Review of Psychology,
2014, Vol. 21, No. 2, 137-143 ORIGINAL SCIENTIFIC PAPER UDC 159.9

Executive function in different groups of university students

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The present study analyses the executive function (EF) skills of 369 students of primary education (n = 116), preschool education (n = 72), social pedagogy (n = 54), and biology (n = 128). It explores how the different groups of students use selected executive skills and whether there are any differences between the groups in this respect. Eleven EF skills were self-assessed using the Executive Skills Questionnaire for Students (Dawson & Guare, 2010). All of the groups of students experienced difficulties rarely to sometimes when using EF skills. The groups of students demonstrated similar use of EF skills for Response Inhibition, Working Memory, Emotional Control, Planning, Meta-Cognition, and Goal Persistence, whereas significant differences appeared in Sustained Attention, Task Initiation, Organisation, Time Management, and Flexibility. In cases where differences appeared, the primary education students stood out as having the fewest difficulties with EF skills, while the biology and social pedagogy students reported the most difficulties. Given that executive functioning is important for students' academic achievement, their everyday functioning, and their future work, university study programmes should encourage the development of EF skills among students by offering knowledge about them and supporting their efficient use.

Key words: executive function, executive skills, university students, education, development

A group of university students are assigned a task to write a paper about a book they have had to read for one of their study subjects. The paper has to be ready in ten days time. Tim promptly starts to prepare his paper. After making a time schedule, he works consistently on the task. Even when his friends invite him to join them for a party, he declines and postpones socialising until after he has finished. Thus, he completes his paper three days ahead of the deadline. In contrast, Ana procrastinates writing her paper until two days before the deadline. Before starting to work, she joins her friends in various activities. Even when she finally starts working on her paper, she realises that she does not know where she has put the book. After she finds it, she experiences difficulties with organising the text and deciding what should be emphasised. She works right through the night prior to the deadline and barely manages to finish the paper in time.

This story illustrates two different approaches to planning, initiating, and completing a task that are of particular importance to the participants of our study–university students–for their everyday functioning, their academic achievement, or their future work. The aforementioned skills are referred to as executive function (EF). EF is a multifaceted construct that refers to a set of complex cognitive skills responsible for the planning, initiation, organisation, flexible adjustment, and monitoring of behaviour, thus controlling the execution of complex activities (e.g., Blair & Diamond, 2008; Jurado & Rosselli, 2007; Royall et al., 2002; Williams, Suchy, & Rau, 2009). It encompasses all high-level cognitive functions that control and regulate low-level cognitive processes and support goal-directed behaviour (Janssen, De Mey, & Egger, 2009; Vuontela et al., 2013).

Different authors conceptualise EF either as a single ability including all of the components of executive functioning or as a set of related, but distinct, processes (Jurado & Rosselli, 2007). Empirical studies support both conceptualisations. All components of EF are highly intercorrelated and are essentially a single component during early childhood (Wiebe, Espy, & Charak, 2008, in Lan, Ponitz, Li, & Morrison, 2011). When defined as a set of distinct processes, the list of cognitive functions referred to as EF varies across studies. However, the majority of authors agree that EF includes three components: inhibitory control, working memory, and attentional control (e.g., Lan et al.; Miyake, Friedman, Emerson, Witzki, & Howerter, 2000; Molfese et al., 2010; Zelazo & Cunningham, 2007). Inhibitory control is defined as a mechanism to stop or suppress pre-potent behavioural and cognitive responses (Enriquez-Gepperd, Huster, & Herrmann, 2013; Lan et al., 2011). Working memory

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is the capacity to hold information in mind for a delayed period of time (Baddeley, 2002, in Lan et al., 2011; Engle, 2002), whereas attentional control is the ability to focus on tasks and resist irrelevant information in order to successfully complete the task (Engle, Kane, & Tuholski, 1999, in Lan et al., 2011).

