	3.94	17.93	.90	3	15	3	
Fear of the Coronavirus Questionnaire (FCQ; Mertens et al., 2020)	18.30	6.73	0.56	0.03	.84	8	40	8	1-5
Coronavirus Disease Concern Scale (COVID-19CS; Dadfar & Lester, 2020)	11.00	9.66	1.28	1.72	.91	0	48	18	0-3
Unsafety	5.80	4.69	0.63	-0.39	.86	0	18	6	
Fear of social isolation	3.93	4.05	1.28	1.37	.80	0	18	6	
Fear of death	1.85	2.74	2.21	5.79	.82	0	15	5	
COVID Stress scales (CSS; Taylor et al., 2020)	25.09	22.35	1.48	2.49	.96	0	120	36	0-4
Danger	8.86	6.21	0.31	-0.73	.89	0	24	6	
Socio-economic consequences	2.75	4.65	2.11	4.45	.94	0	24	6	

Xenophobia	3.70	5.23	1.76	2.84	.92	0	24	6	
Contamination	4.64	5.43	1.39	1.53	.93	0	24	6	
Compulsive checking and reassurance seeking	5.14	5.37	1.25	1.18	.88	0	24	6	
Coronavirus Pandemic Anxiety Scale (CPAS-11; Bernando et al., 2020)	5.57	6.17	1.81	3.52	.91	0	33	11	0-3
Somatic symptoms	2.07	3.22	1.89	3.20	.90	0	15	5	
Non-somatic symptoms	3.51	3.52	1.48	2.27	.83	0	18	6	
COVID-19 Pandemic Anxiety Scale (COVID-19 PAS; Kumar et al., 2020)	5.00	5.51	1.79	3.49	.88	0	30	10	0-3
Somatic concerns	1.97	2.61	1.60	2.12	.82	0	12	4	
Fear	3.02	3.41	1.74	3.33	.81	0	18	6	
COVID-19 Phobia Scale (Dilbaz et al., 2020)	39.54	15.70	1.30	1.58	.94	20	100	22	1-5
Mood	6.98	2.67	0.51	-0.05	.47	3	15	3	
Precaution	9.74	4.28	1.09	0.91	.81	2	25	5	
Avoidance	4.74	2.40	0.52	-0.81	.79	2	10	2	
Worry	18.09	8.87	1.44	1.34	.94	10	50	10	
COVID-19 protective behaviors	14.00	4.58	-0.02	-0.90	.80	5	24	5	0-4
Knowledge about coronavirus	8.64	1.51	-0.44	0.64	.49	3	12	12	0-1
General anxiety disorder (GAD-7)	0.69	0.80	1.22	0.55	.94	0	3	7	0-3
Neuroticism	2.86	0.87	0.25	-0.18	.67	1	5	4	1-5
Extraversion	3.14	0.90	-0.08	-0.34	.72	1	5	4	1-5
Agreeableness	3.80	0.74	-0.41	-0.25	.61	1.50	5	4	1-5
Conscientiousness	3.63	0.89	-0.45	-0.46	.71	1.25	5	4	1-5
Openness	3.81	0.88	-0.54	-0.21	.55	1	5	4	1-5
Political orientation	5.21	2.37	-0.22	-0.27	-	0	10	1	0-10

Horn's parallel analysis under the principal component analysis on 28 (sub)scales of coronaphobia resulted in one component that could be extracted ($\lambda_1 = 16.46$, $\lambda_2 = 1.33$, whereas in parallel analysis $\lambda_1 = 1.64$, $\lambda_2 = 1.53$) which explained 58.79% of the total variance. The highest loadings on this component have scales referring mostly to what could be categorized as the cognitive aspect of coronaphobia (e.g., worry, fear, and anxiety, see Table A in Supplement for loadings), but it should be noted that all scales have high loadings (in a range from .57 to .90). The lowest loadings had scales referring to economic consequences. The component score was calculated through the regression method and used in further analyses. Preliminary, we conducted principal component analysis on item-level, however it also resulted in a one-component solution (the 1st component explained 42.97% and the 2nd only 5.44% of the total variance). Items with the highest loadings belong to different instruments but capture mostly (increased) fear of getting infected and catching coronavirus, persistent concern and worry about one's health, as well as preoccupation with thoughts about the disease which mostly refers to the cognitive aspect of coronaphobia. Results from analysis on item-level could be seen in Table A at https://osf.io/rnmqh/.

Correlations between coronaphobia component and the rest of the correlates indicated that women had higher level of coronaphobia compared to men and that there was a positive correlation with age (Table 2, for the rest of correlations between all variables see Tables B, C, D at https://osf.io/rnmqh/). GAD showed the highest and positive correlation with coronaphobia, followed by neuroticism, while extraversion and openness showed significant negative correlations. Other variables (e.g., knowledge about coronavirus, political orientation) showed no significant correlations with coronaphobia.

In the hierarchical regression analysis of the prediction of coronaphobia, demographic characteristics were included in the 1st block (gender, age, and education), knowledge about the coronavirus in the 2nd block, GAD and basic personality traits in the 3rd block, and political orientation in the 4th block. Results showed that the 1st and the 3rd blocks of predictors had significant contributions

to the explanation of coronaphobia (Table 2), with the total $R^2 = .44$, $p < .001$. In the final model, the highest significant contribution had GAD and then age in positive and openness in a negative direction.

Table 2

Predictors of coronaphobia component in hierarchical regression analysis

Predictors	Step 1	Step 2	Step 3	Step 4	*r*
Gender	.12*	.12*	.002	.003	.15***
Age	.17**	.17**	.16***	.16***	.16**
Education	-.01	-.01	.004	.004	.01
Knowledge about coronavirus		.06	.05	.05	.07
General anxiety disorder			.64***	.64***	.61***
Neuroticism			-.05	-.05	.28***
Extraversion			-.03	-.03	-.15**
Agreeableness			.05	.05	.08
Conscientiousness			.04	.04	.08
Openness			-.15**	-.15**	-.16**
Political orientation (higher scores indicate right-wing orientation)				.01	-.07
ΔR^2	.04**	.004	.40***	.000	

Note. In the case of gender, point biserial correlation (r_{pb}) was calculated. Gender coded as 1 = male, 2 = female. ***$p < .001$, **$p < .01$, *$p < .05$.

Finally, preventive behaviors showed a significant positive correlation with coronaphobia component (r = .44, p < .001), as well as vaccination status (r_{pb} = .17, p < .001), with those who plan to apply for and applied for/have already been vaccinated showed higher coronaphobia[1].

Similarities between the coronaphobia and GAD

Based on their correlations with the variables included in this research (knowledge about coronavirus, Big Five traits, political orientation, preventive behaviors, and vaccination status), we calculated profile similarity[2] between the coronaphobia component and GAD and it was .28, indicating a similar to moderately similar profile. The main distinction between the coronaphobia and GAD is in correlations with protective measures. Thus, GAD does not show significant correlation with vaccination status (.099) and correlation with protective behaviors is lower (.28), compared to coronaphobia component. In addition, we tested incremental predictive validity of coronaphobia component over and above GAD in prediction of vaccination status. Overall model was significant ($\chi^2(2)$ = 18.26, p < .001), explaining from 5% (Cox & Snell R^2) to 7% (Nagelkerke R^2) of vaccination status. Results showed that GAD was not significant predictor (Exp(B) = 0.90, p = .441), even when it is the only predictor in the model (Exp(B) = 1.23, p = .067), while coronaphobia component was

[1] One-way ANOVA was conducted to test the differences in coronaphobia based on the vaccination status of participants (F (2,344) = 8.93, p < .001). The *LSD* post-hoc test's results showed no significant differences between the group of participants who planned to apply for vaccination (2) and the group of participants who have already applied for/have already been vaccinated (3) (M_{diff} = -0.10, p = .486), which is why these two groups were merged into one. Further, both of these two groups significantly differed from the group of those who were not planning to get vaccinated (1) (M_{diff12}= -0.40, p = .001; M_{diff13} = -0.51, p = .001).

[2] Profile similarity was calculated as Cronbach and Gleser's D statistic, which represents (dis)similarity with lower values indicating smaller distance or higher similarity. D statistic could be interpeted in terms of Cohen's d effect size measure (Cohen, 1988), with values 0.20, 0.50, and 0.80 indicating high, medium, and low-profile similarity.

(Exp(B) = 1.74, p < .001). Therefore, coronaphobia is related to corona-specific outcomes which is expected based on its conceptualization, while GAD showed lower association with these specific aspects.

Discussion

The main aim of this research was to explore the structure of coronaphobia aspects based on 12 available measures with a total of 28 (sub)scales. Contrary to our expectation, we extracted one component instead of several components referring to different aspects of coronaphobia (physiological, cognitive, and behavioral). The first component captures a large amount of the total variance (58.79%) with the scales having the highest loadings referring mostly to what could be classified as cognitive aspect of coronaphobia (e.g., worry, fear). The highest loading had the subscale Worry from The COVID-19 Phobia Scale (Dilbaz et al., 2020) followed by Psychological factors from another COVID-19 Phobia Scale (Arpaci et al., 2020) both encompassing such aspects of coronaphobia as fear and anxiety caused by potential virus infection, or just by listening and thinking about coronavirus, then Social factors from the same scale and Fear of Social interaction from The COVID-19 Anxiety Scale (Chandu et al., 2020). However, all scales have relatively high loadings, so it cannot be concluded that the extracted component is limited to one aspect of coronaphobia, particularly considering that some scales assess multiple aspects simultaneously. These results indicate that the differentiation of coronaphobia aspects is not clear, at least not at the measurement level. Thus, we should better label coronaphobia as a syndrome that captures various cognitive, emotional, physiological, behavioral, and socio-economic aspects. Previous research have also suggested that different aspects of fear (disease anxiety and COVID-related fear about income) are central in the network of pandemic anxiety, coronaphobia, and other factors (Vargová et al., 2023), indicating the complexity and interconnectedness of various symptoms and aspects of coronaphobia. However, it is worth noting that previous research, which explored the factor structure of four COVID-19 fear measures, resulted in four latent factors, including both fear symptoms and fear related to

various consequences (Mertens et al., 2021). Therefore, although a distinction could be made based on fear themes, it seems that it could not be made based on a wider range of symptoms surrounding coronaphobia.

The second aim of this study was to explore a wide range of correlates of coronaphobia. First, predictors of coronaphobia were explored in domains of demographic characteristics, knowledge about the coronavirus, personality traits, and political orientation. Results showed that the main predictor of coronaphobia was GAD. Considering the correlational design of our study, we could conclude that individuals with a tendency towards developing GAD posed a major risk for developing coronaphobia, as well as that individuals with coronaphobia could suffer from GAD. Although GAD was not explored in the context of other potential predictors in previous research, our findings are in line with previous studies in which GAD showed a high association with coronaphobia (e.g., Lee et al., 2020). Additionally, previous research also found that coronaphobia was more related to general anxiety, indicating its eligibility in being dysfunctional and clinically significant (Vargová et al., 2023).

Considering that the dominant predictor of coronaphobia was GAD, we should take into account the similarity between these two constructs. Based on the variables included in this research, profile similarity between them ranges from high to moderate, but results do not support that they are the same construct. The main distinction between them is in their relationships with corona-specific outcomes, which is stronger for coronaphobia. Similarly with the distinction between broad and narrow personality traits, empirical evidence confirmed that narrow traits better predict complex, real-world criteria (e.g., Paunonen & Nicol, 2021).

Considering that GAD showed a high correlation with neuroticism (r = .56, p < .001), including both of them in the model resulted in a non-significant effect of neuroticism, despite a significant correlation between neuroticism and coronaphobia. In the final model, among the basic personality traits, only openness showed a small and negative effect on coronaphobia. It could be assumed that intellectual curiosity and information-seeking captured in openness (e.g., Goldberg, 1999) reduce fear and worry about the infection and

consequences of coronavirus. Since the fear of coronavirus is mostly due to unknown circumstances of infection and the course of the disease, it could be assumed that individuals who are more open to experience invest more resources in information gathering, as well as in coping with crisis, which repeals the coronaphobia.

