Studia Psychologica, Vol. 62, No. 2, 2020, 89-108
https://doi.org/10.31577/sp.2020.02.793

Emotion Regulation Strategies in Paramedic Crew Leaders during a Simulated Stressful Task: A Qualitative Inquiry

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In spite of a large body of research in the field of emotion regulation, this subject has not yet been studied vigorously in naturalistic settings, especially not in the context of task performance. Therefore, it remains uncertain whether predominant theoretical conceptualizations of emotion regulation (e.g., Gross, 1998) can be applied to this sort of situation. In this qualitative study, we aimed to identify emotion regulation strategies of paramedic crew leaders (n = 30) in a simulated task with a sudden onset of a stressful incident. For this purpose, we analyzed their emotional behavior (i.e., facial expression, voice volume, body posture and movements etc.) on video recorded performance, and their affective states and emotion regulation strategies based on interviews conducted right after the task. Verbal reports were analyzed via phenomenologically-laden template analysis. We classified emergent strategies into two basic categories: task-related (e.g., attention narrowing, mobilization to action, monitoring) and self-supportive (e.g., emotional distancing, behavioral withdrawal, detachment and selective attention). Results of our analysis suggest that regulatory strategies are largely implemented on an implicit level of processing and their function might be a better criterion for their distinction than a type of mental process.

Key words: coping with stress and fatigue, emergency medical service, non-technical skills, naturalistic decision making, simulated task

Introduction

Despite both emotion regulation and naturalistic decision making being established traditions in psychological research, the two paradigms have barely crossed their paths. With human error being discussed in occupations such as aviation (Wiegmann et al., 2005) or medicine (Kohn, Corrigan, & Donaldson, 2000), and stress being mentioned as one of the major variables behind it (Sexton, 2000), scientific justification for collaboration between the two mentioned research traditions is obvious. In Japan, almost half of the fatal medical accidents (46.6%) are likely caused by the human factor (Uramatsu et al., 2017). The research of naturalistic decision making (Klein, 2008) and closely related non-technical skills (Flin, 2013) has been driven by an ambition to

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Received April 8, 2019

reduce the human error by studying macrocognitions and teamwork processes of professionals during performance. Coping with difficult subjective states such as stress or fatigue was also acknowledged as a vital skill for enhancing work performance (Kodate et al., 2012). Several studies point to the detrimental effects of stress on both technical and non-technical skills in medicine (e.g., Crewther et al., 2016; Harvey et al., 2012; Krage et al., 2017), which is likely due to a limited acquisition of information or acceleration of pace with trade-offs for accuracy (Maule, 1997). However, experts can be much more immune to losing accuracy compared to novices (Pavlidis et al., 2012). This is in line with claims of Orasanu (1997) and Klein (1997), who both theorize that experts should be least affected by stress in familiar situations where rule-based decisions are optimal, because they rely on intuitive, bottom-up processes.

However, due to methodological difficulties of studying coping with stress in terms of observable and measurable behavior (Shields & Flin, 2013), naturalistic studies still resort to examining effects of various stressors on physiological markers of stress and performance (Orasanu, 1997), while mechanisms of coping with acute stress remain poorly understood. Therefore, unlike other mental processes, such as situation awareness, decision making or uncertainty management, coping with stress was not conceptualized for the purpose of study in high-fidelity simulated tasks. Because coping strategies are framed as global patterns of behavior and cognition, utilized on regular basis according to most theories and measurement tools (e.g., Carver, Scheier, & Weintraub, 1989; Folkmann & Lazarus, 1988), they are not categories sufficient for understanding management of affective states in short time periods (see Boyle et al., 2011). On account of this limitation in the study of coping, Gross (1998) presented emotion regulation as a more nuanced and fine grained conceptualization of how emotions are managed, and he proposed the process model of emotion regulation as a framework for understanding and studying emotion regulation strategies.

The process model still remains the most satisfactory classification of ER strategies in contemporary psychology. Koole (2009) and Gross (1998, 2015) find an agreement in differentiating three emotion-regulatory systems – attention (e.g., attentional deployment), cognition (e.g., reappraisal, emotional distancing) and body (e.g., ventilation, suppression, relaxation). Gross (1998, 2015) distinguishes behavioral strategies of situation selection and situation modification as forms of emotion regulation as well. Cognitive reappraisal – reinterpreting the meaning of a situation into a more positive framing – is widely considered as the most adaptive strategy based on empirical evidence (Gross, 2002). Reappraisal is often put into contrast with suppression, which is an emotion regulatory strategy that inhibits bodily emotional response. The use of suppression has several negative consequences for the subject, including amplification of experienced negative emotion (Gross, 2002) and physiological arousal (Hagemann, Levenson, & Gross, 2006), and deterioration of cognitive performance (Richards & Gross, 2000). Turning one's attention away from an aversive stimuli – attentional deployment – is an effective strategy when the intensity of negative emotion is high (Sheppes, Catran, & Meiran, 2009).

At this point, it is important to note that multiple emotion-regulatory systems or strategies are likely to be implemented in real-life situations (Aldao & Nolen-Hoeksema, 2013), and the context of task performance consists of some additional particularities and methodological challenges. The lines between desirable action and emotion regulation may become blurred. Working memory's preoccupation with the task may itself serve as a distractor from aversive stimuli, causing the neutralization of emotional experience (van Dillen & Koole, 2007). Objections were raised with regards to the model's focus on effortful, top-down regulatory strategies (Koole, 2009; Koole & Rothermund, 2011) and its ability to represent regulatory strategies in real-life conditions (Campos et al., 2011).

The process model was vastly extended and improved over time (see Braunstein,

Gross, & Ochsner, 2017; Gross, 2015; Tamir, 2016). Knowledge from self-regulation research and motivational factors were taken into account. Hedonic and instrumental motives were differentiated. Adopting an endless feedback loop between situation (or its perception) and emotion regulation strategy brought a more authentic representation of real-life dynamics in which emotion regulation is taking place. However, Koole and Veenstra (2015) argue that the model still relies on static mental representations as a driving force. Therefore, it is still lacking in capturing the emotion regulation as a process that is interacting with changing environment. At the same time, it remained unchanged in its rigid classification of emotion regulation strategies by the type of process. Rice and Hoffman (2014) believe that a functional perspective, such as the one in theory of defense mechanisms, could be a better a criteria for differentiation between regulatory strategies, compared to process model's schematic approach.

Baumann, Sniezek, and Buerkle (2001) constructed a theoretical model of self-regulation in naturalistic decision making under stressful conditions based on their review of empirical literature. The central assumption of their model is that successful management of task anxiety is dependent on the perception of one's own performance during the task. If one's personal resources and capabilities are perceived as insufficient for the task's demands, the anxiety raises above a tolerable level. The performer is thus at a risk of becoming stuck in a loop between negative self-evaluation of performance and task anxiety. Motivated self-evaluation (focusing on manageable subtasks) is a protective factor against overwhelming task anxiety. However, not all negative or intense emotions need to be regulated as they might carry a cue to a goal-fulfilling action (Mosier & Fisher, 2010).

The cyclical model of impact of emotions on paramedics' experience during critical incidents, constructed by Avraham, Goldblatt, and Yafé (2014) with a grounded theory approach, postulates similar claims. Negative emotions lead to a sense of professional inadequacy and a lack of perceived control over the task, which further amplifies these emotions. However, paramedics themselves highlight that a certain level of detachment from their emotions is the key protective factor, not positive self-evaluation of their performance. Because detachment is not explicitly mentioned in the process model of emotion regulation (Gross, 1998, 2015), this finding emphasizes the need to study emotion regulation in professional performance as a specific phenomenon. The same principle applies to motivated self-evaluation proposed by Baumann et al. (2001), which might have reappraisal as one component, but it also consists of attention management.

Paramedics have not been given that much attention by researchers of naturalistic decision making, compared to other medical occupations. Assessment manuals of non-technical skills have been created for surgeons, anesthesiologists, and assistants of surgeons (Flin, 2013), but not yet for paramedics. Moreover, as was elaborated in the previous text, coping with stress or fatigue has yet to be put to an extensive empirical probation in the study of medical or even naturalistic decision making. However, coping may not be the most appropriate term to conceptualize management of emotions in naturalistic settings. We argue that emotion (or affect) regulation (Gross, 1998, 2015; Koole, 2009) offers more sufficient terminology for this purpose. A few theoretical models (Avraham et al., 2014; Baumann et al., 2001) attempted to set a starting point for the study of management of distracting emotions while performing in naturalistic conditions, but more effort is required. It is our intention to contribute to this line of research. In this study, we aim to identify, classify and describe emotion regulation strategies in paramedic crew leaders during stressful task on the level of mental processing and observable behavior as well. Our intention was to design a study that would enable us to examine affective states and strategies of their regulation in complex, naturalistic and experience-near settings.

Methods

Two sources of data were utilized for the purpose of this study. Both video recorded procedure of paramedic crews during a simulated task and transcribed interviews with paramedic crew leaders were analyzed to accomplish a fusion and triangulation of behavioral and phenomenological approach.