EF is strongly dependent on the function of the pre-frontal cortex (Vuontela et al., 2013). Substantial structural and functional changes (i.e., changes in synaptogenesis, myelination, and synaptic pruning) in this brain area co-occur with the development of cognitive and behavioural control during childhood and adolescence (Huttenlocher & Dabholkar, 1997; Vuontela et al., 2013). Brain changes important to EF are influenced by learning and experience (Molfese et al., 2010).

This function improves throughout childhood, adolescence, and beyond (Carlson, 2005; Zelazo & Carlson, 2012), but the improvement does not occur linearly. Spurts of EF development have been identified between birth and 2 years of age, between 7 and 9 years, and in late adolescence, between 16 and 19 years of age (Anderson, 2001, in Jurado & Rosselli, 2007). Furthermore, different components of EF have different developmental trajectories that may not reach their final level until late adolescence (Passler et al., 1985, in Jurado & Rosselli, 2007).

For each individual, EF is important, as it mediates independent and goal-oriented behaviour (Lezak, Howieson, Loring, Hannay, & Fisher, 2004, in Janssen et al., 2009). Individual differences in EF influence a range of important aspects of everyday functioning throughout life (e.g., Best & Miller, 2010; Miller & Hinshaw, 2010; Williams & Thayer, 2009). Some of the aspects influenced by EF are mental health (Enriquez-Gepperd et al., 2013; Fikke, Melinder, & Landro, 2011), physical health (Booker & Mullan, 2013; Moffitt et al., 2011), and academic performance (Molfese et al., 2010; Rabin, Fogel, & Nutter Upham, 2011). The latter is of particular importance to the participants of our study, university students. Academic and social success in school is associated with efficient executive functioning (Molfese et al., 2010). Moreover, EF in childhood predicts academic achievement and social functioning in adolescence (Miller & Hinshaw, 2010). Furthermore, problems in EF are associated with several neurodevelopmental disorders including ADHD, autism, and learning disorders (e.g., Henry, 2001, in Vuontela et al., 2012).

In the present study, EF skills were assessed in different groups of university students. The EF skills included were those selected by Dawson and Guare (2010), who studied EF in the educational context. Our study explored EF skills in different groups of university students–students of primary education, preschool education, social pedagogy, and biology–for whom EF skills are important for their academic achievement and everyday adaptive functioning, as well as for their future work. Following the list of competencies needed in their future work that each of aforementioned groups of students should achieve many connections to EF skills can be found. Systematic and goal directed transmission of teaching contents, flexible adaptation of procedures and demands to the individual characteristics of each child, and ability to reflect upon and evaluate their work (Razdevšek Pučko & Rugelj, 2006) are the competencies connected to EF that primary education students should develop. The competencies connected to EF, which future preschool teachers should develop, are planning, performing, and evaluating of their work, efficient and flexible organisation of space and time, acknowledging developmental differences among children, and enhancing research and active learning in children (Pedagoška fakulteta v Ljubljani, 2014). As for future social pedagogues, their competencies connected to EF include planning individualised programmes of social-pedagogic work, preparation, implementation, and evaluation of social-pedagogical projects, and analytical and research work in this field (Kobolt & Dekleva, 2006). Students of biology should achieve expert biological knowledge, and the competence to plan, implement, and evaluate research of biological phenomena (Biotehniška fakulteta v Ljubljani, 2012) – competencies connected to EF. It is important to notice that the pedagogic students (primary education, preschool education, and social pedagogy), all of whom are future human-relations professionals who will work with various groups of people in the educational context, will also need to model EF skills for their students, to identify individuals with poor EF skills, and to intervene to strengthen these skills (Molfese et al., 2010).

The selection criteria for the majority of study programmes in Slovenia include academic achievement in secondary school. It can therefore be expected that students, who were sufficiently successful to enrol in university, possess reasonably well-developed EF skills. However, due to specific competencies that are being enhanced in different study programmes, in our study we therefore seek to explore how different groups of students use the selected executive skills. Moreover, does the fact that pedagogical students might eventually be in position to model EF skills for other people in their future work, and should therefore have good EF skills themselves, lead to any significant differences especially between them and the group of biology students?