Regarding demographic characteristics, the only significant predictor of coronaphobia is age, in a positive direction. Previous research showed mixed results regarding the relations with age (e.g., Silva et al., 2020; Lippold et al., 2020). However, our results indicated that older people manifest higher levels of coronaphobia. This finding is in line with some prior research (e.g. Jain & Jha, 2020; Niño et al., 2020) suggesting that due to their vulnerable immune system, older people face higher risk of being infected as well as the susceptibility to severe forms of the disease, which consequently results in increased levels of fear.

Previous studies showed mixed results regarding the effects of gender (e.g., Cao et al., 2020; Silva et al., 2020) and positive effect of education (Lippold et al., 2020), but in our study, they do not show significant effects in the final model. Gender only showed a significant correlation, with women having higher levels of coronaphobia, although this effect was rather small. Similarly, knowledge about the coronavirus as well as political orientation were not significant correlates of coronaphobia. Considering that data were collected in 2021, it could be assumed that more information regarding coronavirus was known and available, which was also indicated in high performance on the Knowledge about coronavirus test. Thus, while knowledge about coronavirus appeared to be an important factor at the onset of the pandemic, in the current stage, other characteristics are more associated with coronaphobia. Results regarding the non-significant role of political orientation in the explanation of coronaphobia are in line with Lippold et al.'s (2020) conclusion that political orientation is not a stable predictor of fear of coronavirus, but rather personality traits.

There are several limitations of this study. First, the sample was convenient which limited the generalizability of the conclusions. Second, this study was limited by its exclusive use of online survey methodology. Third, due to a large set of measures, it is possible that participants got tired, which could induce response biases. Although participants had the option to fill out the measures on two occassions and not all at once, we did not have attention-check items. Finally, given the cross-sectional and convenient sample, the causal ordering of the variables could not be determined.

Despite these limitations, this study provides valuable insights into coronaphobia phenomenon. The results indicated that coronaphobia is rather a syndrome and that its specific dimensions could not be easily distinguished, at least based on existing measures. Furthermore, the main correlate of coronaphobia is in the domain of psychopathological disorder (GAD), followed by rigid cognitive style (openness) and older age. Based on our findings, it is evident that certain groups of people may be more vulnerable, and it is important for healthcare and mental health professionals to adjust their practices accordingly. Therefore, interventions should be prioritized and tailored to meet the specific needs of individuals. Healthcare professionals should pay particular attention to individuals with GAD and similar disorders to provide adequate support in coping with corona-related thoughts, emotions, psychosomatic issues and consequences. This is especially important due to pre-existing vulnerabilities and increased risk of adverse effects on mental health of these individuals caused by prolonged stress exposure during the pandemic. In addition, our results highlight the importance of adopting an age-specific approach. Older individuals are more prone to coronaphobia and they may require a different counseling approach compared to younger ones. Practitioners should focus on providing targeted support to this age group, which may involve engaging in clear and reassuring discussions about their specific risk factors and safety measures. Encouraging individuals to stay informed through reliable sources and maintaining a balanced perspective can also contribute to reducing excessive fears. Future studies should examine

coronaphobia and its influence on mental health over time by using a large and representative sample.

Following the Open Science practices

The authors of this paper are dedicated to following the core principles of open science. We believe that adopting such practices is highly beneficial since it promotes a transparent, collaborative, and accessible research enviroment. Moreover, open science practices enhance the visiability, reproducibility, and verifiability of the produced scientific findings and can also have the positive impact on the general trust in science. In line with this, we deposited all used coronaphobia instruments in this research, including all relevant information, original items and items adapted to Serbian, a codebook, all utilized data and syntaxes, as well as the supplementary materials. All of the aforementioned can be found at the Open Science Framework (OSF) at the following link: https://osf.io/rnmqh/.

Ethical approval

The study was approved by the Ethical Committee for the Psychological Research of the Department of Psychology, Faculty of Philosophy, University of Novi Sad (code 202103300011_f4Tx).

Conflict of interest

We have no conflicts of interest to disclose.

Data availability statement

Data, material, and syntax are available at https://osf.io/rnmqh/.

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Supplement

Table A

Loadings of coronaphobia scales on the first component

Scale or subscale	Loading
Worry (COVID-19 Phobia Scale; Dilbaz et al., 2020)	.90
Psychological factors (COVID-19 Phobia Scale; Arpaci et al., 2020)	.87
Fear of social interaction (COVID-19 Anxiety Scale; Chandu et al., 2020)	.86
Social factors (COVID-19 Phobia Scale; Arpaci et al., 2020)	.85
Contamination (COVID Stress scales; Taylor et al., 2020)	.84
Anxiety of COVID-19 (COVID-19 Anxiety Scale; Silva et al., 2020)	.83
Fear of the Coronavirus (Fear of the Coronavirus Questionnaire; Mertens et al., 2020)	.83
Fear (COVID-19 Pandemic Anxiety Scale; Kumar et al., 2020)	.82
Unsafety (Coronavirus Disease Concern Scale; Dadfar & Lester, 2020)	.81
Non-somatic symptoms (Coronavirus Pandemic Anxiety Scale; Bernando et al., 2020)	.81

Emotional fear reaction (Fear of COVID-19 Scale; Tzur Bitan et al., 2020)	.80
Precaution (COVID-19 Phobia Scale; Dilbaz et al., 2020)	.79
Illness anxiety (The COVID-19 Anxiety Scale; Chandu et al., 2020)	.78
Danger (COVID Stress scales; Taylor et al., 2020)	.77
Fear of social isolation (Coronavirus Disease Concern Scale; Dadfar & Lester, 2020)	.77
Fear of death (Coronavirus Disease Concern Scale; Dadfar & Lester, 2020)	.77
Xenophobia (COVID Stress scales; Taylor et al., 2020)	.76
Obsession with COVID-19 (The Obsession with COVID-19 Scale; Lee, 2020)	.74
Compulsive checking and reassurance seeking (COVID Stress scales; Taylor et al., 2020)	.73
Somatic concerns (COVID-19 Pandemic Anxiety Scale; Kumar et al., 2020)	.72
Somatic symptoms (Coronavirus Pandemic Anxiety Scale; Bernando et al., 2020)	.72
Psycho-somatic factors (COVID-19 Phobia Scale; Arpaci et al., 2020)	.71

Avoidance (COVID-19 Phobia Scale; Dilbaz et al., 2020)	.70
Anxiety of COVID (Anxiety of COVID Scale; Evren et al., 2020)	.66
Symptomatic expression of fear (Fear of COVID-19 Scale; Tzur Bitan et al., 2020)	.66
Socio-economic consequences (COVID Stress scales; Taylor et al., 2020)	.65
Economic factors (COVID-19 Phobia Scale; Arpaci et al., 2020)	.63
Mood (COVID-19 Phobia Scale; Dilbaz et al., 2020)	.57

Primenjena psihologija
Vol. 16, No. 4, pp. 553-580, 2023

Research Article

Open Access Practice in Personality Research: a Bibliometric Perspective

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ABSTRACT

The primary aim of this study was to investigate the structure and dynamics of current research in personality psychology, with a particular focus on open access (OA) practices. A set of 57296 research articles in personality psychology indexed in the Scopus database were analyzed based on their online accessibility: closed (39523), green OA (8770), gold OA (4506), bronze OA (2704), and hybrid gold OA (1793). Although the proportion of OA articles in the overall sample was relatively modest (31%), there has been a consistent upward trend since 2012. Notably, the most significant increase was observed in the proportion of gold OA articles, whereas the number of deposited articles (green OA), not otherwise freely available online, experienced a decline. The knowledge domain of non-OA articles in personality psychology can be broadly delineated into five clusters: (Big Five) personality traits, personality disorders, emotion regulation, Dark Triad/Tetrad, and psychometrics. The emergence of COVID-19 as a "hot" research topic resulted with significant differences in the knowledge domain of non-OA and OA articles. Co-authorship network analysis revealed that authors from Western countries act as the central hub in personality research, though this centrality diminishes when only gold OA articles were taken into account. Gold OA articles performed the worst on most impact and outreach metrics except one, significantly surpassed by green OA articles. As a takeaway, it may be said that although you may need a significant amount of money to do the research, you don't need it to make your research open and make an impact.

Keywords: personality psychology, open access, alternative metrics, bibliometric analysis

UDK: 159.923.072:001
DOI: 10.19090/pp.v16i4.2511
Received: 12.10.2023.
Revised: 05.12.2023.
Accepted: 12.12.2023.

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Introduction

The open science movement has brought about radical changes in scientific research over the past two decades. It emerged mainly as a reaction to constantly growing journal subscription fees and limited accessibility to scientific publications (Nabe & Fowler, 2012; Jones et al., 2013; Schiermeier & Mega, 2017). The main motive behind this movement was to make all society members able to freely access scientific results, primarily articles, but also data, methodology, reviews, educational material, and software. Nowadays, a growing number of research funding institutions requires researchers to make their results freely accessible both to other academics and to general public (Piwowar et al. 2018). This requirement refers particularly to the results of publicly funded research. After adopting several relevant legal documents related to open science in 2012, European Commission started to strongly support opening research for all. These endeavors resulted in the development of two comprehensive open science portals: Open Access Infrastructure for Research in Europe (OpenAIRE) and European Open Science Cloud (OESC).

The number of open science tools and services, aimed to support both sharing and finding free scientific knowledge, is constantly growing. These include, but are not limited to, various repositories for scientific publications (e.g., PsyArXiv hosted at OSF), primary data repositories (e.g., Zenodo), general open platforms (e.g., ScienceOpen), open educational resources (e.g., OER Commons), services for open evaluation (e.g., Dimensions), and even browser extensions (e.g., Unpaywall). Academic social networks like ResearchGate and Academia.edu are widely used for self-archiving research papers. However, the sustainability of this trend is uncertain due to possible legal issues concerning the archiving of articles without publisher's consent (Björk, 2016). The problem of accessibility to scientific publications is also reflected through the growing popularity of illegal services like Sci-Hub and LibGen, which are basically peer to peer networks for sharing full-text articles (Greshake, 2017).

Open access (OA) is the most well-known aspect of open science, often wrongly equated to open science itself (Smederevac et.al., 2020). It refers to

providing free and open online access to scientific publications based on one or more of three typical OA models. Gold OA denotes publications that are published in journals that provide free online access to all of their articles but requiring authors to pay the article processing fee (APC). Most of these journals are listed in the Directory of Open Access Journals (DOAJ) (Gargouri et al., 2012). Hybrid OA articles are published in journals with subscriptions, but the authors also need to pay APCs to make their articles freely available for reading. Unlike the hybrid OA articles, bronze OA articles published in subscription journals lack open license information and are accessible only through the publisher's website. Availability of these articles are usually based on journal editorial decision, and it is often unclear for how long free access to these articles will be provided (Piwowar, 2018). Additionally, articles often become available on the publisher's website only after a certain period of time called the "embargo period" (Laakso & Björk, 2013). Finally, green OA refers to publications deposited to various institutional or disciplinary repositories. Publishers usually have clearly defined policies allowing authors to deposit their original manuscripts prior to peer review (pre-print) or even after the manuscript has been peer reviewed (post-print).

Bibliometric analysis can provide valuable insights into the practice of open-access publishing. Björk et al. (2010) discovered that, on average across all disciplines, the open-access availability of papers published in 2008 was 20.4%, with 8.5% falling under gold OA and 11.9% categorized as copies available through repositories and websites (green OA). Gargouri et al. (2012) conducted their study using two large samples - the first included articles with a publication year range of 2005-2010, while the second comprised articles with a publication year range of 1998-2006. Their results are similar to those of Björk et al. (2010). In the first sample, the average overall percentage of OA articles was 24%, and this remained steady throughout the period under examination. In the sample taken from 1998 to 2006, the average overall percentage was 20%, which increased from 14% in 1998, to 21% in 2006. According to the study conducted by Piwowar et al. (2018), only 28% of scientific papers were found to be freely accessible online. Many of these papers were found to be of bronze OA type, which is

surprising since this type of OA is underexplored in the literature, suggesting a need for further investigation.