Participants

Our research sample consisted of 30 paramedic crew leaders (17 male, 13 female) of Czech and Slovak nationalities. The age of the participants ranged from 23 to 47 years (*AM* = 31.17, *SD* = 6.67, *Mdn* = 29.50). Each crew consisted of the crew leader, paramedic – driver, and paramedic – operator, with the exception of two crews having one extra member. However, in our study, we focused solely on crew leaders. One of the crews was excluded from our research sample due to technical issues of the video record from our main camera. Three crews consisting of medical students were included, while all others were professional paramedics with a various length of practice in their occupation, ranging from 1 to 26 years (*AM* = 7.33, *SD* = 5.80, *Mdn* = 7).

Participants were recruited at an international paramedic competition Rallye Rejvíz 2017. After an agreement with the organization board of this competition, every paramedic that was interested in competing in this event had to explicitly agree with taking part in data collection as a participant in order to be registered. Each registered competitor received information about the planned research a month before the start of the competition. Specifically, the information mentioned video recording of their performance during one of the task and a post-task interview with the crew leader. Our entire methodology had been approved by the ethical board of Slovak Academy of Sciences.

Data Collection

Paramedic crews were video recorded while performing a simulated task. Four static cameras were placed in a room where the task was taking place and one camera was handled by a cameraman who was targeting the crew leader. An interview with the crew leader was carried out right after the task had been completed. The semi-structured interview had a format of a retrospective verbal protocol with an intention to make the crew leader recall and describe his/her experience during the task including his/her intentions, thoughts, emotions and means of coping with them. The interviewer was supposed to make the interviewee as specific as possible, so that his/her experience of the task could be reconstructed on a timeline (more in Data analysis). Interviews were conducted by a group of three researchers and they took from 10 to 15 minutes.

Task

The task named “Grill” started as a routine-type mission, even though paramedic crews had been informed beforehand about the possibility of a domestic violence. On the scene, one paramedic crew (played by figurants) was taking care of a pregnant drug-addict and the competing crew was supposed to take care of an injured female pensioner who was denying any domestic violence, and her distraught sister who was blaming the drug addict. After a few minutes, the drug-addict stabbed a member of the other paramedic crew right after the arrival of a police crew (who are also competitors, not figurants, and therefore their behavior was not scripted). The aggressor (i.e., the drug addict) ran to the backroom and was threatening the police with a knife. Stabbing of the paramedic caused an acute bleeding, so the competing paramedic crew was supposed to attend, stabilize and monitor the injured paramedic, and possibly take care of the aggressor if she got injured by the police. The pair of pensioners, who needed to be properly examined, was supposed to have an antagonistic reaction if the policemen shot the aggressor in their sight. Paramedic crew leaders were supposed to report the means and directions

of transportation of every patient to dispatching at the end of the task.

Data Analysis

A codebook for emotional behavior (Appendix 1) was developed by a certified FACS (Facial Action Coding System; Ekman & Friesen, 1978) coder after analyzing video records of every crew during the task "Grill". The codebook was largely inspired by basic emotions and emotion families (see Ekman, 1977; Ekman & Cordaro, 2011; Wallbott, 1998) and listed 25 categories of emotional behavior. The certified coder schooled one of the researchers in this coding tool, so he could independently code emotional behavior of crew leaders. Subsequently, all video records were coded by both coders, the codes were compared, discussed and consensus on mismatched data segments was reached. In addition, the paramedic crew leaders' behavior was described as precisely as possible and notable situational cues were also recorded in writing.

Interviews were transcribed and analyzed via template analysis to identify affective states, goals and regulatory strategies of crew leaders during the task. We applied the combined, exploratory-theoretical approach. Especially our effort to identify regulatory strategies was theoretically grounded in contemporary knowledge as they are conceptually complex processes. A list of regulatory strategies was constructed by authors of this study prior to analysis based on four articles (three review articles and one meta-analysis) that provided extensive summaries of strategies (Gross, 2015; Koole, 2009; Peňa-Sarrionandia, Mikolajczak, & Gross, 2015; Webb, Miles, & Sheeran, 2012). We did not include macro-level means of emotion management such as coping styles, mindfulness meditation, etc. Strategies on our list were grounded in the process model's framework and each of them was precisely defined. Strategies proposed by Avraham et al. (2014) and Baumann et al. (2001) were also added to this list. The list was applied in data analysis as a coding system that was open to adjustments and changes based on data. Because any statement regarding cognitive processing, attention direction or behavioral action might indicate emotion regulation without the subject's explicit awareness (Koole & Rothermund, 2011), more latent and interpretative coding procedure had to be applied at times to identify regulatory strategies. Every statement indicating emotion regulation was coded initially and stricter selection process was applied when re-evaluating our codes. In comparison, affective states and goals were coded more semantically (see Guest, McQueen, & Namey, 2011). A codebook for interviews was created by one of the authors and another coder tested it on a limited dataset. After initial comparisons and consultations, adjustments to the codebook were made and both coders used it to analyze the entire dataset. Inter-rater agreement was calculated and reached moderate levels ($\kappa = 0.66$), but both coders were at liberty to suggest their own codes via memos if they found it appropriate. Data segments where agreement was not found or new codes were suggested were reappraised afterwards.

After video records and transcriptions of interviews were analyzed, timeline of the task "Grill" for every paramedic crew leader was constructed using both sources of data. Interviews proved to be rich enough to enable matching the reported subjective experience with behavioral data without much doubt and confusion regarding their placement on a timeline (illustration of a data segment on a timeline is in Appendix 2). During this triangulation, we adjusted our categories for regulatory strategies and even proposed a few more (more in results). We looked for patterns in our timelines regarding regulatory strategies – what is the situational context of implementation, which affective state is regulated, what is the participant's behavior, etc. – in order to describe them in the greatest possible depth. We distinguished time frames where a good fit between the two sets of our data was not achieved (i.e., the self-reported and observed affective state did not match), which resulted in a greater level of ambiguity and interpretation. One of the identified subcategories – de-

tachment and selective attention – was inferred based on this lack of fit.

Results

Our analysis produced 14 subcategories of emotion regulation strategies which were classified as either task-related or self-supportive. We abandoned the classification system of our prior coding scheme based on the process model, because the differentiation by a type of process was not a good fit for the content of identified subcategories. Identified strategies were not distinguishable purely on merits of process-type. Functional approach seemed more appropriate. The primary intention of task-related strategies was to enhance performance, which included regulation of distractive emotions and management of emotional arousal to meet the task's demands. Tolerable and activating level of distress, which leads to a desirable form of action, is a more desirable effect of task-related strategy compared to a positive mood or relaxation. On the other hand, self-supportive strategies served the purpose of attenuation of negative emotions and/or induction and amplification of positive emotions, and they had no direct connection to task-related action. In presentation of our results, we describe the most comprehensibly portrayed strategies in greater detail. All emergent strategies are summarized and shortly characterized in Table 1.

Table 1 *Overview of emergent emotion regulation strategies and frequencies of their occurrence*

	Strategies	Short definition	Occurred in *n* participants
Task – related	Attentional narrowing	Focusing one's attention to a specific set of stimuli or a subtask.	16
	Mobilization to action	Directing emotional arousal towards immediate action.	14
	Mobilization to deliberative concentration	Attempt to think and plan sequentially, step-by-step.	12
	Distancing from the scene	Viewing the situation as a whole.	11
	Vigilance	A state of readiness to react to any critical event.	13
	Monitoring	Keeping specific stimuli in check.	11
	Relying on a rule-based procedure	Finding comfort in sticking to guidelines and automatized processes.	9
	Reflection of previous decisions and events	Dealing with a disappointment by asking oneself whether an aversive event was preventable.	4
Self – supportive	Emotional distancing	Observing one's own emotions from a distanced perspective.	9
	Establishing a sense of connection with the other	Seeking the experience of being in contact with another person.	5
	Detachment and selective attention	Disconnection from one's emotions, directing attention away from negative aspects of performance.	7
	Behavioral withdrawal	Withdrawal from a dangerous situation.	6
	Venting	Reduction of tension by behavioral expression.	6
	Positive self-talk	Encouraging oneself by positive statements.	3

Table 2 *Summary of the descripted experience and behavioral signs of major task-related emotion regulation strategies*

Strategy	Experiential component	Behavioral signs
attentional narrowing	- absorption with a set of stimuli or a subtask - some stimuli or all surroundings are blurred or completely disappeared - awareness of emotional state is dissolved in favor of a limited number of situational cues and action	- focused on the current task, not looking around - does not respond to stimuli or requests from his/her team members - reverts his/her attention back to a previous activity if disturbed - reacts surprised when informed about course of events not in his/her immediate proximity
mobilization to action	- feeling time pressure and urge to act, even when not understanding the meaning of what is happening in the situation - feeling professional responsibility to act - energizing one's own body	- a sense of emergency in performed procedures - acceleration of pace - insisting on colleagues to assist quickly - increased volume of voice, quick pace of speech - proptosed eyes and slightly open mouth, similar but not as intense as worry - checking clocks
mobilization to deliberative concentration	- the situation is perceived as suddenly overwhelming - a step-by-step thinking brings a sense of order into chaotic situation	- does not act, remains vigilant towards the situation, might even appear confused about the appropriate course of action - action is either hesitant or rushed, but with moments of interruption - summarizing and discussing information with colleagues
monitoring	- having a specific expectation or suspicion that something might get out of control - tension arising from this expectation - keeping that aspect of situation in check by attention or direct action	- being watchful towards an unstable aspect of the situation - examining the patient anxiously, checking for some symptoms or vital signs multiple times
vigilance	- tension arising from an expectation of some dangerous, averse event - being in a state of readiness to react to a change of situation	- visually scanning the scene - reacting to sounds (turning of the head) - being attentive, but suspicious towards reports of people on the scene, asking about specific details
distancing from the scene	- stimulating or routine level of stress - being above the situation - situation is observed as a whole and thinking is almost effortless	- instructing and organizing the work of colleagues - no visible emotional expression, appearing calm and collected

Specific behavioral and experiential features of task-related strategies (except minor ones) are presented in Table 2. The same was not done for self-supportive strategies, as they were less tied to specific moments of task completion (or time units in our timelines), and therefore we assumed textual description to be sufficient. Because we had to settle for a limited set of sample due to constraints of the competition, we could not achieve a satisfactory theoretical saturation for every subcategory we identified in our analysis. We did not want to exclude less saturated subcategories from the results as they might be elaborated in future studies. The density of our data was satisfying for most subcategories of emotion regulation except for three – ventilation, establishing a sense of connection with the other, and positive self-talk.