METHOD

Sample

A total of 369 students participated in the study, all of whom were enrolled at the Faculty of Education and the Biotechnical Faculty in Ljubljana, Slovenia. The sample included 116 students of primary education, 71 students of preschool education, 54 students of social pedagogy, and 128 students of biology (microbiology and biology students). The average age of the primary education students

was 19.34 years (*SD* = 0.82), while it was 19.58 years (*SD* = 1.08) for preschool education students, 19.70 years (*SD* = 0.54) for social pedagogy students, and 20.38 years (*SD* = 1.51) for biology students. The majority of the students were female (94.6% for primary education, 98.7% for preschool education, 92% for social pedagogy, and 87.3% for biology students).

Measures

Executive Skills Questionnaire for Students was used to assess EF (Dawson & Guare, 2010)*. There are 11 subscales included in the questionnaire, each representing one executive skill with three items. These subscales are: (a) Response Inhibition–the capacity to think before acting, to stop or suppress pre-potent behavioural and cognitive responses; (b) Working Memory–the ability to hold information in mind; (c) Emotional Control–the ability to manage emotions; (d) Sustained Attention–the capacity to attend to a task despite distractions; (e) Task Initiation–the ability to start a task in a timely manner; (f) Planning–the ability to create a plan to complete a task, deciding what is important and what is not; (g) Organisation–the ability to design and maintain a system for keeping track of information or materials; (h) Time Management–the capacity to stay within time limits; (i) Flexibility–the ability to adapt to changing conditions; (j) Meta-Cognition–the ability to look at the situation from an observational perspective; and (k) Goal Persistence–the capacity to follow through to the completion of a goal.

When completing the questionnaire, the students indicated the degree to which they usually comply with each executive skill on a 5-point Likert-type scale (1 – *almost never true for me*, 2 – *rarely true for me*, 3 – *sometimes true for me*, 4 – *often true for me*, 5 – *almost always true for me*). Each executive skill has three items, all of which are formed so that higher scores indicate a lower level of executive functioning.

Internal reliabilities (Cronbach α) for each subscale representing the executive skills are presented in Table 1, alongside with intercorrelations between subscales. Internal reliabilities (Cronbach α_s) of subscales are mostly above .60, confirming that these reliabilities are acceptable as recommended by Ferligoj, Leskošek, and Kogovšek (1995). However, internal reliabilities of Flexibility and Goal Persistence are below .60, with α_s .52 and .55, respectively. Taking in consideration that a relatively small sample may contribute to these lower reliabilities and following reviewer's suggestion these two subscales were also included into further analysis. Subscales' intercorrelations (Spearman rho) indicate low to moderate positive correlations between EF skills (according to Cohen's [1988] suggestion on the magnitude of relationships). Average Spearman rho is .34, ranging from .10, between Response Inhibition and Planning, to .63, between Time Management and Task Initiation, meaning that these skills are partly connected.

Procedure

Students from the Faculty of Education – studying primary education, preschool education, and social pedagogy – and biology students from the Biotechnical Faculty completed the questionnaire during one of their lectures. Student participation was anonymous and voluntary, based on informed consent.

Table 1
Spearman rho intercorrelations of executive skills subscales and their Cronbach α internal reliabilities

Executive skills	2	3	4	5	6	7	8	9	10	11	α
Response Inhibition	.27**	.31**	.22**	.25**	.10	.21**	.24**	.17**	.23**	.25**	.72
Working Memory	-	.20**	.38**	.53**	.28**	.47**	.44**	.15**	.35**	.33**	.80
Emotional Control		-	.38**	.27**	.33**	.15**	.23**	.38**	.24**	.27**	.72
Sustained Attention			-	.51**	.40**	.35**	.40**	.37**	.51**	.45**	.77
Task Initiation				-	.39**	.45**	.63**	.23**	.43**	.51**	.75
Planning					-	.22**	.43**	.41**	.36**	.33**	.76
Organisation						-	.44**	.21**	.35**	.36**	.77
Time Management							-	.36**	.35**	.46**	.63
Flexibility								-	.35**	.32**	.52
Meta-Cognition									-	.48**	.64
Goal Persistence										-	.55