Previous studies show differences in OA availability across disciplines. Chemistry and earth sciences had the lowest overall share of OA, while medicine, biochemistry, genetics, and molecular biology had higher rates of gold OA. Green OA was most prevalent in mathematics, social sciences, and physics (Björk et al., 2010). Research by Gargouri et al. (2012) found that social sciences, chemistry, engineering, and technology had the lowest percentage of gold OA, while biomedical research, clinical medicine, and health sciences had the highest. Piwowar et al. (2018) found that over half of the articles in biomedical research and mathematics were open access, while in chemistry and engineering, this proportion was below 20%. Green OA was found to be particularly popular in physics and mathematics, where more than a fifth of papers were available in repositories. Hybrid articles were most prevalent in mathematics (9.4%), biomedical research (8.1%), and clinical medicine (6.3%). The highest proportions of gold OA were identified in biomedical research (15.3%), health sciences (11.7%), mathematics (11.2%), and clinical medicine.

According to the study conducted by Gargouri et al. (2012), it was discovered that the percentage of OA articles in the field of psychology was 28% on average in the sample that included articles published between 2005 and 2010, while it was 25% in the sample that included articles published between 1998 and 2006. Six years later, Piwowar et al. (2018) reported a small increase in the proportion of OA articles, which was around 30%. More recently, Björk and Korkeamäki (2020) discovered that almost 40% of psychological journals included in the Scopus database and published outside the top four leading countries in scientific publishing (namely, the USA, UK, Germany, and the Netherlands), were open access.

Open science holds particular significance for the field of psychology, especially in light of the replication crisis it experienced over the past decade. This crisis originated with the findings of the Open Science Collaboration study (Open Science Collaboration, 2015), followed by numerous articles criticizing the use of questionable research procedures (Shrout & Rodgers, 2018). As a

consequence, a credibility revolution ensued, prompting the adoption of improved standards for evaluating psychological science. These standards include focus on transparency and openness, requirement for preregistration of studies before conducting them, increased emphasis on direct replication studies, and application of stricter criteria for both quality and quantity of evidence necessary to support scientific claims (Vazire, 2018).

According to Atherton et al. (2021), personality psychology played a significant role in research credibility revolution. In the 1970s, there was a debate among authors about factors that determine behavior, such as personality traits or situations. This debate threatened to cast doubt on the whole field. However, it turned out to be good preparation for credibility revolution that would occur later. This is because researchers from the field of personality psychology adopted some of the norms and values that credibility revolution advocates, such as transparency of research methodology and sharing data. Furthermore, personality psychology plays a central role in various subfields of psychology, as evidenced by bibliometric studies (Yang & Chiu, 2009). Over the past decade, studies in the field of personality psychology have covered various topics, including different models and theories, social and partner relations, conceptual and theoretical frameworks of the Five-Factor Model, statistical analyses, and personality traits. Substantial interest has also been directed towards exploring well-being, motivation, emotions, perception of others, and the lifelong development of personality. Additionally, there has been noteworthy research on biological and medical aspects, including behavioral genetics and biological foundations of personality (Piotrowski, 2021).

To the best of our knowledge, there are very few studies that used bibliometric analysis to explore the knowledge domain within personality psychology (Allik, 2013; Piotrowski, 2021), and none of them have explored the specifics of open access publications. Furthermore, most of the similar studies in psychology were focused on citation analysis (Pajić, 2023), often focusing merely on the number of citations of specific journals, authors, or countries, and neglecting other relevant aspects of scientific communication, such as patterns of international collaboration or alternative measures of research impact, e.g.,

citations in policy documents or mentions in social media. Finally, most of bibliometric studies have been of relatively limited scope, focusing solely on specific topics within personality psychology (Chen et.al., 2019) or only on particular, often the most influential, international journals in the field (Allik, 2013).

A study conducted by Babić and Jevremov (2021) looked into differences in topic structures between open and closed access articles in psychological research. The study also analyzed trends in the number of OA articles across various subfields of psychology. Although the study found that personality psychology was not among the top disciplines with a high prevalence of OA, there was a noticeable growing trend in publishing OA articles. However, this research did not address other relevant questions regarding the specifics of personality research. One such query pertains to the prevalent research topics in personality psychology found in OA articles and their potential variations compared to articles available solely through subscription. This type of variability in the field of personality psychology may be expected due to its broadness, heterogeneity, and numerous relations with other disciplines. Themes in personality psychology primarily relate to social and medical disciplines, but previous studies reveal differences in OA type prevalence between these two disciplines (e.g., Gargouri et al., 2012).

Current study

The current study is based on explorative bibliometric analyses and has two main goals. The first is to explore the trends in publishing research results in personality psychology under typical OA models. It is expected that the share of OA articles will show a growing trend as it was suggested by some previous research. The second aim is to analyze the differences between non-OA articles on one side, and OA articles of different types (gold, hybrid, bronze, green) on the other. These differences are expected in at least three aspects. The first is the structure of predominant research topics described by the most frequent keywords mentioned in articles of different types. The second aspect are differences in general outreach and impact of articles, measured by the number

of citations and different alternative metrics, such as the number of shares on social media, number of mentions in online sources, and the number of captures in reference management software. Finally, the third aspect is differences in patterns of co-authorships on a country level which could point out variations in OA practice among the authors originating from countries of different economic and cultural backgrounds.

Method

Data Sample

The sample consisted of 57296 publications, 17773 OA and 39523 non-OA, published in the twenty-year period from 2003 till 2022. Publications metadata were retrieved in October 2023 from the Scopus database using *pybliometrics*, a Python wrapper for the Scopus RESTful API (Rose & Kitchin, 2019). The sample was limited to scientific articles (DOCTYPE(ar)) published in psychology journals (SUBJAREA(PSYC)) and having the term "personality" in the title, abstract or keywords (TITLE-ABS-KEY(personality)). Some of the articles were classified into two OA categories which means that they are available in some OA form (gold, bronze, or hybrid), but are additionally deposited in a repository. For those articles, only the primary OA model was kept, which means that in this study, green OA refers to articles that are not freely available outside a repository. However, the information on depositing gold and bronze OA articles was used to analyze the general trend in the practice of sharing pre-print or post-print versions of manuscripts.

Data analyses

Bibliographic mapping is often used to visualize landscapes of scientific fields. Most bibliographic maps are created by identifying patterns of connections among elements that co-occur in documents using graphs to depict their mutual proximity and incidence by their position and size. Data from different fields in bibliographic records can be visualized, such as author names, subject descriptors, or affiliations. Additionally, various elements from

references, including cited authors, cited journals, or cited documents, can also be depicted as nodes on a bibliographic map. Each of these components offers a distinct viewpoint on the structure of science (Noyons, 2001).

This research employed maps of coincidence among article descriptors, namely author keywords, to highlight predominant research topics. Keywords that frequently co-occur in articles are closely positioned on the map, suggesting clusters of research topics. The term "personality" was excluded from the analysis in order to create clearer map and more separated clusters. The maps were created for non-OA and OA separately. Co-authorship maps were used to visualize collaboration on a country level for each category of (non-)OA articles. These maps display relationships between countries based on frequency of collaboration among authors affiliated with them but are also used to explore differences in incidence of various OA practices among nations. Both keywords and countries are depicted on maps as circles connected by lines that indicate the strength of their connection. The circles size is proportional to the number of articles related to a certain term or country, and their color indicates cluster membership.

Bibliographic mapping is basically an explorative technique, much like other types of visualizations or the component analysis, for example. In that sense, a decision on the threshold value for the number of occurrences an element should have to be shown on the map cannot be fully objective. This threshold will always depend on the number of analyzed documents, but the main principle is to find a balance between the richness of information and clarity of the map, since they shouldn't be neither to cluttered, nor too sparse. Since the bibliometric distributions are known to be highly skewed (Seglen, 1992), it is actually possible to describe a large set of articles with a relatively small number of keywords. Based on several preliminary maps we generated using different criteria, the threshold was defined as the occurrence of a keyword (or multiple keywords) that, together with all of the more frequent keywords, account for at least 50% of the total number of occurrences of unique keywords in the sample.

Data manipulation, curation, and preparation for visualization were carried out using the *pandas* package in Python (The pandas development team, 2020). Bibliographic maps were generated in VOSviewer v.1.6.20 (Van Eck & Waltman, 2023a) using fractional counting for calculating link weights (Perianes-Rodriguez et al., 2016) and LinLog/modularity as a normalization method (Van Eck & Waltman, 2009; Van Eck & Waltman, 2023b). All additional graphs were generated using the *Plotly* (Plotly Technologies Inc., 2015) and *Matplotlib* (Hunter, 2007) Python packages. Due to high variability and skewness of most of the variables, Kendall's Tau-B (τ) rank coefficient was used to analyze correlations, while ANOVA with Brown-Forsythe correction was used to analyze differences among the various categories of articles.

Results

Trends in publishing OA articles

Open access articles account for 31% percent of the total number of research articles published in the analyzed period in the field of personality psychology. Out of this percent, the largest proportion of articles were published under the green model (8770 – 49%), followed by gold (4506 – 25%), bronze (2704 – 15%), and hybrid gold (1793 – 10%). However, these proportions varies a lot across the span of twenty years as shown in Figure 1.

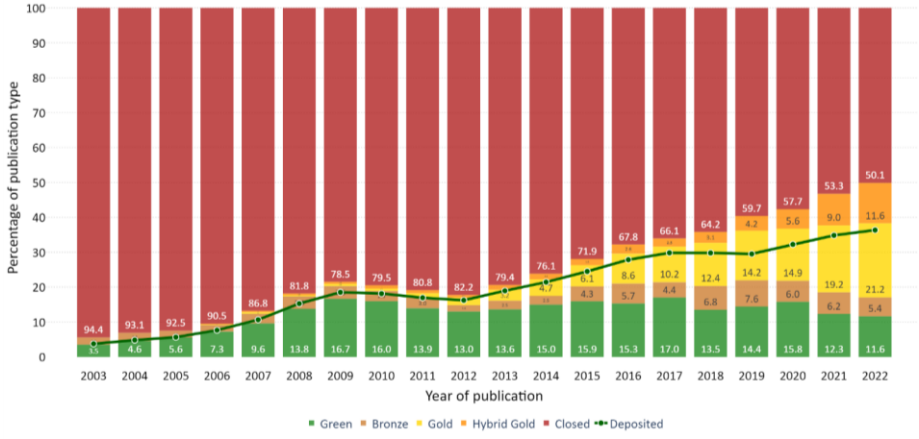

Figure 1. Trends in publishing OA articles of different types in personality psychology

Figure 1 shows the obvious growing trend of publishing OA articles in personality psychology. The share of OA articles in personality psychology has grown from around 5% in 2003 to almost 50% in 2022. The most intensive growth is within the group of (hybrid) gold OA articles. Although the trend of depositing articles in repositories is also showing an increase, it seems that the authors are depositing mainly articles that were already freely available online or became available after the deposition of pre-print. The initial growth in the number of green OA articles practically stopped in 2009 and since then the proportion of articles that aren't freely available in any other form is actually stagnating or even dropping. As for the bronze OA articles, it appears that the incidence of this type of OA depends on contextual factors. For example, a slight increase in the proportion of bronze OA articles visible in 2009-2011 can be attributed mostly to a single journal that was later discontinued (*Procedia - Social and Behavioral Sciences*), while the growth in the period after 2019 is probably the effect of specific editorial policies aimed at opening articles related to COVID-19 pandemic (e.g., *Frontiers in Psychology*).

Scientific landscapes of research in personality psychology

Since the numbers of OA articles in different categories were relatively small compared to the number of non-OA articles, the first two maps were generated for non-OA and for all OA articles together. Using the procedure explained in the introduction, threshold for the non-OA articles was set at 13 which yielded 1.510 different keywords. For OA articles of all types, the threshold was 8 occurrences resulting with 1.360 keywords displayed on the map[1]. Figure 2 shows predominant topics in research articles from the field of personality psychology not freely available online. Five distinct clusters emerge. The first one on the left (red) consists of topics related to the exploration of personality

[1] JSON files for a more detailed inspection of the maps using VOSviewer Online (https://app.vosviewer.com/) are deposited in OSF repository (https://osf.io/7mnwc/).

traits in general, predominantly in the context of Five-Factor Model (FFM). All Big Five dimensions are visible on the map, with neuroticism being the most frequent. Individual differences are explored in various contexts, from well-being and general health, to motivation, social identification, internet behavior, prejudices, attitudes, and organizational setting.