Task-Related Strategies

Attentional Narrowing

Referred to as the so-called tunnel vision, often following mobilization to action and accompanied by the use of intuitive rule-based procedures, this strategy was characterized by an attentional preoccupation with a specific set of stimuli or a specific subtask while other stimuli and subtasks are being ignored. The most typical situation of use was during an effort to stop the acute arterial bleeding and stabilize the patient, which was accompanied by a sense of trust that the police will keep the paramedic team safe. Surroundings became acknowledged once a sense of control over an urgent subtask was maintained. This could take just one minute or it could last until some of the patient's vital signs were checked several times. Self-awareness was also compromised by the use of this strategy, as was explicitly noted by some of our participants.

We were safe, because police was on the scene, so I could take care of my colleague [the injured figurant] and I didn't feel anything... I guess, because I'm used to making my tunnel for what I need to do. And I totally let my surroundings go, so I just found out there's another patient [the aggressor] right before the end of the task, because I'd been so focused on my patient, so I had no idea about what's going on around me. (P1/26)

The tunnel thing, that's adrenaline, you know. The adrenaline is pumping, one is just running through it and he only looks just at what's in front of him, you know. No interest in what's on one side or the other. (P3/72)

I usually feel like... empty, emotionally. I'm just thinking about what needs to be done and maybe I feel something, but I'm not aware of it. (P29/53)

The implementation of this strategy was not always successful. Two participants report using this strategy, but feeling highly aroused, in danger and showing signs of fear and alertness towards the physical conflict between the police and the aggressor. However, the strategy was not implemented only as an absorption with a high-priority subtask during emergency, but also as a means to filter out frustrating distractors when the situation was still calm.

Of course, you need to filter out those people, those that don't matter at that moment. And people do complain quite often as the old lady did there. (P7/16)

Mobilization to Action

When the situation was interpreted as an emergency, a sense of responsibility and a need to act arose. These feelings were associated with their professional role as a paramedic and as a leader. The fact that it was another paramedic, a colleague, who was in a need of help, was also significant for them. A belief that a paramedic is supposed to act and not be stunned by any event was explicitly present in some verbal reports.

I know I need to do something, that I'm not there to break down. That's why I'm doing this job. (P6/064)

It's some kind of mechanism – like we have to do something. That someone needs help, probably even the factor that it's our colleague [plays a role]. (P28/44)

Even if the paramedic crew leader did not fully comprehend the situation, was unsure

about his or others' safety, or was in a freeze reaction, this urging to act was often expressed in a confused tendency to walk towards the injured paramedic. In some cases, this was an automatic, reflex-like reaction without any moment of hesitation.

Priorities changed and that, like… alertness of organism and mobilization to act immediately [changed also]. (P15/050)

It's like I was born this way that I have to press on the wound. Like you don't even think about it. You just rush and do it. (P23/068)

Behavioral manifestations of mobilization to action included acceleration of pace, a sense of emergency in sensorimotor operations, and insisting on colleagues to assist quickly.

Mobilization to Deliberative Concentration

Several participants experienced the situation as overwhelmingly stressful, chaotic and engulfing, and may have displayed either shock or fear. Above all, they acted as confused (being stuck between multiple courses of action or switching from one operation to another) or uncertain, lacking in natural fluidity of behavior. As a result of this strategy, action was rushed at some moments, but there were multiple moments of interruption when the leader was stuck.

This typically occurred to less experienced paramedic crew leaders (n = 5, avg. length of practice: 2.4 years) during and immediately after the incident with the police. For instance, one of our participants in this study reacted with vigilance and confusion during the incident, undecided whether to assist colleagues whose reaction was quicker or to stay with the pensioners to keep them safe. He described his means of dealing with the emotional arousal as an attempt to approach demands of the situation with sequential thinking.

"I guess I'm trying to focus on stuff singularly… like… what should I do first, what's next… that I refuse to accept that this is not going so well, we're not gonna make it, but I'd rather tell myself 'well, now I need to do this, then I need to do that'." (P29/094)

In more experienced paramedics (n = 4, avg. length of practice: 9.25), this strategy was applied after initially reacting on impulse to the acute bleeding and narrowing their focus to the paramedic figurant for a period of time. As they were trying to acknowledge other situational aspects, they had to exert some extra effort to compensate for their lack of perspective and to have a sense of control. They described their cognitive processing as sequential and systemizing. On a behavioral level, collecting, summarizing or discussing information in communication with colleagues was observed.

I was thinking rationally about it, I was thinking we might need some psychological support for witnesses, those who saw the injured paramedic. So I was thinking about the next step. (P25/062)

Monitoring

When a certain aspect of the task seemed out of control or was likely to cause some trouble in the leader's perception, he remained watchful and prepared to react. Most typically, he would be concerned about the aggressor before the incident took place, which was provoked by his verbal conflict with one of the pensioners. There was a tendency to turn towards the source of suspicion or even come to the figurant paramedic crew to make sure they're handling their patient.

Monitoring also occurred when observing the physical conflict between the police and the aggressor or during stabilization of the wounded paramedic when checking his vital signs multiple times, sometimes overlapping with narrowed focus. The difference between the two strategies is that narrowed focus includes taking action to fix something that is out of order as a vital component, while in monitoring the stimuli is only a prospective cue for action, likely resulting in lesser demands on concentration. Thus, refocusing towards different stimuli or operation would happen more fluidly.

I was checking my colleagues who were examining them [pensioners] and because the

colleague [from figurant crew] told us they're taking care of the restless woman [the aggressor], I wanted to keep an eye on her. (P2/020)

Vigilance

Compared to monitoring, vigilance had no specific focus. Many participants had an expectation that some danger might be present in the situation, but did not stick to any hypothesis due to their previous experience with being unpleasantly surprised in paramedic competitions. Mostly, they expected some form of aggression and set themselves into a state of readiness to react to any significant event, but hypervigilance to any sort of danger (e.g., gas poisoning) expressed behaviorally as visual scanning of the scene or hyper-reactivity to sounds was also present. This could lead to catching on irrelevant situational cues. For instance, one of the crew leaders was curious when one of the pensioners mentioned they had been making coffee prior to paramedics' arrival, because he considered the possibility of a gas leak.

I was looking around every corner because I was expecting some kind of a catch. That lady was saying they had been making coffee, so I was thinking there might be a gas leak, that there might be some danger. (P2/036)

Hypervigilant participants experienced the first phase of the task as quite demanding, while participants vigilant on a lower level described their experience as a non-disturbing tension.

Unfortunately, you expect at some subconscious level that something is going to happen behind your back on these competitions. (P17/08)

Distancing from the Scene

Initially identified in the same category as compensation through deliberative concentration, distancing from the scene was later distinguished as a separate regulatory strategy after triangulation with behavioral data. While also having the aim of comprehending and handling all unresolved aspects of the situation, some participants described their cognitive processing as less effortful, more holistic, and relaxed. This was behaviorally manifested as a tendency to step outside the scene and observe it not just in a mental, but also physical distance. They generally showed no signs of emotion in their behavior and they felt above the situation, which was visible in their tendency to instruct their colleagues or provide them with information while speaking calmly.

Like I said, it's a competition, so I didn't feel that much. I was more concerned with handling it logistically – to help our patient and also to take care of the old ladies here. I felt no emotions at that moment. (P10/30)

I was with my colleagues at that moment and I was telling them what to do, how to proceed, what should be checked… (P2/024)

Minor Task-Related Regulatory Strategies

Few other strategies beyond the aforementioned ones were identified, but were not as prevalent and rich in participant's verbal reports. *Reflection of previous decisions and events* was present when crew leaders felt frustrated and disappointed with paramedic's injury or the pregnant woman's death. They were obsessively asking themselves whether they could have prevented this event or whether it was their fault. In terms of emotional behavior, this was manifested as attenuation – being passive, absent-minded, and mentally isolated from what was happening. Relief or disappointment was observed by the end of the task. Although likely adaptive in some forms after the task, this seemed to be deteriorative to their performance.

Also, some participants found comfort in *relying on a rule-based procedure*. They reported that the clarity of guidelines for taking care of acute arterial bleeding and their internalized knowledge of these guidelines made them feel confident in what they were doing, but this was also the case for one participant, who applied the ABCDE heuristic when examining the injured pensioner after being observably confused and insecure in reaction to the incident.