** $p < .01$.

* This questionnaire is published in the *Executive skills in children and adolescence. A practical guide to assessment and intervention* (Dawson & Guare, 2010) and therefore publicly accessible. Both authors also gave their written consent to the translation and use of their questionnaire. The translation was done by the authors of this article under a supervision by a professor of Didactics of English language at the Faculty of Education, University of Ljubljana.

Table 2
Medians for executive skills in groups of students

Executive skills	All groups	Primary education	Preschool education	Social pedagogy	Biology
Response Inhibition	2.33	2.33	2.33	2.50	2.33
Working Memory	2.67	2.67	2.67	2.67	2.67
Emotional Control	3.00	3.00	3.00	3.00	2.67
Sustained Attention	2.67	2.33	2.67	2.67	2.67
Task Initiation	2.67	2.67	2.67	3.17	2.67
Planning	2.33	2.33	2.33	2.33	2.00
Organisation	2.00	1.83	1.67	2.17	2.33
Time Management	2.33	2.00	2.33	2.50	2.33
Flexibility	2.33	2.00	2.33	2.33	2.33
Meta-Cognition	2.33	2.33	2.33	2.33	2.67
Goal Persistence	2.00	2.00	2.00	2.33	2.00

Data analysis

The average score of the three items was calculated for each executive skill. Then, the normality of distribution for the average score of each executive skill was tested. Since the normality was not confirmed (Shapiro-Wilk tests and Kolmogorov-Smirnov tests, all $p < .000$), non-parametric statistical procedures were used. Medians were calculated for each executive skill for all groups of students and for each group of students separately (Table 2). Kruskal-Wallis tests were used to compare the results regarding the executive skills of all four groups of students. If the differences between groups were significant, Mann-Whitney tests were used to determine the differences between each pair of student groups (Table 3).

RESULTS AND DISCUSSION

In the results and discussion section, the frequency of the self-assessed use of selected executive skills will be commented upon for all student groups together and for primary education, preschool education, social pedagogy, and biology students separately (Table 2). Differences between the groups of students in the use of these skills will also be identified (Table 3).

The average scores (Table 2) for all EF skills for all groups of students together range between 2.00 (Organisation and Goal Persistence) and 3.00 (Emotional Control). These results mean that the students rarely to sometimes experience difficulties in executive functioning. In general, the students can therefore be described as individuals who usually delay their immediate response in order to follow a more distant goal (Response Inhibition), have an ability to remember information for a certain period of time (Working Memory) and to regulate their emotions quite successfully (Emotion Control), remain attentive to the task despite distractions (Sustained Attention) and commence the task in a timely manner (Task Initiation). They plan (Planning) and organise their actions (Organisation), stay within time limits (Time Management), adapt to changing conditions

Table 3
Significant differences in mean ranks of executive skills between groups of students

Executive skills	Mean rank				Kruskal-Wallis test		Mann-Whitney test
	Pri	Pre	Soc	Bio	χ^2 (*df*)	*p*	
Sustained Attention	151.46	202.81	215.67	192.58	18.84 (3)	.000	Pre > Pri Soc > Pri Bio > Pri
Task Initiation	161.58	187.49	218.59	190.67	11.48 (3)	.009	Soc > Pri Bio > Pri
Organisation	168.69	165.35	189.11	208.94	11.83 (3)	.008	Bio > Pri Bio > Pre
Time Management	88.36	103.22	97.67	100.02	8.64 (3)	.034	Soc > Pri Bio > Pri
Flexibility	83.27	110.08	96.55	130.25	11.65 (3)	.009	Pre > Pri Soc > Pri

Note. > = the first group assessed the executive skill as more frequently used than the second; Pri = primary education students; Pre = preschool education students; Soc = social pedagogy students; Bio = biology students.