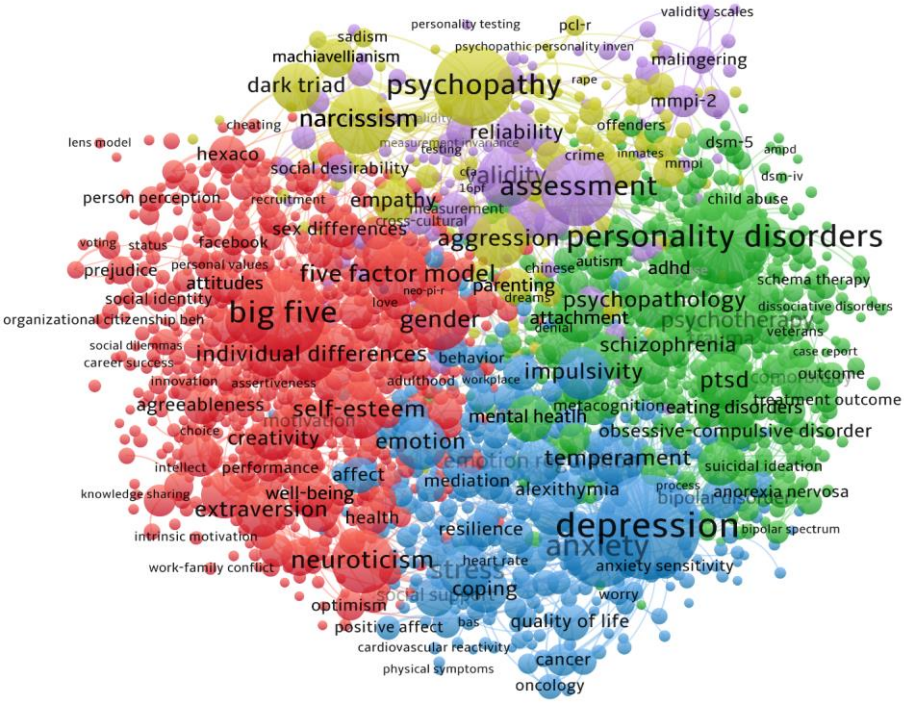

Figure 2. Co-occurrence map of author keywords from non-OA articles in personality psychology

Another large cluster on the opposite side of the map (green) incorporate topics related to various personality disorders. Most frequent keywords in this group of articles refer to different psychopathological phenomena, such as schizophrenia, PSTD, OCD, ADHD, eating disorders, suicide, and autism, but also to their treatment (psychotherapy) and prevention. This cluster is to a large extent interweaved with the third large cluster at the bottom of the map (blue) that encompasses topics related to emotional regulation and emotional aspects of mental health: anxiety, depression, impulsivity,

alexithymia, and stress. It is worth noting that, apart from the term "mental health" itself, the two most frequent terms connecting green and blue clusters are "temperament" and "bipolar disorder".

Finally, two rather specialized clusters are positioned at the top of the map. Unlike the first three, these clusters are more homogeneous and almost singular in its thematic emphasis. The yellow one comprises of keywords related to negative personality traits and behaviors. The most prominent keywords in this clusters are traits of the so-called Dark Triad: psychopathy, narcissism, and Machiavellianism. It is worth nothing that HEXACO, as an alternative model to the FFM, is positioned more closely to the Dark Triad cluster. The violet cluster contains keywords from the articles with psychometric focus on personality research, both in the sense of validating existing instruments and constructing new ones: assessment, validity, reliability, and factor analysis. This aspect of personality research is particularly relevant in the context of growing popularity of cross-cultural research and research on measurement invariance of various psychological instruments.

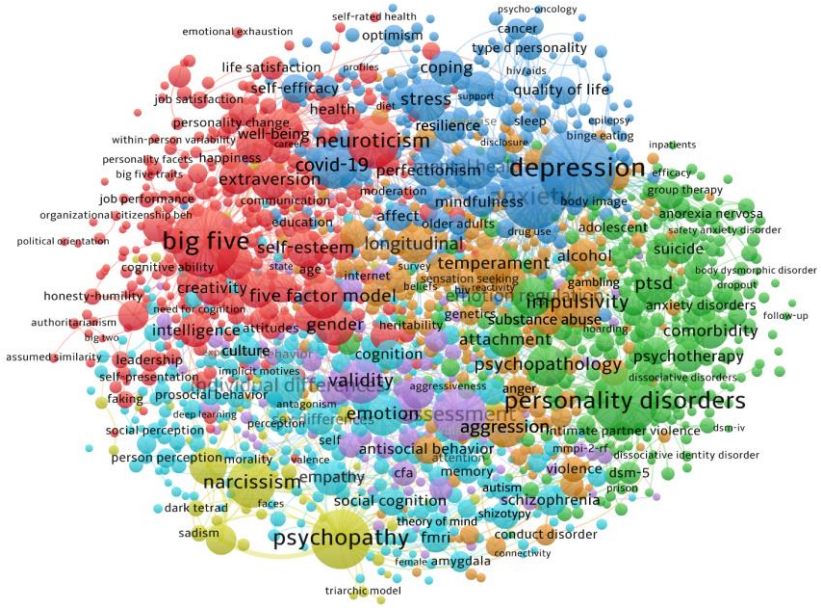

Figure 3. Co-occurrence map of author keywords from OA articles in personality psychology

Figure 3 shows the co-occurrence map of keywords from OA articles in personality psychology. Although the five main clusters from the non-OA map are clearly present, some obvious changes are noticeable. First, COVID-19 pandemic emerges as "hot" research topic appearing at the intersection of clusters related to mental health and personality traits. This new node is most strongly connected to terms denoting common effects of the pandemic (stress, anxiety, depression) and possible ways of coping with them (resilience, empathy, extraversion, compliance, well-being). Another noticeable difference between the maps in Figures 1 and 2 is larger dispersion of nodes, i.e., lower density of the clusters. Although this may be attributed to a smaller sample of words and lower keyword occurrences, a change in the structure of prevailing topics is evident. For example, the terms "aggression", that was clustered with the negative traits (Dark Triad), and "impulsivity", that were closer to emotion regulation, now forms a completely new cluster of topics. This cluster is focused on different aspects of antisocial behavior, risk-taking, and sensation seeking (alcohol, substance abuse, gambling, violence).

Another noticeable cluster division is the separation of individual differences research from the personality traits (FFM) cluster, now forming a cluster of terms like "emotion" (not "emotion regulation), "culture", "social cognition", "empathy", and "sex differences". Although it is not directly visible on the map, terms from this cluster have strong connections with COVID-19, which indicates that emergence of a new research topic have moved research focus away from the exploration of individual difference towards the cultural aspects of emotional responses to the pandemic. Finally, due to higher dispersion of topics in OA articles, an additional field of research is now more visible – neuroscience and cognitive aspects of personality (fMRI, attention, memory, theory of mind).

Networks of international collaboration in personality research

Patterns of international collaboration in personality research were explored using the maps based on co-occurrences of country names in authors' affiliations. Maps were generated for non-OA articles and all types of OA articles

separately in order to analyze both typical forms of publishing in different countries, and international diversity of personality research within each category of articles. Gold and hybrid gold articles were merged since the APC is required for both types of articles to be published. Figure 4 shows the collaboration networks for four categories of articles. The same threshold criterion was used as before, which means that each map shows at least 50% of the most productive countries in the field of personality research.

Collaboration networks clearly differ across different categories of articles, but basically show the predominance of Western countries. Patterns of collaboration in green OA articles is most similar to those of non-OA articles, although some of the non-Western countries emerge, such as Russia, Serbia, Poland, South Korea, and Brazil. The network of collaboration in research published in gold OA articles differs most from the other types of articles since Russia, Poland, and Ukraine are now among the most productive countries. Furthermore, additional countries appear on the map, mostly due to common cooperation with authors from Russia: Slovakia, Slovenia, and Croatia. Finally, the map of bronze OA also shows the slight skewness towards some of the most productive and most economically influential Western countries: USA, UK, Canada, France, and Germany.

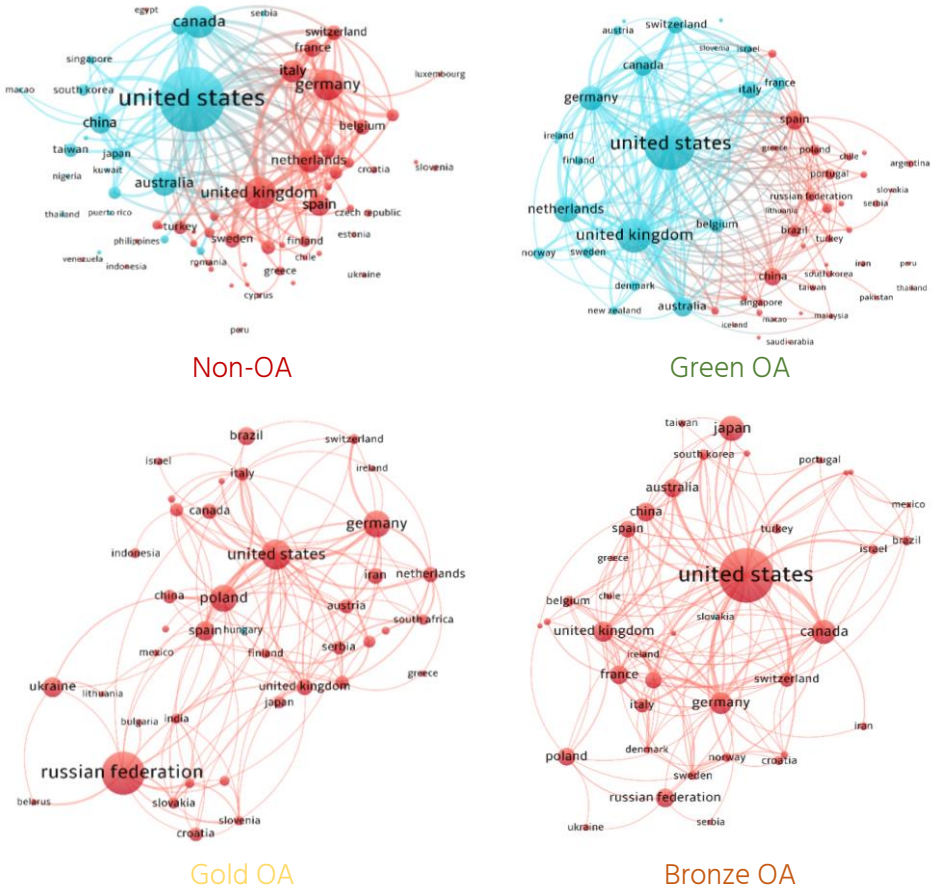

Figure 4. Collaboration networks and patterns of OA publishing in personality research

Scientific impact and general outreach of personality research

In order to explore the impact of different types of articles in personality psychology, PlumX data were retrieved for all articles from the sample. These include number of citations in Scopus, number of citations in policy documents, number of captures (e.g., in Mendeley and similar reference management software), number of mentions in online documents (e.g., Wikipedia), and number of posts in social media. Due to large differences in subsample size and variability, we conducted comparisons using ANOVA with Brown-Forsythe correction for homogeneity. Additionally, in order to make citation windows

more meaningful and comparable, the sample was limited to the articles published after 2012 when the number of OA articles started to grow significantly, as previously shown in Figure 1. PlumX data were not available for some of the articles, so the total sample in this analysis consisted of 31555 articles, out of 31658 published after 2012. Results are presented in Table 1.

Table 1

Statistical significance of impact and outreach among the articles of different (non-)OA type

	SS	df	MS	F	p
Citations (S)	684983.89	4	171245.97	105.52	<.001
Citations (P)	79.00	4	19.75	21.85	<.001
Captures	$3.61*10^6$	4	903859.71	95.89	<.001
Mentions	812.03	4	203.01	7.34	<.001
Social media	$1.02*10^7$	4	$2.56*10^6$	1.92	.104

Note: S – Scopus, P – policy documents.