Self-Supportive Strategies

Emotional Distancing

Emotional distancing, in a sense of assuming a distanced position towards one's own emotions, was largely dependent upon an interaction with the environment. If the situation was perceived as a game or a sport, emotions were still elicited by external events, but one could remain safe from engulfment by their intensity. However, it is unclear when this is caused by conditions of the competition (such as the presence of referees in the room, authenticity of figurants' performances, etc.) and when this is a motivated emotion regulation. It is very likely that both factors come into play, but to draw a precise line between them is difficult from our data. However, at least one of our participants reported consciously reminding himself of the nature of the situation.

(What helped you to handle this situation?) This time? I reminded myself it's a competition. (P21/50)

It's different in real-life. I'd be more scared, definitely. More fear, more respect. There, I have this subconscious sense of safety because it's a competition. (P11/008)

Relieving smile or joking was observable on those participants who described their emotional attitude towards the task as distanced multiple times, usually in a reaction to the rambling of one of the pensioners.

Establishing and Maintaining a Sense of Connection with the Other

Another mechanism or regulating one's affective state that was co-implemented in interaction with the environment was founded on experiencing some form of connection with another person, which could have been a colleague or a figurant. The familiarity of colleagues was a good regulator in words of our participants and it was not just their presence in a passive sense of the word that had this effect, because crew leaders were intuitively but actively reminding themselves of their presence.

(What was is it specifically that helped you to handle this situation?) Well, my colleagues, my contact with them. Verbal or nonverbal, their body language. We're a well-coordinated unit, we're used to each other. (P15/097)

A few direct behavioral manifestations were observed, which includes touching or having a common relieving smile, indicating that this process is enacted rather under the skin than outwards.

Communication with figurants could also be a way of managing one's own emotions, though this was reported in a number of ways. A simple exchange of first names could have a regulating effect, but this was also reported about soothing figurants' emotions. A tendency to calm and ground distraught pensioners was particularly apparent in crew leaders that were shocked and overwhelmingly stressed by the incident.

For instance, calming that miss [helped me feel better] and I tend to touch patients by the shoulder when I see they might be disturbed, maybe because I am disturbed too, so that's definitely automatic. (P29/64)

Detachment and Selective Attention

Discrepancies between participants' verbal reports and observable behavior can often be caused by imperfections of cognitive apparatus, but in some participants they happened to be so severe they could be interpreted as implicitly motivated. Their emotional distress was noticeable in forms of shock, freeze reaction, worries, confusion, uncertainty, helplessness, etc., but signs of this distress were absent in their verbal reports. For instance, when asked directly about their freeze reaction to the stressful incident, two participants answered they are not even aware this happened and they believed they had reacted immediately to the figurant's bleeding. However, this discrepancy was not strictly tied to the incident when the paramedic figurant was stabbed, but manifested throughout their whole narrative about the course of this task.

After an initial stressful reaction to the incident, their behavior became inhibited to the

point of giving the impression of carelessness, but their facial expression had mild features of worry (e.g., redness in face, open mouth, proptosed eyes). They answered the interviewer's questions usually in terms of mechanistic description of their behavior and they were either unaware of any emotional reactions or unable to elaborate their answer beyond terms such as stressful or difficult. A tendency to describe their approach and overall performance as professional and well-handled was present in some of them.

I don't even know if something is going through my head when I'm on the job. You just do what you're supposed to do, you think about diagnosis and there's nothing else [on my mind]. (P26/16)

Minor Self-Supportive Strategies

Some participants interpreted the incident as a danger to them and/or to pensioners in the room and immediately decided to either flee away from the scene or step further away to keep a distance, which can be evidently identified as a *behavioral withdrawal*. However, this could be classified as a task-related strategy when their intention was to take pensioners with them to keep them safe.

Though not reported in interviews by participants, signs of behavior that could be marked as *venting* were observable, but they were not too frequent. The most significant sign were sarcastic remarks, usually towards one of the pensioners who was very outspoken, but only once was this expressed with visible frustration and anger (e.g., headshaking, raised tone of voice). Unintentional body movements (e.g., pulling up sleeves, playing with one's hair) do also fit into this category. Also, *positive self-talk* occurred in three participants, either reported in an interview or observed on a video record (e.g., saying aloud "great, that should be it").

Discussion

Two broad categories of emotion regulation strategies emerged in our qualitative analysis – task-related and self-supportive. Task-related strategies are largely overlapping with macrocognitive processes such as situation awareness, uncertainty management, decision making, etc. For a long time, all mental processes in naturalistic decision making paradigm were listed as macrocognitions while their emotional component was omitted (Mosier & Fischer, 2010). Therefore, instead of just adding a whole new package of mental processes to the existing body of knowledge about naturalistic decision making, results of our study are pointing out a rather different function of previously described processes. Phenomena such as tunnel vision were already described in literature concerning situation awareness (e.g., Endsley, 1995), but their emotion-regulatory function was not discussed. How professionals cope with difficult affective states during task performance remains a huge question mark in existing literature, maybe because it is not something that professionals do separately from procedures directed at task completion.

Holistic and functional nature of emotion regulation strategies in naturalistic setting is another implication of our qualitative analysis. Attentional processes seem to be of high importance, but most strategies have multiple components or occur simultaneously with others, such as the narrowed focus that had cognitive and behavioral elements, and often initially co-occurred with mobilization to action. This is line with findings of Adamovová and Halama (2013), who found through an abbreviation of critical decision method that paramedics regulate their emotions mostly by directing their attention and utilizing their emotional arousal towards desirable action.

In comparison to strategies proposed by Gross (1998, 2015) in the framework of process model of emotion regulation, all of the task-related strategies present novel findings. Nevertheless, this is not too controversial, in our perspective, considering that the process model framework was originally designed for the study of hedonically motivated emotion regulation. Our study hints at a possible necessity of a different framework for emotion

regulation motivated by external goal. However, the distinction between task-related and self-supportive strategies is not without its predecessor, as it is quite compatible with problem- and emotion-focused coping of Lazarus and Folkman (1984).

While some of our participants declared that the use of intuitive rule-based procedures had boosted their self-confidence, mobilization towards deliberative concentration was also identified as a task-related regulatory strategy. While the classic macrocognitive framework would attribute this simply to a lack of automatized processes in inexperienced crew leaders (Klein, 2008), alternative explanation may come into play. Because the association-based system produced an output (i.e., emotional response) that preoccupied explicit processing, the action tendency of this response takes priority and bodily signals of intuition are not available to the conscious mind (for a review on effects of emotion on information processing, see Yiend, 2010). However, this interpretation is very much an open to debate.

Two of the self-supportive strategies were quite prevalent – emotional distancing and detachment along with selective attention (which happened to co-occur in our research sample). Both of them appeared to have a character of a generalized attitude or perhaps even a personality pattern, because they were mostly not applied in a specific moment, but carried out throughout the whole experience during the task. This is why we distinguished emotional distancing from distancing from the scene, which was implemented at specific time frames. It is likely that the emotional distancing is a prerequisite for the other, but a paramedic could have described his task experience from a distanced perspective without explicitly reporting or exhibiting signs of distancing from the scene. Emotional distancing is a well-established strategy in the process model framework (Ochsner & Gross, 2008) and could be considered as an adaptive strategy according to some empirical studies (e.g., Kross et al., 2012; Webb et al., 2012). Adaptiveness of emotional distancing is also supported by low emotional awareness in good female paramedic decision makers in the Iowa Gambling task, according to the study of Pilárik and Sarmány-Schuller (2011). We cannot provide quantitative evidence for this claim in our study, but the use of this strategy was associated with reporting the experienced level of stress as positively stimulating.

In line with studies of Avraham et al. (2014) or Clompus and Albarran (2016), detachment was also present in paramedic crew leaders. As was noted earlier, detachment is not mentioned in the process model (Gross, 1998, 2015), likely because it is concerned with explicit forms of emotion regulation, while this phenomena remarkably resembles the construct of alexithymia (Taylor, Bagby, & Parker, 1999) and repressive coping style (Weinberger, 1990). Both of them are presumed to operate on implicit level of processing. Detachment is even classified as a dissociative process by some authors (e.g., Brown, 2006). We decided to put detachment and selective attention into one bin because that is what emerged from our data, but they may be two separate strategies. Selective attention might be considered as an equivalent of attentional deployment (Gross, 1998, 2015).

Two of the most famously studied regulatory strategies – reappraisal and suppression (Gross, 2002) – were not mentioned by our participants. In the case of reappraisal, this can be explained by cognitive demands of this strategy (Koole, 2009; Sheppes et al., 2009). Implementation of reappraisal could decrease cognitive resources available for completing the stressful and time-limited task. Signs of positive self-talk were found in our data, which might indicate the use of cognitive reappraisal, but it also might be a way of preserving focus on the task (Manera et al., 2014).

The explicitness and implicitness of implemented regulatory strategies is another issue that arises from our findings. Though it is not possible to draw precise lines between implicit and explicit strategies (or their components), this is not an uncommon issue as current neuroscientific evidence suggests that boundaries between implicit and explicit processing are gradual and blurred (Miller &

Schwarz, 2014). Most mental operations or their components function on both levels of processing. Some instances of strategy use might be classified as either explicit or implicit. For example, attentional narrowing was often described as a reflex-like mechanism of dealing with a situation, but it was also characterized as a conscious effort to filter out unwanted stimuli on some occasions. In other instances, strategy could have an explicit goal and implicit implementation (e.g., vigilance) or vice versa (e.g., reflection of previous decisions and events), but to claim that this was always the case with a specific strategy would be an oversimplification at this point. The fact that the proportion of implicit processing in strategy choice and implementation might also be determined by previous experience and automatization should be considered as well. Therefore, this is an issue of great gravity, but further investigation is necessary for valid answers.