(Flexibility), and are able to view the situation from a meta-cognitive perspective (Meta-Cognition). Also, they have a capacity to follow through to the completion of their goals (Goal Persistence). All of these EF skills enable the students to function quite well in academic and everyday situations. These results are also welcome given that EF skills are important for effective functioning throughout life (Lezak et al., 2004, in Janssen et al., 2009), for mental and physical health (Booker & Mullan, 2013; Enriquez-Gepperd et al., 2013), and for academic performance (Molfese et al., 2010). The results are in line with our expectations that university students who have managed to gain entry to university by meeting the criterion of academic success in secondary school possess reasonably well-developed executive functioning. Furthermore, one spurt of EF development has been identified between 16 and 19 years of age (Anderson, 2001, in Jurado & Rosselli, 2007), which means that the students participating in our study may well be experiencing this development, and that their EF skills may even improve further, reaching their final level in late adolescence (Passler et al., 1985, in Jurado & Rosselli, 2007).

In the continuation, we examine the executive functioning within each group of students (Table 2). The average scores for all four groups of students range between 1.67 (Organisation in preschool students) and 3.17 (Task Initiation in social pedagogues). Primary education and preschool education students have the fewest difficulties with Organisation and the most difficulties with Emotional Control. This means that students have an organised workplace and notes (Organisation items), but experience more difficulties with regulating their unpleasant emotions if they encounter obstacles when performing a task (Emotion Control items). Similarly, social pedagogy students also have the fewest difficulties with Organisation, but they experience the most difficulties in Task Initiation. From the Task Initiation items, it can be concluded that these students sometimes do their work at the last minute and have difficulties postponing any pleasant activities. Biology students have the fewest difficulties with Planning and Goal Persistence, and the most difficulties with Working Memory, Emotional Control, Sustained Attention, Task Initiation, and Meta-Cognition. As such, biology students are quite good at planning complex and extended tasks (Planning Items) and at following their goals (Goal Persistence items); on the other hand, they experience more difficulties due to forgetting or losing something (Working Memory items), as well as having more difficulties managing emotions (Emotional Control items) and focusing on and persevering with a task (Sustained Attention items). Sometimes, biology students do their work in the last minute and they have difficulties postponing any pleasant activities (Task Initiation items). Also, they only sometimes evaluate their work in order to improve it (Meta-Cognition items). However, it should be emphasised that the range of EF skills medians within each student group is very small, especially in biology students.

Executive functioning is similar between the groups of students for Response Inhibition, Working Memory, Emotional Control, Planning, Meta-Cognition, and Goal Persistence. However, there are significant differences between the groups of students in Sustained Attention, Task Initiation, Organisation, Time Management, and Flexibility (Table 3). With regard to Sustained Attention, primary education students have significantly fewer difficulties than preschool education, social pedagogy and biology students. Primary education students again have significantly fewer difficulties than their social pedagogy and biology colleagues when it comes to Task Initiation and Time Management. For Organisation, primary and preschool education students have significantly fewer difficulties than biology students. For Flexibility, primary education students have significantly fewer difficulties that preschool education and social pedagogy students. Compared to the other groups of students, primary education students stand out as having the fewest difficulties with EF skills where differences actually appear; on the other hand, biology and social pedagogy students reported the most difficulties in these executive skills. Primary education students have comparatively fewer difficulties in focusing on and persevering with a task (Sustained Attention items); they begin their work in time and can postpone interfering pleasant activities (Task Initiation items). Also, they have fewer difficulties organising their workplaces and notes (Organisation items), have control over time (Time Management items), and are flexible when performing a task (Flexibility items). These results are encouraging, since good EF skills are important for primary education students, as they will work with children in primary school and model EF skills to them (Molfese et al., 2010). Also, they will have to present knowledge in a systematic and goal directed manner and to flexibly adapt their procedures and demands to the individual characteristics of each child (Razdevšek Pučko & Rugelj, 2006). Their results especially regarding EF skills Organisation and Flexibility are quite in line with abovementioned competencies. However, it might also be possible that primary education students, because of their future work orientation as teachers, are more aware of the importance of EF skills, and consequently self-assessed these skills significantly higher.