All differences are statistically significant except for the number of posts in social media. In order to get a better insight into the patterns of these differences, graphs showing means and standard errors for each category was generated and displayed in Figure 5. The number of citations in policy and online documents are shown separately since value ranges for these variables were significantly lower compared to the other measures. Most of the articles have zero policy citations and mentions, 93% and 86% respectively. Gold OA articles have lowest means on all measures of impact and outreach, except for social media where they are second worst, scoring higher only compared to bronze OA articles. On the other hand, Green OA articles have the highest average citation rates in Scopus, as well as the highest average number of captures. As for the number of posts on social media, closed and green OA article have the largest mean values, but also show the highest variability which was probably the main reason why this difference was not marked as statistically significant. Finally, average numbers of policy citations and mentions show different pattern, since bronze OA articles are most often cited in policy documents.

However, these results should be taken with a grain of salt due to the high skewness and low median values of those variables.

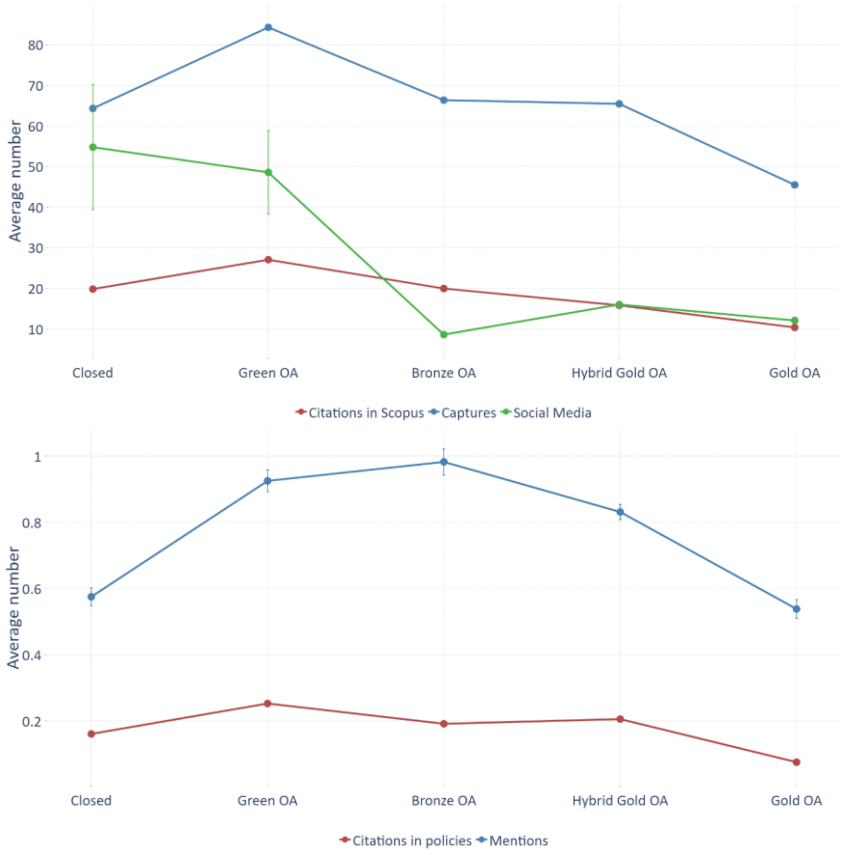

Figure 5. Impact and outreach of the personality psychology articles of different (non-)OA type

Results presented in Figure 5 indicate that the number of captures and the number of citations in Scopus are highly correlated. In fact, all analyzed measures correlate significantly, but only the correlation between these two is practically significant ($\tau = 0.64$, $p < .001$). Correlations between the number of citations in Scopus and other measures are negligible and practically

insignificant - social media ($\tau = 0.13$, $p < .001$), policy citations ($\tau = 0.23$, $p < .001$), and online mentions ($\tau = 0.20$, $p < .001$).

Discussion

The main purpose of this study was to explore the open access practice in personality research. A set of 57296 research articles in personality psychology available in the Scopus database were analyzed based on their online availability: closed (39523), green OA (8770), gold OA (4506), bronze OA (2704), and hybrid gold OA (1793). The specific aim of the study was twofold. The first goal was to analyze trends in providing open access to articles by publishing in specialized gold OA journals or by depositing them in various repositories. The second aim was to explore differences among different types of articles from several aspects: predominant topics, patterns of international collaboration, and impact, measured both by traditional citation counts, and by alternative metrics, such as the number of captures or the number of mentions in online documents and social media.

Although the share of OA articles in the total sample is relatively small (31%), our analysis has shown that it is constantly rising. Two growing trends are noticeable. The first refers to the increase in the number of deposited articles (green OA) in the period 2003-2009, and the other to the increase in the number of articles made freely available by paying APC (gold and hybrid gold OA) in the period 2013-2022. The second one is particularly pronounced and may be attributed to the growing popularity of the open science movement in general, but also to changes in research funders' policies. For example, the European Commission adopted several relevant documents in 2012 that made all researchers receiving EU funds obliged to make results of their research freely available. Thus, almost 50% of articles in personality psychology published in 2022 are available in some form of open access.

Despite the obvious growing trend in depositing articles in repositories, one different pattern is somewhat perturbing. The proportion of green OA articles in 2022 has surpassed 35%, but this mainly refers to articles that are already available, or will be available upon publishing, via gold OA. In fact, the

proportion of closed articles that are being deposited in open repositories is stagnating from 2013, and even decreasing from 2020, after the initial growth in 2003-2009. It seems that the emergence of gold OA and a growing number of journals providing gold and hybrid gold modes of publishing, have to some extent demotivated researchers to deposit manuscripts to (institutional) repositories. Moreover, this discouragement often comes from the publishers themselves, since they are constantly increasing the number of restrictions and conditions constraining the right to self-archive, while at the same time offer more options for paid OA (Gadd & Troll Covey, 2019). It could be said that this trend is a negative side-effect of the growing popularity of gold OA since most articles in personality psychology are still not freely available online in any form.

Bibliometric mapping has revealed five large clusters of topics in non-OA personality research. The largest cluster is made of keywords from articles exploring individual differences in various contexts, predominantly using the Five-Factor Model of personality as a theoretical paradigm. HEXACO seems to be gaining prominence, offering a new perspective by introducing the dimension of Honesty-Humility to the FFM and indicating a possible paradigmatic shift in personality psychology. The second cluster is focused on psychopathology and personality disorders, such as autism, OCD, eating disorders, and schizophrenia, while the third is consisted of topics related to emotional regulation and emotional problems, most often anxiety, depression, and stress. Finally, the fourth and fifth clusters are much smaller and more specialized, one focusing on the negative personality traits (Dark Triad/Tetrad), and the other on psychometric aspects of personality research, mostly on validation of psychological instruments in a cross-cultural context, but also on designing new ones. It should be pointed out that division of topics into different clusters does not mean that the authors are creating their own niches, doing studies within strictly bordered research settings or frameworks. Although this may be true to some extent for the "Dark Triad" and "psychometric" clusters, all topics in personality research are generally highly connected and interweaved, meaning that research problems in this field are usually comprehensively covered from various theoretical and practical aspects.

Bibliographic mapping of OA articles revealed a non-negligible change in the research landscape within personality psychology. Most prominent shift is the move of research focus towards the exploration of COVID-19 pandemic and its effects on mental health. COVID-19 has appeared as a hub connecting previously detected "personality traits" and "emotion regulation" clusters. Another noticeable change was the shift of topics related to impulsivity and aggression to a separate cluster, now including problems related to antisocial behavior, alcoholism, anger, and substance abuse. Research on individual differences have moved from the FFM cluster closer to the exploration of empathy and emotional reactions, again most often in the context of COVID-19. Finally, neuropsychological research of personality, previously not distinctively shown on the map, now came to light as a clearly visible cluster of topics. It is obvious that personality research in OA and non-OA articles show different structural patterns, which means that readers who are not able to access all available articles may be provided with different insights into research in personality psychology. It was already shown in previous studies that an emergence of new and "hot" topics may produce perturbations, not only in our perception of a certain knowledge domain, but also in research evaluation practice (Pajić, 2023).

The analysis of collaboration networks based on the number of co-authorships in different types of articles has revealed several interesting patterns. As it was expected, the knowledge corpus on personality psychology is mostly based on research conducted by the authors from highly developed and rich Western countries, exclusively or within multinational research teams. This is when non-OA articles were taken into account, but the situation is very similar in the groups of green, bronze, and hybrid gold OA. The most similar network to that of non-OA articles is the network of co-authorships in green OA papers. However, small but obvious differences between the two maps can indicate which authors are practicing depositing to repositories more regularly. Based on the nodes that appear on the second and not on the first map, those countries seem to be mostly outside Western Europe and North America: Brazil, Poland, Serbia, Russia, Singapore, Chile, and many others.

Both collaboration network structure and the incidence of different countries significantly changes when co-authorships in gold OA articles are visualized. It seems that the authors from Russa and Poland most often choose to publish in gold OA. Also, some new co-authorships, not presented on the non-OA map, appear. For example, collaborations between the Russian authors on one side, and the authors from Croatia, Slovenia, Slovakia, and Bulgaria on the other. Another example is collaborations between the authors from the USA on one side, and the authors from Iran, Austria, Poland, and Serbia on the other. Although it shouldn't be marked as a common practice, this may indicate the authors from less economically influential countries are relying on their co-authors from richer countries to pay for the APCs. This is in line with some previous research in the field of personality psychology (Atherton et al., 2021).

Apart from the USA, highly developed countries, such as UK, China, the Netherlands, and Canada, are practically underrepresented on the gold OA map. Furthermore, some of the countries disappear completely, at least from the group of countries whose authors most often opt for publishing under the gold OA model. Most remarkable examples are Australia and France. It should be noted, though, that Scopus OA classification does not recognize so-called platinum OA journals that don't charge APCs, but still offer all articles for free. It is possible that most of the articles by authors from non-Western countries are actually published in national platinum journals that were classified as gold or hybrid gold. The proportion of such journals in highly developed countries is negligibly small.

The final aim of the current study was to analyze the impact and general outreach of articles in personality psychology, as measured by the number of citations in Scopus and several alternative metrics. Contrary to many previous results, or even some intuitive assumptions, gold OA articles showed the weakest results on practically all measures. They are least cited, least captured, and second least mentioned in social media. If all measures were taken together, green OA articles seem to perform the best. They have significantly higher numbers of citations, captures, and mentions than other OA articles. They were also more often cited on average than non-OA articles. This corresponds with

some earlier studies conducted before the surge of gold OA (Antelman, 2004; Lawrence, 2001).

It may be hard to explain the reasons behind the somewhat unexpectedly poor impact and outreach of gold OA articles, having in mind that both green and gold OA articles are equally accessible online, e.g., through Google Scholar. One possible explanation could be traced to the authors' perception of journal and research quality. It may be that authors generally tend to perceive gold OA journals as dubious or even "predatory" and thus more willingly choose to cite "verified" sources, i.e., freely available versions of articles published in prestigious closed journals. In addition to that, since national platinum journals indexed in Scopus are classified as (hybrid) gold OA, it is possible that instead of comparing gold and green OA articles, we are actually comparing articles published in national journals with those published in highly influential international journals.

The number of citations in Scopus has the strongest correlation with the number of captures, i.e., number of downloads to reference management software. This is somewhat expected since both practices are basically measuring the impact on peer researchers. On the other hand, mentions in social media and, to some extent, the number of citations in policy documents, are referring to other groups of stakeholders, government officials, or even general public. In this context, correlations with the number of citations should not be considered a way to validate alternative metrics. Instead, they should be used to choose appropriate measures that could complement traditional impact indicators. For example, bronze OA articles have generally not performed very well on most of the measures but had the highest number of citations in policy documents. This indicates that articles recognized as relevant by fellow researchers do not have to be perceived in the same way by other knowledge consumers. It may also be used as a validation of editorial boards' decisions to make certain articles freely available, since bronze OA articles have most successfully reached policy stakeholders.

Limitations of the study

The two largest limitations of the current study refer to criticism that may be thrown to practically any bibliometric analysis. The first is related to the article selection criteria. There were concerns that using the term "personality" to locate articles in personality psychology may be inappropriate since in many of them this term is not even mentioned (Allik, 2013). However, we believe that other commonly used criteria, such as selecting only articles from a limited set of (the most influential) journals, would have led to even more biased picture, particularly having in mind that our sample included significant number of articles from national, non-Western journals. The second possible criticism is related to the selection of threshold values. It is possible that due to the methodology used in this study, selected subsets of entities do not adequately represent the whole knowledge domain in personality psychology. Nevertheless, the quality, richness, and interpretability of presented maps, as well as the large size of our sample, ensures that the results presented in this paper have provided a sufficiently objective picture of the structure and dynamics of current research in personality psychology with the unique insight into the role of open access.