Limits of the Study

Limits of our study are related to ecological validity of the simulated task and to validity of retrospective verbal protocols. As for the limits of the task "Grill", the lack of a real menace is a strong factor. It was admitted by a number participants that an escape from the room would be their first choice if this situation happened in reality, but the simulated nature of the task enabled them to stay cool and emotionally distanced from the situation. The absence of script for police crews resulted in largely varying conditions, which complicates the generalization of our results. On the other side, the particularity of this task (physical assault and acute bleeding) means that the results cannot extend beyond situation of emergency and different type of strategies might be present in different situations in the work of a paramedic. Besides, due to characteristics of a paramedic competition, we were unable to follow the established rules of sampling and theoretical saturation in qualitative research precisely, as we had to stick to the data set that was available. Satisfactory theoretical saturation was still achieved for a vast majority of identified regulatory strategies. Data set painted a very varied picture about some of the less frequent and less comprehensively described strategies which resulted in difficulties with fitting them into a unifying conceptualization.

Inaccuracies in recall of past experience present a limit of retrospective verbal reports. These might occur because of the automaticity of mental processes and the mind's tendency to fill gaps in introspection in order to tell a coherent narrative (Nisbett & Wilson, 1977), even when the recalled experience is quite recent. For this reason, it would be more valid to carry out the retrospective verbal protocols with the assistance of the crew's video recorded performance being replayed, but this was not technically accomplishable in our conditions.

Nevertheless, we believe our results are a valuable contribution to the study of emotion regulation in naturalistic setting because data collection was done using a high-fidelity simulated task and because of validation through triangulation of verbal reports with video recorded performance. Even though simulated tasks have their shortcomings, compared to real-life situations, the physiological stress during simulation can reach the same levels (Ghazali et al., 2018).

Acknowledgement

This work was supported by grant agency VEGA, no. 2/0070/18, Cognitive and social skills supporting the quality of performance of emergency medical services' professionals.

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Appendix

Appendix 1 Brief codebook for emotional behaviour on video records

No emotional reaction	Definition	No visible change in person's behavior.
	Signs	No visible change compared to neutral valence and arousal.
Attunement	Definition	Attempt to understand patient's distress through perception and mirroring of his emotional state.
	Signs	Visually scanning patient's face, adjustment of facial expression and body posture to patient, attunement of speech pace to patient's mood.
Conversational smile	Definition	Social smile invoked from a communication between protagonists.
	Signs	Raised angle labials, some sign of a genuine smile is missing (most typically raising cheeks).
Smile	Definition	Spontaneous positive reaction to a humorous situation.
	Signs	Raised angle labials, raised cheeks.
Alertness	Definition	Increased sensitivity to environmental stimuli.
	Signs	Quick reaction to environmental stimulus, visual scanning of surroundings.
Emergency	Definition	Quick and decisive action with a clear purpose.
	Signs	Quick reaction to an emerged situation, movement towards a goal or patient, decisive and brisk commanding of colleagues, fluid execution of procedures.

Appendix 1 continues

Appendix 1 continued

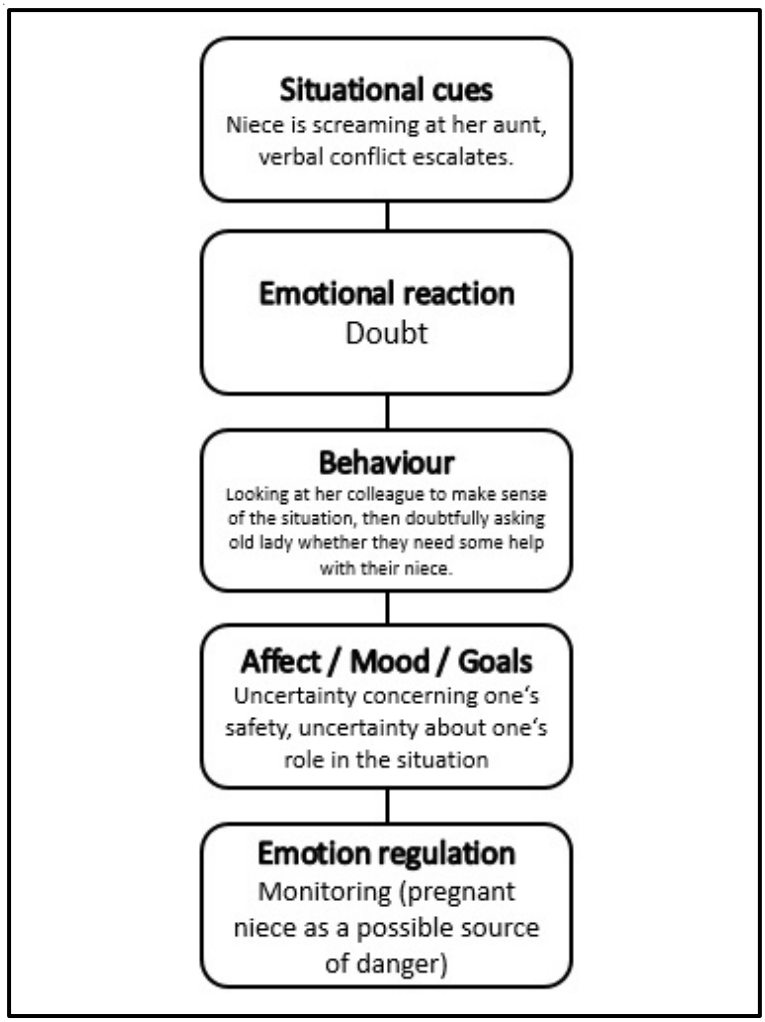
Fright	Definition	Quick scared reaction to a possibly dangerous situation.
	Signs	Dodge backwards, possible vocal reaction.
Freeze reaction	Definition	Absolute cessation of a current action.
	Signs	Being stuck in a certain body posture, remaining in a position of observer.
Fear / Worry	Definition	Caution in a contact with potentially endangering stimulus.
	Signs	Keeping distance from potential danger, being cautious but not stuck, possibly a scared facial expression (eyes: AU 5 - upper lids raiser, AU 7 - lids tight; mouth: AU 20 lip stretcher, or 25 - lips part).
Nervousness	Definition	Agitation and a tendency to act even if a situation is currently calm.
	Signs	Body movements (jiggling, goalless arm movements), touching one's own body, clumsy and inarticulate speech, avoiding eye contact.
Confusion	Definition	A tendency to do multiple tasks at once.
	Signs	Sudden change of goal or direction, indecisiveness between two options, shuffling one's feet, gazing in multiple directions in a short time period.
Doubt	Definition	Being unsure about the chosen course of action.
	Signs	Heading towards a specific goal, but hesitating, asking questions, making sure of the legitimacy of chosen procedure.
Doubtful smile	Definition	Slight smile expressing insecurity about the present social situation.
	Signs	Slightly raised angle labials, downcast eyes or avoiding eye contact, short duration.
Relieving smile	Definition	Smile with a function of easing stress and pressure.
	Signs	Raised angle labials, following after visible tension, possibly accompanied by a sigh, possible absence of raised cheeks (AU 6).
Ironic smile	Definition	Smile communicating devaluation of the person who is being addressed.
	Signs	Pulling angle labials inside (AU 14 dimpler), possibly just on one side, possibly accompanied by raised eyebrows.
Sarcasm	Definition	Verbal communication of one's authority and position above the other.
	Signs	Joking on someone else's account.
Joking	Definition	Humorous relief of situation's tension.
	Signs	Verbally communicating humorous remarks and allusions.
Frustration	Definition	Slightly angered emotional reaction to an aversive condition in the situation.
	Signs	Headshaking, cessation of current action, sigh, raised voice, defense against the trigger.

Appendix 1 continues

Appendix 1 continued

Helplessness	Definition	Inability to execute the desirable action.
	Signs	Loss of initiative, withdrawal, choosing different procedure/subtask.
Attenuation	Definition	Realization of the weight of overcome task/subtask.
	Signs	Complete lack of action or slowed down movement.
Relief	Definition	Dissolution of tension.
	Signs	Sigh, relaxation of arms and shoulders.
Carelessness	Definition	Not reacting to a relevant stimulus.
	Signs	Ignoring or underestimating a critical situation, attentional deployment, attending another aspect of the situation.
Shame	Definition	Appraising one's previous behavior as socially unacceptable.
	Signs	Redness in face, descent of body posture, downcast eyes or avoiding eye contact, behavioral tendency to not be in the center of attention.
Disappointment	Definition	Failing to fulfil one's expectations and hopes.
	Signs	Slouching body posture (head and shoulders), inhibition of all activity, possibly sad/relaxed facial expression.
Surprise	Definition	Reaction to an unexpected event.
	Signs	Acquisition of new information (listening or gazing), open mouth and wide-open eyes, movement towards the source of surprise.