On the other hand, the comparatively worse results of biology students can be in contradiction with their competencies of planning and implementation of research of biological phenomena (Biotehniška fakulteta v Ljubljani, 2012), connected to Sustained Attention, Task Initiation, Organisation, and Time Management EF skills. Also, the comparatively worse results of social pedagogy students can indicate less developed competencies of planning individualised programmes and preparation and implementation of social-pedagogical projects (Kobolt & Dekleva, 2006) that may be connected to Sustained Attention, Task Initiation, Time Management, and Flexibility. Preschool education students have-compared to primary school students-

worse results regarding Sustained Attention and Flexibility and-compared to biology students–better results regarding Organisation, showing mixed portrayal of their competencies such as planning and flexible organisation of space and time (Pedagoška fakulteta v Ljubljani, 2014).

In summary, where differences between groups of students in EF skills do appear, primary education students reported comparatively fewer difficulties with EF skills than other groups of students, while biology and social pedagogy students reported difficulties more frequently. The possible higher executive functioning in all groups of pedagogical students in comparison with biology students was not entirely present. Therefore, each study programme should provide tailored information regarding executive functioning, specifically regarding those skills where students have more difficulties.

CONCLUSION

By including university students in our study, we emphasised the importance of EF skills in the educational context, which is not abundantly represented in otherwise more clinically oriented studies in the EF area. These skills are important to students in order for them to successfully achieve their goals in the academic field and in their future work environment, as well as in everyday functioning. In the study, EF skills are analysed in four groups of university students: primary education, preschool education, social pedagogy, and biology students. For the eleven EF skills included, the students reported rarely to sometimes experiencing difficulties with their use. This is in line with the fact the participating students had managed to gain entry to university programmes for which previous academic success is crucial, and such success is also associated with executive functioning (Molfese et al., 2010). Executive functioning is similar between the groups of students for the majority of EF skills, although the profile of EF skills is not entirely homogenous. However, there are some significant differences in the use of EF skills between the groups of students with regard to Sustained Attention, Task Initiation, Organisation, Time Management, and Flexibility. Primary education students reported the fewest difficulties with these EF skills, while biology and social pedagogy students reported such difficulties more frequently. The possible higher executive functioning in all groups of pedagogical students compared to biology students was not found.

As mentioned above, EF skills are important to all students for academic achievement, for their future work, and for everyday goals; however, primary education, preschool education, and social pedagogy students, who are likely to work with different groups of people in the educational context, will also need to model EF skills to their students. They might also have to identify individuals whose distractibility, inattentiveness, difficulties with initiation, poor organisation, and similar EF skills may interfere with their learning (Molfese et al., 2010), and to intervene to better meet the needs of such individuals and encourage their development of EF skills. In order to accomplish this task, awareness and knowledge of EF skills is crucial. Study programmes should therefore provide information on this area and encourage students themselves to use their EF skills efficiently.

In addition to investigating the typically emphasised areas of inhibitory and attentional control and working memory, the instrument used in the present study provides information about several EF skills simultaneously. However, the attained results for Flexibility and Goal Persistence scales should-due to their lower internal reliabilities-be taken cautiously. Cautious generalisation of results is also needed since the participants in our study represent specific groups of students, and the majority of them were women. Furthermore, the EF skills were self-assessed by the students, and as such the subjectivity of the participants should be taken into consideration. In future research, self-assessment may be combined with direct observation.

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