Conclusions

The presented study has offered a comprehensive overview of the structure and dynamics of current research in personality psychology. As a takeaway, three key conclusions should be considered. First, the emergence of "hot" topics can easily disrupt the current research practice in a sense of moving the focus towards more popular, but not necessarily more relevant topics in science. This stands particularly for relatively small and specialized fields such as personality psychology. The intention is not to devaluate the importance of COVID-19 as a research subject nor as a globally significant phenomena, but to stress the importance of choosing research problems not by their attractiveness or potential academic benefits, but by their importance in answering fundamental questions in a field. Second, the practice of publishing articles in gold OA journals seems to be less effective than it was expected, at least

judging by their scientific and public impact. This is particularly problematic bearing in mind that authors are abandoning the practice of green OA, although the expected impact of those articles seems to be the highest. Finally, our study has shown that most of the highly economically developed countries are actually preferring green over gold OA. It is obvious that, although you may need a significant amount of money to do the research, you don't need it to make your research open and make a broader impact.

Funding statement

This research was supported by the Science Fund of the Republic of Serbia (#7744418, Genetic and environmental influences on psychological adaptation of children and adults – GENIUS)

Conflicts of Interest

The authors declare no conflicts of interest with respect to the authorship or the publication of this article.

Data availability statement

Primary data used in this study are not available for sharing due to Elsevier's terms and conditions. All figures in high resolution and JSON files for bibliographic maps are deposited to the OSF repository: https://osf.io/7mnwc/.

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Primenjena psihologija
Vol. 16, No. 4, pp. 581-605, 2023

Research Article

Open Science Practice in Western Balkan Countries

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ABSTRACT

This comprehensive review explores the landscape of open science in the Western Balkan Countries (WBCs), offering insights into existing policies, infrastructure, and practices. The analysis spans a spectrum of stakeholders, encompassing decision-makers, research funds, institutions, and individual researchers. The review is structured into four sections, each shedding light on crucial aspects of open science. The initial section investigates Open Science /Open Access (OS/OA) policies in WBCs, providing a foundation for understanding the regulatory landscape. The second section delves into OS/OA repositories within the region, emphasizing the significance of digital platforms for research dissemination. The third section focuses on OA practices, elucidating the prevalence of national OA scientific journal in Directory of Open Access Journals (DOAJ). Additionally, a bibliometric analysis of OA publishing in the WBCs, based on Scopus-indexed articles since 2012, offers valuable insights into disciplinary representation in OA practices. The final section examines the intersection of OS/OA and public engagement, particularly within the realm of psychology. Highlighting examples from the STAR Center, this section showcases initiatives that contribute to the development of OS/OA policies, infrastructure, and practices in Serbia, underscoring the Center's dedication to citizen science.

Key words: open science, open access, citizen science, keyword coincidence analysis, DOAJ

UDK: 001(497)
DOI: 10.19090/pp.v16i4.2515
Received: 20.10.2023.
Revised: 08.11.2023.
Accepted: 11.12.2023.

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Introduction

One of the fundamental principles of Open Access and Open Science (OA/OS) is the imperative that research, funded by various entities, should be made accessible to the public. Changes in the approach to scientific research are illustrated by the UNESCO recommendation on open science (UNESCO recommendation on Open science; UNESCO, 2021), as a universal framework for access to scientific work. According to UNESCO, the key pillars of open science are open scientific knowledge, open scientific infrastructure, scientific communication, open engagement of members of society and open dialogue with society as a whole (UNESCO, 2021).

This accessibility ensures that the scientific community, industry, citizens, and others can derive benefit from the outcomes of these endeavors. The prominence of this principle is evident across OA/OS policies, underscoring the societal responsibility inherent in scientific research. Consequently, OA/OS assumes a key role in increasing trust in scientific practices, addressing the reproducibility challenges facing the field, and fortifying the reliability and integrity of research outcomes.

The disposition of decision-makers and the research community toward open science is manifested in their willingness to embrace transparency in the rules and procedures governing scientific research. Namely, respect for the principles of OS has become an integral part of the policies of science financiers, both international, such as the European Commission (European Commission, 2016), and national (e.g., Zakon o nauci i istraživanjima - Law on Science and Research, 2019). Achieving this transparency involves the implementation of policies, the development of infrastructure, and the raising of awareness regarding the significance of open science for the advancement of knowledge (Lawrence, 2001).

This review aims to offer a comprehensive understanding of the prevailing policies, infrastructure, and practices related to open science in the Western Balkan countries. Such an analysis is crucial for gaining insights into past initiatives and anticipating future developments in OS involving a diverse range

of stakeholders, including decision-makers, research funds, research institutions, and individual researchers. The review is organized into four sections: the first focuses on Open Science policies in Western Balkan countries, the second on Open Science repositories in the region, the third on Open Access practices, and the final section delves into Open Science and public engagement practices within the realm of psychology, featuring examples from the STAR Center.

Open science policies in Western Balkan countries

The survey conducted for this review resulted from the Embedding RRI in Western Balkan Countries: Enhancement of Self-Sustaining R&I Ecosystems (WBC-RRI.NET) project. It employed a custom-made questionnaire designed to comprehensively address all pertinent aspects of Open Access and Open Science (OA/OS) resources in the WBCs. Divided into three distinct parts, the questionnaire aimed to elucidate national or institutional legislative documents related to the implementation of OA/OS principles, assess existing open science practices and technical resources, and gauge attitudes towards OA/OS among decision-makers.

The questionnaire, created using the open-source Google Form, was distributed online in English. Invitations to participate were extended to all universities and research institutes in Albania, Bosnia and Herzegovina, Montenegro, North Macedonia, and Serbia—approximately 50 institutions in total.

The responsible individuals from diverse institutions in the WB region, including academic entities, research institutes, and governmental bodies, contributed to the survey. Notable participants include Co-PLAN Institute for Habitat Development in Albania, POLIS University in Albania, the Ministry of Science and Technological Development in Montenegro, and the University of Belgrade in Serbia, among others.

The survey encompasses data collected up to July 1st, 2022, with additional information gathered until December 1, 2023. The questionnaire remains continuously accessible for interested participants on the WBC-RRI.NET website: Survey Questionnaire Link.

In broad terms, OA/OS policies are categorized as national, funding, and institutional. This classification, while not always explicit, helps in understanding the diverse nature of documents considered as policies, ranging from laws and strategies to guidelines (Table 1).

As of now, Albania does not have a national OA/OS policy. However, there is a notable initiative among researchers to sign the Declaration on Open Science at the national level as part of the National Initiatives for Open Science in Europe (NI4OS) project. Additionally, research grants from public funds necessitate an OA Policy Regulation document, and specific projects incorporate Data Management Plans.

Table 1

Links to the OS policies at WBCs

Country	National OS policies	Institutional OS policies	Open data policies
Albania	*Declaration on OS*		
Bosnia and Herzegovina			Data Archive for Social Sciences in Bosnia and Herzegovina – DASS-BiH
Montenegro	Ministry of Education of Montenegro		
North Macedonia	National Open Science Cloud Initiative		
Serbia	Ministry of Education, Science and Technological Development of Republic of Serbia	University of Novi Sad University of Kragujevac University of Belgrade State University of Novi Pazar University of Niš University of Priština University of Arts in Belgrade Criminal Police University Institute of Technical Sciences of SANU Balkan Institute of SANU Institute of Plant Protection and Environment Institute of Architecture and Urbanism of Serbia Institute of Animal Husbandry, Belgrade-Zemun Institute of Field and Vegetable Crops University of Belgrade – Faculty of Chemistry Faculty of Special Education and Rehabilitation Maize Research Institute „Zemun Polje“	University of Novi Sad: Decision on Amendments to the Bylaw on Doctoral Studies – related to the Data Management Plan

Bosnia and Herzegovina lacks national or institutional OA/OS policies. Nevertheless, the Data Archive for Social Sciences was established in 2018,

serving as the national service for the preservation and dissemination of social science research data. The archive, developed within the Centre for Development Evaluation and Social Science Research, has adopted a preservation policy.

Montenegro has made strides by adopting a National policy of OA/OS in 2020. This policy encompasses an action plan focusing on various aspects, including OA to scientific papers, national academic publishing, research data, research infrastructures, and the promotion of OS skills through training programs.

In North Macedonia, the National Open Science Cloud Initiative has adopted a National policy in the form of a declaration in 2021. Embracing The European Open Science Cloud ecosystem and existing international thematic repositories, researchers and stakeholders are encouraged to sign the declaration.

Serbia has demonstrated commitment to OS with the adoption of the National open science platform by the Ministry of Education, Science, and Technological Development in 2018 (MPNTR, 2018). The platform mandates open access to the final, published or peer-reviewed versions of scientific publications and recommends immediate open access to primary research data. Higher education and research institutions, including the University of Novi Sad, have also adopted institutional open science policies, with specific regulations regarding Data Management Plans. The Science Fund of the Republic of Serbia has implemented open access publishing and open data treatment in alignment with FAIR (findability, accessibility, interoperability, and reusability) principles for all research projects applying for grants.

This overview provides a snapshot of the current landscape of OA/OS policies and practices in the WBCs, paving the way for a detailed exploration in the subsequent sections of this review (e.g. WBC-RRI.NET, 2022).

Open science infrastructure in Western Balkan countries

The second part of the previously described survey was related to the technical resources, and information infrastructure at WBCs, as well to attitudes

towards OA/OS among decision makers and includes questions such as "How do researchers at your institution pay for Article Processing Charges (APC)?"

In Albania, researchers predominantly utilize international OA/OS repositories, such as Zenodo. Notably, a public repository is housed within the non-profit organization Co-PLAN, dedicated to sustainable development and good urban governance. The repository is managed by IT professionals and researchers, with institutional resources supporting its maintenance. Publishing in open-access journals incurs APC costs, primarily covered by project funds. However, researchers also rely on personal and institutional resources, showcasing a multi-faceted funding approach (Figure 1).

Table 2

Links to the OS repositories at WBC

Country	National repositories	Institutional repositories	Thematic repositories
Albania		Co-PLAN: a non-profit organization	
Bosnia and Herzegovina		University of Banja Luka "E-theses" of the University of Banja Luka University of Zenica	Data Archive for Social Sciences in Bosnia and Herzegovina – DASS-BiH
Montenegro		University of Montenegro "E-theses" of the University of Montenegro	
North Macedonia		University Ss. Cyril and Methodius in Skopje, Faculty of EE and IT	
Serbia	NaRDuS (National Repository of Dissertations in Serbia) Repositories of the PhD theses at the University of Belgrade, University of Novi Sad, University of Niš and University of Kragujevac are included in NaRDuS	University of Belgrade - SPIRA Collection of 32 institutional repositories University of Kragujevac University of Novi Sad State University of Novi Pazar* University of Arts in Belgrade* University of Niš* Full lists of repositories in Serbia can be found at National portal of Open Science	*National Repository of Agricultural Education* - CaSA NaRA The Jewish Digital Library Repository of psychological instruments in Serbian - REPOPSI

While Bosnia and Herzegovina lacks formal OA/OS policies, certain higher education institutions have established repositories to enhance the visibility of scientific work. Institutions like the University of Banja Luka and the

University of Zenica, along with the Data Archive for Social Sciences in Bosnia and Herzegovina (DASS-BiH), maintain digital repositories with a combination of Ministry of Science support and internal funding. Maintenance responsibilities fall on IT professionals, librarians, and researchers. APC costs for open-access journal publication are primarily borne by project funds and researchers' personal resources (Figure 1). Some institutions also offer occasional support. Despite these positive initiatives, it's acknowledged that these examples may not represent the entire research community in Bosnia and Herzegovina.

In Montenegro, only the University of Montenegro currently practices depositing research results into an institutional repository. However, the survey lacks information on how the repository is financed and maintained, as well as the resources researchers depend on for APC.