Appendix 2 Illustration of a time unit on timeline of paramedic crew leader's task experience



Studia Psychologica, Vol. 62, No. 2, 2020, 109-122
https://doi.org/10.31577/sp.2020.02.794

Is there a Gap or Congruency Effect? A Cross-Sectional Study in Students' Fraction Comparison

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Many studies have addressed the natural number bias in fraction comparison, focusing on the role of congruency. However, the congruency effect has been observed to operate in the opposite direction, suggesting that a deeper explanation must underlie students' different reasoning. We extend previous research by examining students' reasoning and by studying the effect of a gap condition in students' answers. A cross-sectional study was conducted on 438 students from 5th to 10th grade. Results showed that the gap effect could explain differences between congruent and incongruent items. Moreover, students' use of gap thinking decreased towards the end of Secondary Education.

Key words: rational numbers, natural number bias, fraction comparison, gap thinking

Introduction

The rational number constitutes one of the most complex and important mathematical concepts that students have to learn. The concept underlies the understanding of a wide range of related concepts, including proportions, ratios and percentages, as well as more advanced concepts of algebra and calculus (Kieren, 1993). However, primary and secondary school students often have difficulties with different aspects of rational numbers, especially with fractions (Merenluoto & Lehtinen, 2002).

Although different explanations have been put forward, research since the 1980s has found that students struggle with understanding different aspects of rational numbers because whole numbers knowledge interferes in their comprehension (Fischbein, Deri, Nello, & Marino, 1985; Moss & Case, 1999; Resnick et al., 1989). The concept of rational number is sometimes inconsistent with the properties of whole numbers (Fischbein et al., 1985). Kieren (1993) stated that "knowledge of the rational number is not a simple extension of the knowledge of the whole number" (p. 56). This tendency to *regress* to a property compatible with whole numbers was termed *whole number dominance* by Behr, Wachsmuth, Post, and Lesh (1984), while recent research has termed it *whole/natural number bias* (Ni & Zhou, 2005; Van Dooren, Lehtinen, & Verschaffel, 2015).

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Received February 22, 2019

The term *bias* describes the fact that knowledge of natural numbers can facilitate students' reasoning when activities of rational numbers are compatible with this knowledge, but it does not facilitate their reasoning when rational numbers behave differently from natural numbers (for a review, see Van Dooren et al., 2015).

Focusing on fractions, difficulties lie in "the tendency of students to treat fractions in the same way as natural numbers" (Streefland, 1991, p. 70). For example, primary and secondary school students believe that a fraction's numerical value is represented by two independent natural numbers (Behr et al., 1984; Stafylidou & Vosniadou, 2004) or that no other fractions can be found between two fractions such as 2/5 and 3/5 (Merenluoto & Lehtinen, 2002). This tendency appears as soon as fractions are introduced and persists at least up to secondary school, decreasing with age but not altogether disappearing (Vamvakoussi, Van Dooren, & Verschaffel, 2012).

Our study continues in this line of research. First, we discuss the theoretical and empirical background of the whole/natural number bias phenomenon, and particularly students' performances in fraction comparison items. We then highlight how our study extends this previous research.

Theoretical and Empirical Background

The Natural Number Bias Phenomenon

Research on natural number bias has focused on four dimensions in which rational numbers differ from natural numbers: density, representation, operations and size (Gómez & Dartnell, 2019; McMullen, Laakkonen, Hannula-Sormunen, & Lehtinen, 2015; Van Hoof et al., 2016; Vamvakoussi et al., 2012).

Density of rational numbers has been described as one of the most difficult concepts that primary and secondary school students have to address (McMullen et al., 2015; Vamvakoussi & Vosniadou, 2004). Students seem to believe that there is no, or only a finite amount of numbers between any two rational numbers, as is the case with natural numbers (Smith, Solomon, & Carey, 2005). For instance, primary school students think that there are no other numbers between 1.23 and 1.24 (Moss & Case, 1999) or secondary school students think that between 1/2 and 1/4 there is only one, namely 1/3 (Merenluoto & Lehtinen, 2002).

With regard to representation, while natural numbers have only one symbolic representation, rational numbers can be represented in different ways. Many studies have shown that primary and secondary school students frequently fail to regard fractions and decimals as representations of the same number (Vamvakoussi et al., 2012). For instance, students have difficulties in considering 3/4, 6/8, 0.75, and 0.750 to be the same number (Beyranevand, 2014).

Regarding arithmetic operations, primary and secondary school students' have shown difficulties especially in multiplications and divisions. Students believe that multiplications always result in a larger and divisions in a smaller number, which is not always the case for rational numbers (Vamvakoussi et al., 2012; Van Hoof et al., 2016). For example, $2 \times 2/3$ leads to a result smaller than 2.

This latter aspect, size, is the focus of this paper. Regarding decimal representation, studies indicate that errors are frequently made in comparison tasks because contrary to natural numbers, the length (number of digits) of a decimal number does not always help to decide which is larger. In fact, primary school students think that "longer decimals are larger" and "shorter decimals are smaller" (Resnick et al., 1989). Difficulties also arise in comparing two fractions, as the counting sequence (order) which applies to natural numbers is no longer useful. In fact, because students have difficulties in understanding a fraction as a number, they tend to incorrectly assume that a fraction's numerical value increases with the increase of its denominator, numerator, or both together (DeWolf & Vosniadou, 2015). For example, when comparing 4/4 and 5/5, primary and secondary school students consider 4/4 smaller than 5/5 because 4 is smaller than 5.

Since our study focuses on fraction comparison, a broader review of the literature addressing students' performances in these items is provided next.

Students' Performances in Fraction Comparison Items

Previous studies have used fraction comparison items in which the largest fraction also has the largest numerator and denominator (e.g., 2/3 vs. 7/8) as well as fraction comparison items in which the largest fraction does not have the largest numerator and denominator (e.g., 2/3 vs. 5/8). A reasoning consistent with natural number order leads to a correct answer in the first comparisons and, leads to an incorrect answer in the second (5/8 is larger than 2/3 since 5 is larger than 2, and 8 is larger than 3).

In a study with 7th and 11th grade school students using fraction comparison items with one common component (numerator or denominator), Van Hoof, Lijnen, Verschaffel, and Van Dooren (2013) found more correct answers in items consistent with natural number knowledge than in items inconsistent with this knowledge. DeWolf and Vosniadou (2011) investigated the natural number bias in undergraduate students using fractions with no common components. Their results also showed that students were less accurate when the largest fraction in a comparison had the smallest numerator and denominator.

However, opposite results have also been found, mostly in studies using fractions with no common components. Students, in these cases, had more difficulties in fraction comparison items consistent with natural number knowledge. These results were found in studies with primary school students (Gómez & Dartnell, 2019; Rinne, Ye, & Jordan, 2017) and with university students (DeWolf & Vosniadou, 2015; Gómez, Silva, & Dartnell, 2017).

The findings above raise questions as to whether the effects obtained can be solely attributed to the natural number bias phenomenon, and whether other mechanisms may be at play at certain ages. Therefore, further research seems warranted. In this context, Gómez et al. (2017) showed that in mathematically-trained individuals, the natural number bias was not the best predictor of different performance in fraction comparison items consistent with natural number knowledge and in items inconsistent with this knowledge. In fact, data from their research with undergraduate Engineering students suggested that gap thinking was a viable way of thinking, which explained the differences in students' success in comparison items ascribed to the natural number bias.

Gap thinking (Pearn & Stephens, 2004) is the belief that "the bigger the gap, the smaller the fraction", when students compare the difference (gap) between numerator and denominator. For example, 1/3 is larger than 5/8 because "from 1 to 3 there is a gap of two and from 5 to 8 there is a gap of three" (Moss & Case, 1999; Pearn & Stephens, 2004). This incorrect way of thinking has been considered a case of natural number dominance, since students overlook the multiplicative relationship between numerator and denominator (Clarke & Roche, 2009). However, in the present study, we consider that gap thinking constitutes a separate phenomenon from natural number biased thinking described above, since there are differences between both reasonings. The first considers the relation between the two components of the fraction (it focuses on the *difference* between numerator and denominator rather than the ratio) while the second centers on the size of the components separately.

In some fraction comparison items, a different gap exists between numerator and denominator in which gap thinking leads to a correct answer such as the pair of fractions 2/7 and 5/8 (5/8 is larger than 2/7 and there is a gap of five between 2 and 7 and a gap of three between 5 and 8). In other items, a different gap between numerator and denominator exists, in which gap thinking leads to an incorrect answer, such as the pair of fractions 7/9 and 2/3 (7/9 is larger than 2/3 and there is a gap of two between 7 and 9 and a gap of one between 2 and 3). Finally, in certain items with

the same gap, gap thinking leads to an incorrect answer, because students can think that the two fractions (e.g., 2/3 and 4/5) are equal "since the difference between numerator and denominator is the same" (Clarke & Roche, 2009; Moss & Case, 1999).

The Present Study

We focused on how Spanish primary and secondary school students solve and justify fraction comparison items in order to explore students' reasoning in these items. Two conditions were taken into account in the following items: items where using natural number knowledge as described above leads students to the correct answer (congruent items) and items where using natural number knowledge leads to the incorrect answer (incongruent items) (in this study *congruency condition*); items with a different gap between the numerator and denominator (where, in this case, relying on the gap leads students to the correct answer) and items with the same gap (where relying on gap thinking leads students to incorrectly believing the fractions are equally large) (in this study *gap condition*).