In North Macedonia, the institutional OA/OS repository is housed at the University Ss. Cyril and Methodius in Skopje, Faculty of EE and IT. Research institutions in the country generally do not allocate funds for OA/OS resources, but researchers receive substantial support for APC charges (Figure 1). The repository maintenance is undertaken by researchers, with minimal involvement from the IT sector or librarians.

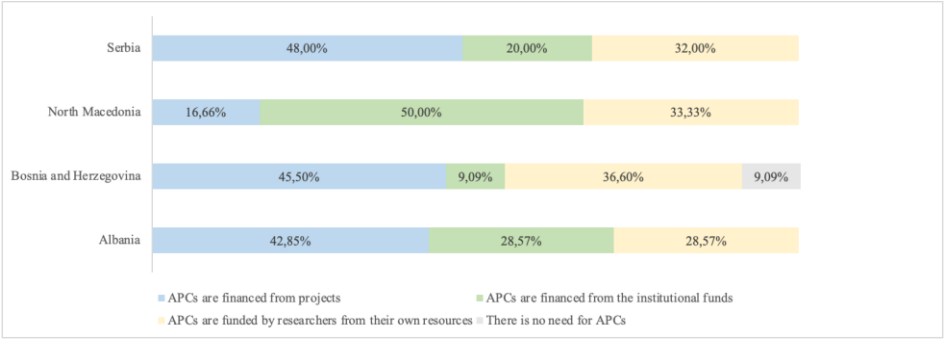

Figure 1. APC charges in WBCs

Serbia hosts numerous research institutions equipped with digital repositories; nevertheless, some repositories face challenges in terms of continuous maintenance and functionality. Examples include the repositories

associated with the University of Niš, State University in Novi Pazar, and the University of Arts in Belgrade, as outlined in Table 2. The responsibility for repository maintenance is predominantly shouldered by librarians and the IT sector, underscoring their pivotal role in supporting science and research initiatives.

A notable issue within the landscape of open access/open science (OA/OS) repositories in Serbia is the absence of a standardized system. Many repositories rely on the dedication of individual institutions rather than a regulated framework, hindering overall progress in this domain. Funding for repositories primarily comes from institutional resources, making them susceptible to fluctuations in institutional income and financial stability.

In general, in all WBCs researchers often resort to project grants or personal funds to cover APCs associated with OA publications (Figure 1). This points to a significant gap in widespread institutional support for open science practices.

The reliance on individual grants or personal finances places a burden on researchers and may impede the broader adoption of open science principles. Addressing these challenges calls for a concerted effort to establish a more structured and sustainable framework for OA/OS repositories in all WBCs. This may involve developing standardized practices, securing dedicated funding streams, and fostering collaboration between institutions, librarians, and the IT sector.

Open access publishing practice in Western Balkan countries

In all WBCs, a prevailing culture exists wherein universities and scientific institutions actively publish scientific journals. These national resources serve as vital platforms for researchers, forming a cornerstone of academic discourse. Aligning publishing practices with the principles of OS/OA becomes crucial for ensuring the continued growth and relevance of these journals. Notably, a significant number of these journals follow the *diamond* OA model, where government funding supports their publication, relieving researchers from the burden of APCs. The indexing of these journals in the DOAJ holds paramount

importance, as it enhances their visibility and accessibility on a global scale. Table 3 provides an overview of the current number of journals from WBCs indexed in DOAJ, signifying their presence and recognition within the broader scholarly community.

These numbers highlight the substantial presence of open access journals, particularly in Serbia. The inclusion of scientific journals in the DOAJ indicates a commitment to OS/OA principles, making research findings more accessible to a global audience. This approach enhances the visibility of local research and fosters collaboration and knowledge exchange on an international scale.

Table 3

Number of scientific journals indexed in DOAJ in WBCs

Country	Number of journals
Albania	4
Bosnia and Herzegovina	44
Montenegro	9
North Macedonia	16
Serbia	211

In order to gain an insight into the practice of OA publishing in the WBCs, a bibliometric analysis of all scientific articles indexed in the Scopus database, since 2012, was conducted. The dataset was compiled in December 2023 using the Python wrapper for the Scopus RESTful API, *pybliometrics* package (Rose & Kitchin, 2019). In the first step, all scientific articles affiliated with one of the WBCs were retrieved, while in the second dataset was limited to articles published in OA. In the Gold OA model, articles are published in fully OA journals. These journals make their content freely accessible to the public. Authors typically pay an APC to the publisher to cover the costs associated with the publication process. This funding model ensures that the final published version of the article is immediately available to readers without any subscription or paywall barriers. Green OA refers to the practice of authors self-archiving a

version of their manuscript in a repository, such as an institutional repository or a subject repository, after it has been published in a subscription-based (non-open access) journal. The term "Bronze Open Access" is not as commonly used as Gold or Green. It might be used informally to refer to articles that are freely available on a publisher's website but are not published in fully open access journals. In the Hybrid Open Access model, a journal is a traditional subscription-based journal, but individual articles can be made open access on payment of an additional fee (Article Processing Charge or APC). This allows authors to choose which articles to make OA while the rest remain behind a paywall. Table 4 shows the number of papers published in different options of OA from all WBCs.

Table 4

Number and % of OA scientific articles indexed in Scopus from WBCs

Year	Albania			Bosnia and Herzegovina			Montenegro			North Macedonia			Serbia		
	N	OA	%OA	N	OA	%OA	N	OA	%OA	N	OA	%OA	N	OA	%OA
2012	245	54	22.04	612	177	28.92	186	75	40.32	464	165	35.56	6052	2323	38.38
2013	412	239	58.01	607	214	35.26	235	104	44.26	556	195	35.07	5982	2458	41.09
2014	447	277	61.97	633	263	41.55	300	146	48.67	629	290	46.10	5961	2698	45.26
2015	366	210	57.38	696	348	50.00	267	108	40.45	673	318	47.25	5944	2807	47.22
2016	286	126	44.06	731	394	53.90	319	147	46.08	663	355	53.54	6069	2984	49.17
2017	292	152	52.05	904	474	52.43	382	184	48.17	658	359	54.56	6145	3228	52.53
2018	355	195	54.93	1015	583	57.44	384	217	56.51	713	431	60.45	6431	3593	55.87
2019	399	236	59.15	1204	779	64.70	472	307	65.04	774	453	58.53	7002	4369	62.40
2020	544	335	61.58	1283	844	65.78	533	362	67.92	780	488	62.56	6941	4427	63.78
2021	684	475	69.44	1532	1051	68.60	501	347	69.26	844	584	69.19	7692	5224	67.91
2022	757	501	66.18	1462	1069	73.12	457	316	69.15	925	616	66.59	7883	5540	70.28
Total	4787	2800	58.49	10679	6196	58.02	4036	2313	57.31	7679	4254	55.40	72102	39651	579.18
Bronze		332	11.85		697	11.24		276	11.93		518	12.17		4330	10.92
Gold		488	17.42		1657	26.74		511	22.09		693	16.29		6572	16.57
Green		1814	64.78		3726	60.13		1470	63.55		2921	68.66		27893	70.34
Hybrid		166	5.92		116	1.87		56	2.42		122	2.86		856	2.16
		2800			6196			2313			4254			39651	

Note. N – number of published articles; OA – number of articles published in OA; %OA – % of articles published in OA.

Across all countries, Green OA is the dominant category, with the highest percentage of articles made freely accessible through repositories or institutional platforms. The distribution between Bronze (predominantly self-archiving) and Gold (articles published in fully open access journals) varies, with

percentage of the Gold OA being higher in Bosnia and Herzegovina and Montenegro. Hybrid OA, where some articles are freely accessible while others require payment, represents a relatively small percentage across all countries. Serbia stands out with a notably higher total number of articles, reflecting a substantial contribution to OA publishing in the region.

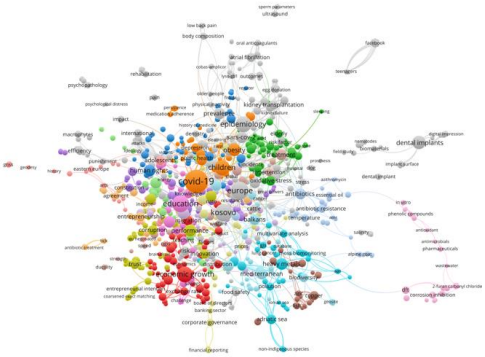

Figure 2. Keyword coincidence map for OA articles in Albania

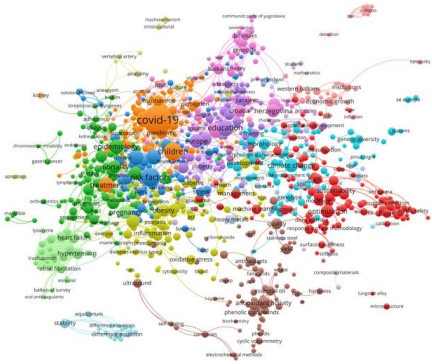

Figure 3. Keyword coincidence map for OA articles in Bosnia and Herzegovina

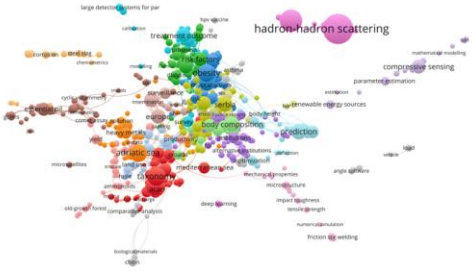

Figure 4. Keyword coincidence map for OA articles in Montenegro

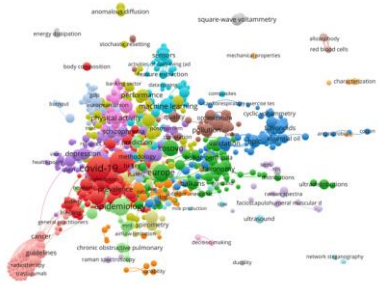

Figure 5. Keyword coincidence map for OA articles in North Macedonia

Figure 2 shows the keyword coincidence analysis of scientific articles published in OA from Albania. The visualization reveals distinct clusters of OA articles, each representing a thematic concentration within the academic landscape. The orange cluster emerges prominently, encompassing scientific papers primarily focused on COVID-19. This cluster extends to incorporate

related health behaviors and conditions, such as obesity, public health, and depression, highlighting the interconnectedness of these topics in the literature. The red cluster stands out as well, featuring a substantial number of OA articles related to economic themes. Topics within this cluster span economic growth, savings, and migration, showcasing a significant scholarly discourse on economic subjects in the Albanian OA literature. The light blue cluster is indicative of marine science, pollution, and biodiversity. This thematic grouping reflects a notable concentration of research on environmental aspects, particularly those related to marine ecosystems and pollution dynamics.

Figure 3 shows shows the keyword coincidence analysis of scientific articles published in OA from Bosnia and Herzegovina. Similar to the previous case, the largest cluster is centered around the topic of COVID-19, signifying a significant scholarly focus on this subject. This cluster is closely associated with the green cluster, which encompasses health-related topics such as epidemiology, prognosis, and pregnancy, indicating a comprehensive exploration of health aspects related to the pandemic. Furthermore, two distinct clusters in light and dark purple delve into broader themes including Europe, education, Bosnia, Herzegovina, the Balkans, and trauma. These clusters suggest a multidisciplinary approach, encompassing geopolitical, educational, and sociocultural dimensions within the scholarly discourse. Additional thematic clusters are evident in the analysis: a brown cluster relates to antioxidants, showcasing a focused exploration of this specific area. Meanwhile, a red cluster pertains to sustainability and traffic, indicating a scholarly interest in issues related to environmental sustainability and transportation dynamics.

Figure 4 provides a visual representation of the shows the keyword coincidence analysis of scientific articles published in OA from Montenegro. A notable and entirely independent cluster is dedicated to physics-related topics, possibly in collaboration with CERN, and specifically mentions hadron-hadron scattering. The independence of this cluster underscores the depth and breadth of scientific contributions in the field of physics from Montenegro. Other clusters within the analysis cover diverse topics. The light green cluster focuses on body composition, suggesting a specialized area of research in health

sciences. The red cluster is associated with taxonomies in biology, indicating an interest in systematic classification within the biological sciences. In addition, the dark green cluster encompasses topics in medicine, including risk factors and disease prognosis. This cluster suggests a substantial body of research in medical sciences, emphasizing factors influencing health outcomes and prognostic indicators.