As we have shown in the literature review, many studies have investigated the natural number bias in the domain of size and, particularly, in fraction comparison. However, we extend previous research in three ways. Firstly, research has been based only – to the best of our knowledge – on multiple-choice questionnaires (DeWolf & Vosniadou, 2011; Gómez & Dartnell, 2019) with a focus on answer correctness, and possibly reaction time. These studies did not examine students' underlying reasoning but rather deduced it from performance and/or reaction time. Qualitative data on students' reasoning could support previous hypotheses. Secondly, as far as we know, apart from the longitudinal studies of Van Hoof, Degrande, Ceulemans, Verschaffel, and Van Dooren (2018) and McMullen et al. (2015), no cross-sectional studies have shown the development from primary education (where fractions are introduced) to secondary education, allowing to investigate the grades in which natural number bias or the use of gap thinking is greater and whether they disappear at the end of secondary education. Finally, we extend previous research by adding the gap condition. This condition allows us to study whether the results obtained in other studies showing better performance in items inconsistent with natural number knowledge could be explained by the fact that students use gap thinking.

Our study had two objectives. First, we sought to test hypotheses raised in previous quantitative studies by analyzing students' reasoning. We expected items consistent with natural number knowledge to have higher accuracies than items inconsistent with this knowledge (Van Hoof et al., 2013). We also expected this effect to decrease with age, while also persisting until the last years of secondary education (DeWolf & Vosniadou, 2011). Second, we wished to study the effect of *gap condition* and in interaction with the *congruency condition.* It could be possible that as the role of congruency diminishes with age, gap starts to influence students' reasoning.

Method

Participants

The participants were 438 primary and secondary school students: 85 fifth graders (10-11 year olds), 81 sixth graders (11-12 year olds) from two different Spanish primary schools and 78 seventh graders (12-13 year olds), 81 eighth graders (13-14 year olds), 57 ninth graders (14-15 year olds), and 56 tenth graders (15-16 year olds) from two different Spanish secondary schools. There was approximately the same number of boys and girls in each age group. The participating schools were located in different cities and students were from mixed socio-economic backgrounds.

Instrument and Procedure

The instrument was a test consisting of four fraction comparison items (Table 1). These items were designed taking into account the *congruency* and *gap* conditions. In each item, students

Table 1 *Characteristics of the items*

	Pair of fractions	Congruent/Incongruent (C/I)	Same/Different gap (S/D)
Item 1	2/3 vs. 7/8	C	S
Item 2	2/7 vs. 5/8	C	D
Item 3	5/3 vs. 9/7	I	S
Item 4	2/3 vs. 5/8	I	D

had to circle the largest fraction and explain why they thought that the fraction they chose was the largest. Furthermore, the following note was included in the test: "if you think both fractions are equally large, circle both".

The first two items required comparing two pairs of fractions consistent with the order of natural numbers (congruent items). The largest fraction had a numerator and denominator larger than the smallest fraction (2/3 vs. 7/8 and 2/7 vs. 5/8). But in the first pair of fractions (2/3 vs. 7/8), the gap between the numerator and denominator was the same (the gap between 2 and 3 is 1, and between 7 and 8 is 1), while in the second pair of fractions (2/7 vs. 5/8), the gap was different (the gap between 2 and 7 is 5 and between 5 and 8 is 3). In this last pair of fractions, gap thinking leads to a correct answer since the gap between 5 and 8 is 3, the gap between 2 and 7 is 5 and 5/8 is larger than 2/7.

The other two items required comparing two pairs of fractions that were inconsistent with the order of natural numbers (incongruent items). The largest fraction had a smaller numerator and denominator than the smallest fraction (5/3 vs. 9/7 and 2/3 vs. 5/8). In the first pair of fractions (5/3 vs. 9/7), the gap between the numerator and denominator was the same (the gap between 5 and 3 is 2, and between 9 and 7 is 2). Despite the fact that both were improper fractions (and therefore may be more complex than proper ones), we had to use them to fulfil the condition of incongruent items with the same gap. Creating such items with proper fractions is mathematically impossible. We believed that the use of improper fractions would not affect students whose reasoning was based on the order of natural numbers, since they only consider the size of numerator and denominator independently. Furthermore, they would not affect students who use gap thinking either, since they consider the difference (additively) between numerator and denominator. In the second pair of fractions (2/3 vs. 5/8), the gap was different (the gap between 2 and 3 is 1 and between 5 and 8 is 3). In this comparison, gap thinking leads to a correct answer since the gap between 2 and 3 is 1, the gap between 5 and 8 is 3 and 2/3 is larger than 5/8. Table 1 summarizes the characteristics of each item.

Therefore, students whose reasoning was based on natural number knowledge would answer congruent items (1 and 2) correctly and incongruent items (3 and 4) incorrectly. Students whose reasoning is based on gap thinking would answer items 2 and 4 correctly and items 1 and 3 incorrectly.

Students could use all the time they needed to solve all items, because we were interested in examining their reasoning. The test took approximately 10 to 15 minutes. There were no further test instructions except that of forbidding students to use calculators or mobile devices.

Analysis

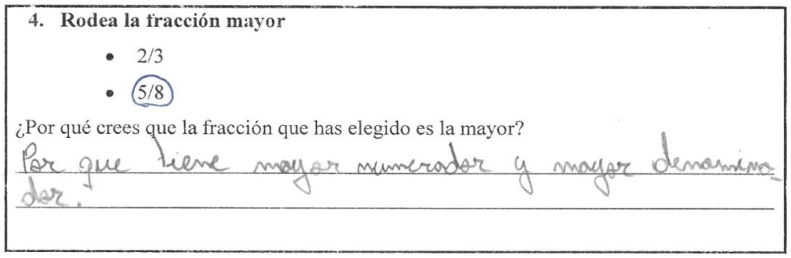
The analysis was conducted in two phases. In the first phase, students' success levels were examined in each item and grade. In the second phase, we examined the type of reasoning used, based on their written justifications.

Answers were first classified as correct if the largest fraction was encircled, and as incorrect otherwise. Correctness was analyzed by means of a repeated measures logistic regression analysis, using generalized estimating of equations (GEE).

Second, the type of reasoning was coded. We carried out an inductive analysis to generate categories. First, a subset of students' answers was independently analyzed by three researchers. We then compared our results and discussed our discrepancies until reaching an agreement. Subsequently, new data samples were added in order to revise our categories. Finally, four categories of correct reasoning and three categories of incorrect reasoning emerged. Since we were interested in this particular study in students' incorrect reasoning based on knowledge of natural numbers or gap thinking, we only describe here these latter two emerging categories.

- *Based on the order of natural numbers*. In this reasoning, the largest fraction is the fraction whose numerator and denominator are bigger. Figure 1 shows an example of the use of this incorrect reasoning in an incongruent item.

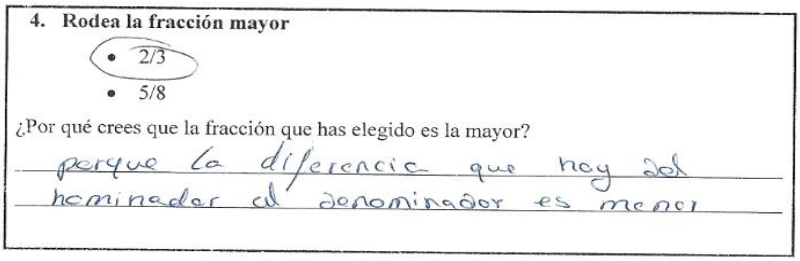
- *Based on gap thinking*. In this reasoning, the largest fraction is the fraction in which the difference between the numerator and denomi-


4. Rodea la fracción mayor
- 2/3
- 5/8

¿Por qué crees que la fracción que has elegido es la mayor?

Por que tiene mayor numerador y mayor denominador.

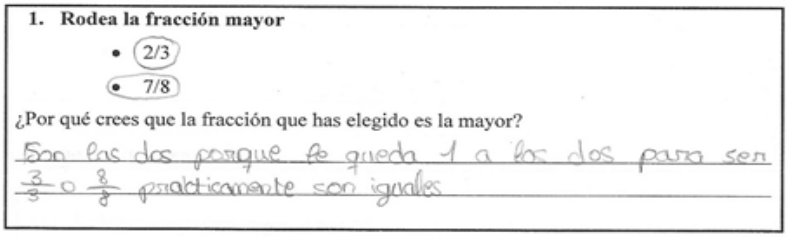
Figure 1 "Because the numerator and denominator of this fraction are bigger" (7th grade student)


4. Rodea la fracción mayor
- 2/3
- 5/8

¿Por qué crees que la fracción que has elegido es la mayor?

porque la diferencia que hay del numerador al denominador es menor

Figure 2 "*Because the difference between the numerator and the denominator is smaller*" (10th grade student)


1. Rodea la fracción mayor
- 2/3
- 7/8

¿Por qué crees que la fracción que has elegido es la mayor?

Son las dos porque le queda 1 a los dos para ser $\frac{3}{3}$ o $\frac{8}{8}$ practicamente son iguales

Figure 3 "*Because both fractions need one to complete the 3/3 or 8/8*" (5th grade student)

nator is the smallest in items with a different gap (Figure 2), or in which both fractions are equal since the gap is the same, in items with the same gap (Figure 3).

Results

This results section is divided into three subsections. First, we describe the results of the main effect of congruency and gap as well as the interaction effect. Second, we discuss changes with age. Third, we look at students' reasoning to provide further explanations of the quantitative analysis.