Figure 5 shows the keyword coincidence analysis of scientific articles published in OA from North Macedonia. The largest cluster, highlighted in red, is dedicated to the topic of COVID-19, indicating a significant focus on research related to the pandemic. The second-largest cluster, depicted in green, encompasses broader geopolitical themes such as Europe and the Balkans. This suggests a multidisciplinary approach within the scholarly discourse, exploring regional and international dimensions. The purple cluster is notable for its emphasis on medical topics, primarily focusing on mental health. This suggests a substantial body of research in the field of medicine, particularly addressing aspects related to mental well-being. The prominence of this cluster underscores the importance of mental health research within the scientific output from North Macedonia.

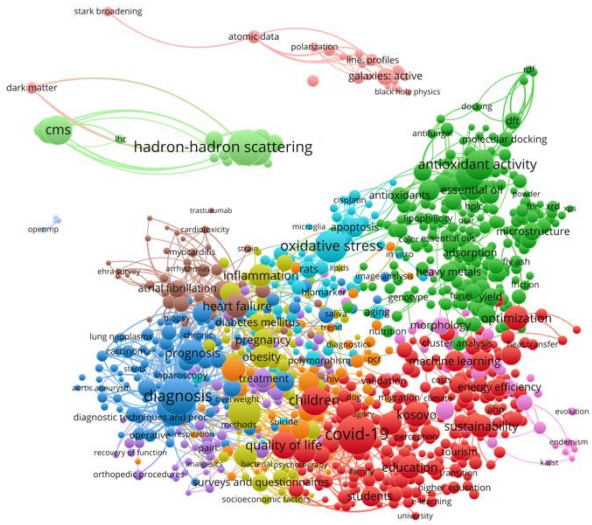

Figure 6. Keyword coincidence map for OA articles in Serbia

Figure 6 shows the keyword coincidence analysis of scientific articles published in OA from Serbia. Similar to Montenegro, there is a notable and independent cluster dedicated to physics, specifically focused on hadron-hadron scattering, indicating collaboration with CERN. Additionally, another independent cluster in light pink also pertains to physics, covering diverse topics such as galaxies, black holes, and polarization, showcasing the breadth of research within this field. The largest cluster, marked in red, is dedicated to the COVID-19. Intriguingly, this cluster intertwines with a range of other themes, including sustainability, education, and even machine learning, indicating a multidisciplinary approach in studying the pandemic's various aspects. The blue cluster concentrates on medical topics, encompassing diagnostics, prognosis, and diagnostic techniques. This suggests a substantial body of research in the field of medicine, particularly focusing on diagnostic methods and prognostic indicators. Another noteworthy cluster, marked in green, is associated with the study of antioxidants with heavy metals and essential oils, reflecting research in the field of chemistry and environmental science.

These findings collectively underscore the dynamic and varied research landscapes within the WBCs, emphasizing both global concerns like COVID-19 and region-specific interests in fields such as physics, medicine, and environmental science. The OA nature of the publications emphasizes a commitment to the accessibility and dissemination of research findings, as well as resources for APC.

Open Science and Public Engagement in Psychology: Insights from STAR Center

Open science in STAR Center

The STAR Center has an important role in advancing Open Science initiatives in Serbia, particularly through its coordination of the first Open Science project in the country, BEOPEN - Boosting Engagement of Serbian Universities in Open Science. This project, supported by

the European Commission, marked a significant step forward in promoting Open Science practices within the Serbian academic landscape. One of the notable outcomes of the BEOPEN project is the establishment of a national *Platform for open science* in Serbia (MPNTR, 2018), as well as national Portal for Open Science. This portal serves as a centralized hub, facilitating and promoting various aspects of Open Science, including OA, data sharing, and collaborative initiatives. Furthermore, as a result of the BEOPEN project, each university in Serbia now manages institutional repositories dedicated to OS.

The first Manual for Open Science in Serbia (Smederevac et al., 2020) addresses various prevailing misconceptions and prejudices against OS/OA in a detailed manner. Also, the manual provides an in-depth exploration of open repositories of scientific publications, offering insights into the functionalities of the DSpace-CRIS platform. This platform serves as the foundation for the institutional repositories of Serbian universities, including the University of Novi Sad, he University of Niš, the State University of Novi Pazar, and the University of Arts in Belgrade. The manual further outlines a comprehensive data treatment plan, emphasizing the adherence to FAIR principles. For researchers engaged in the review processes for scientific journals, the manual presents a dedicated chapter on Open Peer Review. The manual extends its coverage to include guidance on the usage and deposit of open-source code, recognizing the paramount importance of open source to researchers in the IT sector. It acknowledges the familiarity of most data processing researchers with the popular statistical environment R (R Core Team, 2013). Moreover, it highlights the relatively rare but evolving topic of Open Methodology in science. It cites examples of good practice in psychology, engineering and technology, and veterinary medicine. The chapter on Open Methodology is positioned as an indispensable component of the overarching narrative of OS, emphasizing its relevance alongside the burgeoning field of citizen science.

Members of the STAR Center have contributed significantly to the advancement of research evaluation practices by translating the Leiden Manifesto for Research Metrics (Hicks et al., 2015, translated in Serbian by Smederevac & Pajić, 2016). This translation provides a framework for establishing

additional criteria in the assessment of scientific impact. The Leiden Manifest is originally formulated to guide research institutions and scholars in the responsible use of metrics. This translation enhances understanding and facilitates the adoption of principles that promote a more comprehensive and nuanced approach to evaluating scientific contributions.

The first OA interactive textbook in statistics in Serbia, entitled Primena tehnika vizualizacije u bazičnoj statistici (Pajić, 2020), signifies a notable milestone in the field of statistical education. This groundbreaking resource provides comprehensive information about various statistical procedures. What sets it apart is the incorporation of state-of-the-art visualizations that go beyond traditional explanations, offering readers an interactive and visually engaging experience. This approach aims to enhance the understanding of the logic behind statistical procedures, making the learning process more accessible and intuitive. By embracing open access principles, this textbook contributes to the broader accessibility and democratization of knowledge in the field of statistics, fostering a culture of open education and collaborative learning in Serbia.

The STAR Center's open questionnaires serve as a valuable resource for researchers engaging in scientific studies, particularly those requiring diverse instruments. In the realm of psychology, numerous instruments are protected by strict authorship and commercial licenses. Therefore, the availability of open questionnaires becomes pivotal, providing researchers with an important and freely accessible repository of various psychological measures.

The first segment of this resource encompasses instruments either created by members of the STAR Center or those translated and validated for use in the Serbian population. This collection serves as a comprehensive toolkit for researchers seeking a wide array of psychological assessments (see Open psychological questionnaires).

The second segment draws from The International Personality Item Pool (IPIP), a pioneering OS project spearheaded by Lewis Goldberg. The project's objective is to grant researchers unrestricted access to questionnaire items for assessing diverse psychological phenomena. With a repository of 3320 items, a

majority of which have been translated into numerous languages worldwide, the IPIP project facilitates the creation of a multitude of instruments for personality and psychological construct assessments. Utilizing this set of items, researchers can freely explore simulations of multidimensional constructs, one-dimensional scales, or items translated into Serbian, enabling the development of new instruments tailored to specific phenomena (e.g., Nikolašević et al., 2012). Currently, 2544 items from the IPIP project have been translated into Serbian, further expanding the range of accessible resources for psychological research in the region (Smederevac et al., 2016) (also see IPIP - International Personality Item Pool; items in Serbian).

Citizen science in STAR Center

STAR Center has been fostering citizen science projects since 2020, when the first psychological citizen science project in Serbia started. In the period from the introduction of the state of emergency, the STAR Center (former Center for Behavioral Genetics) conducted research to study emotional reactions to the COVID-19 pandemic in Serbia. Citizen scientists worked actively to promote research, engage participants and motivate them to fill out questionnaires every day. The results of the survey were regularly available on the website created for this study, and social networks, media and citizen scientists contributed to their dissemination. The survey lasted 5 weeks and included 1526 participants and a total of 18 478 responses. In the first week, 889 respondents participated in the research, during the second week 885, during the third week 698, during the fourth week 639 and during the fifth week 595 (Branovački et al., 2021; Oljača et al., 2020; Sadiković et al., 2020).

EkOtisak, a project on climate science and artistic action for the citizens of Novi Sad, received funding from Novi Sad, the European Capital of Culture. This initiative addressed climate challenges through the innovative fusion of art and science, facilitated by the Center for the Promotion of Science. In collaboration with the Faculty of Philosophy, the Academy of Arts at the University of Novi Sad, and the organization Zeleni Sad, the project unfolded from July 20 to August 7, 2022. Themed as art+science: EkOtisak (ecoprint), this unique intersection actively engaged artists, scientific researchers, civil society organizations, and citizens in exploring daily habits contributing to the carbon footprint. The project included a

survey probing citizens on various aspects, workshops covering topics like eating habits and climate change, and culminated in an exhibition at the Rectorate of the University of Novi Sad, and a program hosted on the Strand as part of the seventh edition of the art+science events.

The ongoing GENIUS (Genetic and environmental influences on psychological adaptation of children and adults) project, supported by the Science Fund of the Republic of Serbia, aims to explore genetic and environmental influences on the psychological adaptation of children and adults. This initiative actively engages diverse societal actors outside academia, utilizing public engagement platforms like science festivals, Researchers' Night, the annual Twin Day, and collaboration with Civil Society. Recognizing the importance of accessibility and engagement, GENIUS emphasizes building on community best practices to foster a new scientific culture. The project involves citizens in mutual learning, facilitates the exchange of scientific information, and ensures the accessibility of research outcomes. A citizen science network, established as part of its open science strategy, serves as a knowledge-exchange platform through a cycle of webinars for citizen scientists, promoting collaborative learning.

In appreciation of citizen scientists' contributions, the STAR Center, a key participant in GENIUS, awards badges and certificates based on the degree and type of involvement in project tasks. Detailed information about the activities and achievements of citizen scientists can be explored on the project's dedicated webpage: GENIUS Webinars. Additionally, students attain the status of citizen scientists upon participating in any project phase, receiving badges and certificates depending on their degree and type of involvement in project tasks.

The STAR Center's commitment to citizen science is further underscored by the translation of 10 principles of citizen science in Serbian (ECSA, 2015), as well as publication of the first Guide for citizen science in Serbia (Dinić et al., 2022), which encapsulates emphasizing engagement with diverse topics. While the STAR Center employs systematic approaches to citizen science, its activities span various scientific disciplines, including biology, medicine, and psychology.

The diversity of projects such as GENIUS, EkoTisak, and the study of mental well-being during the COVID-19 pandemic reflects the center's dedication to

fostering interdisciplinary engagement. It is crucial to acknowledge the STAR Center's role as a driving force in facilitating citizen science initiatives and its commitment to advancing scientific knowledge while integrating these activities into diverse academic realms.

The members of the STAR Center play a proactive role in elevating the standing of social sciences and humanities, as evidenced by their active contributions to various programs aimed at popularizing science (Smederevac, 2022). Their engagement reflects a commitment to advancing the fields of social science and humanities in Serbia. Notably, the STAR Center holds a unique position as the only center of excellence in social science and humanities within the country. This distinction underscores the center's pivotal role in driving excellence, fostering research, and promoting the broader impact of social sciences and humanities in the Serbian academic landscape.

Acknowledgment

We would like to thank: our colleague Dejan Pajić for the bibliometric data and analysis; all members of the STAR Center for their engagement in open science practice; all citizen scientists for participation in citizen science projects.

Funding statement

This research was supported by the Europen Comission, programme H2020 (#101006279, Embedding RRI in Western Balkan Countries: Enhancement of Self-Sustaining R&I Ecosystems – WBC-RRI.NET) and Science Fund of the Republic of Serbia (#7744418, Genetic and environmental influences on psychological adaptation of children and adults – GENIUS).

Conflict of interest

We have no conflict of interest to disclose.

Data availability statement

The data used in this study is not available for sharing due to Elsevier's terms and conditions. They can easily be retrieved using a valid institutional subscription.

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Primenjena psihologija
Vol. 16, No. 4, pp. 607-610, 2023

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