Effects of Congruency and Gap on Students' Answers

Students were much more successful in congruent items (82.56%) than in incongruent ones (50.16%). A repeated measures logistic regression analysis showed that this difference was significant, $\chi^2(1, N = 438) = 182.51$, $p < 0.001$. Furthermore, students were significantly more successful in comparisons with a different gap than with the same gap (71.06% vs. 61.67%), $\chi^2(1, N = 438) = 30.93$, $p < 0.001$.

There was also a significant 'gap' × 'congruency' interaction effect, $\chi^2(5, N = 438) = 4.11$, $p < 0.043$. Pairwise comparisons (Figure 4) showed that in both congruent and incongruent items, students were significantly more successful in the item with a different gap than in the item with the same gap (88.70% vs. 76.41% in congruent items, $p < 0.001$ and 53.71% vs. 46.91% in incongruent items, $p = 0.006$). However, that gap effect was bigger in congruent items (odds ratio = 2.42) than in incongruent ones (odds ratio = 1.31).

Changes with Age

Figure 5 shows the percentages of correct answers per grade. There was a decrease from 5th to 8th grade in congruent items (in both, with the same and different gap) and then, an increase from 8th to 10th grade. However, differences between grades were not significant. Regarding incongruent items, there was an increase in the number of correct answers from 5th to 9th grade (in both, with the same and different gap) and then a decrease from 9th to 10th grade. Differences were significant between 5th and 6th grade ($p = 0.01$) and between 8th and 9th grade ($p = 0.002$).

There was a significant 'grade' × 'congruency' interaction effect, $\chi^2(5, N = 438) = 53.00$, $p < 0.001$, revealing that students were more successful in congruent items than in incongruent items in each grade. There were sig-

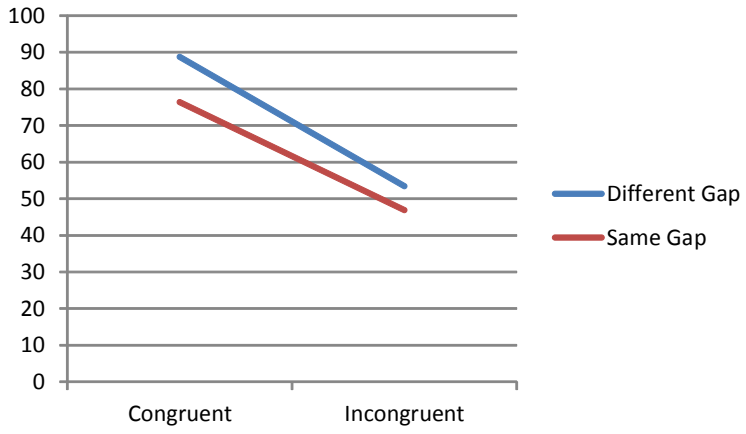
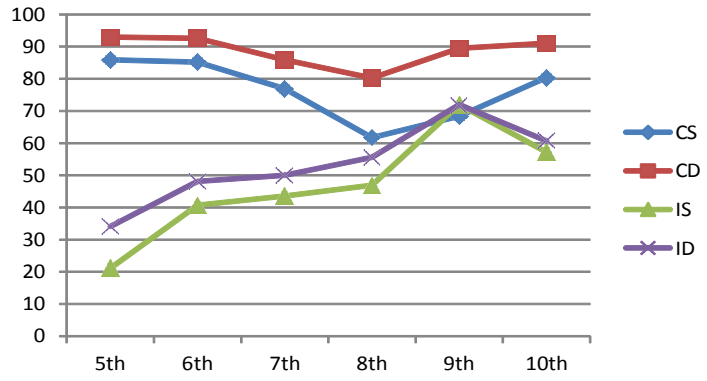


Figure 4 Interaction between congruency and gap

nificant differences in all grades except 9th grade ($p < 0.001$ in 5th grade; $p < 0.001$ in 6th grade; $p < 0.001$ in 7th grade; $p = 0.001$ in 8th grade; $p < 0.001$ in 10th grade) (Table 2). Although differences between congruent and incongruent items were significant from 5th to 8th grade, these differences became smaller with age. In fact, differences in 8th and 9th grade between congruent and incongruent items were the smallest.

There was no significant interaction effect of the variables 'grade' × 'gap', $\chi^2(5, N = 438) = 1.86$, $p < 0.868$. However, differences between items with a different and same gap were significant in all grades except 10th grade ($p < 0.001$ in 5th grade; $p = 0.029$ in 6th grade; $p = 0.046$ in 7th grade; $p = 0.006$ in 8th grade; $p = 0.017$ in 9th grade) (Table 3). Table 3 also reveals that although differences between items with a different and same gap were significant, the differences were greatest in 8th grade. In fact, 8th grade students obtained the lowest percentages of accuracy in items with the same gap (54.32%), where gap thinking leads to an incorrect answer. On the other hand, 9th grade students obtained the highest percent-



Note. CS: Congruent with the same gap; CD: Congruent with different gap; IS: Incongruent with the same gap; ID: Incongruent with different gap

Figure 5 Percentages of correct answers from 5th to 10th grade

Table 2 *Percentages of students' correct answers in congruent and incongruent items*

Grade	Congruent	Incongruent
5th	89.41	27.65
6th	88.89	44.44
7th	81.41	46.79
8th	70.99	51.23
9th	78.95	71.93
10th	85.71	58.93

ages of accuracy in items with a different gap (80.70%), where gap thinking leads to the correct answer.

Finally, there was a nearly significant interaction effect of the variables 'grade' × 'congruency' × 'gap', $\chi^2(5, N = 438) = 10.65$, $p < 0.059$. Figure 5 and Table 4 show that a greater gap effect existed in the congruent items than in the incongruent items from 6th to 9th grade. Differences were significant for congruent items in 5th grade ($p = 0.029$) (85.88% in same gap and 92.94% in different gap), 7th grade ($p = 0.016$) (76.92% vs. 85.90%), 8th grade ($p = 0.002$) (61.73% vs. 80.25%), and in 9th grade ($p < 0.001$) (68.42% vs. 89.47%). They were not significant for incongruent items in these grades, except in 5th grade ($p < 0.005$) (21.18% in same gap and 34.12% in different gap).

Students' Reasoning

Figure 6 shows the percentages of the students' use of reasoning based on the order of natural numbers (NN) and the use of reasoning based on gap thinking (GT) out of the total number of given justifications from 5th to 10th grade. The remaining percentage in each item corresponds to other correct and incorrect students' reasoning.

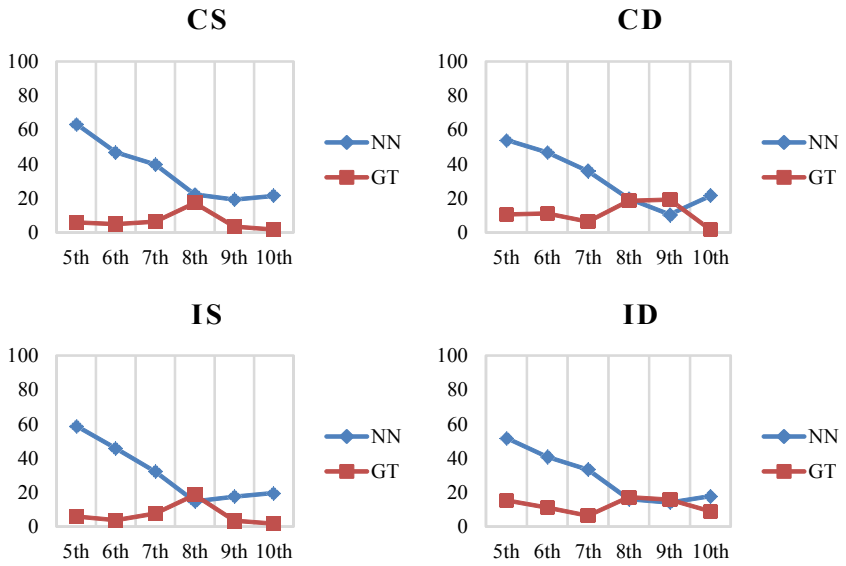
In the four items, natural number bias reasoning (NN) decreased, but at the same time also predominated, from 5th to 8th grade. In 8th grade, natural number bias reasoning and reasoning based on gap thinking was used approximately to the same degree. In 9th grade, natural number bias increased again in the items with the same gap (where gap thinking does not lead to

Table 3 *Percentages of students' correct answers in items with a different and same gap*

Grade	Same	Different
5th	53.53	63.53
6th	62.96	70.37
7th	60.26	67.95
8th	54.32	67.90
9th	70.18	80.70
10th	68.75	75.89

Table 4 *Percentages of students' correct answers in congruent and incongruent items with a same and different gap along grades*

	Congruent		Incongruent	
Grade	Same	Different	Same	Different
5th	85.88	92.94	21.18	34.12
6th	85.19	92.59	40.74	48.15
7th	76.92	85.90	43.59	50.00
8th	61.73	80.25	46.91	55.56
9th	68.42	89.47	71.93	71.93
10th	80.36	91.07	57.14	60.71



Note. CS: Congruent with the same gap; CD: Congruent with a different gap; IS: Incongruent with the same gap; ID: Incongruent with a different gap

Figure 6 Students' use of reasoning based on the order of natural numbers (NN) and the use of reasoning based on gap thinking (GT)

the correct answer) and in items where the gap is different, the use of gap thinking exceeded the use of natural number bias, though its use decreased in 10th grade.

Overall, we can conclude that reasoning based on the order of natural numbers (NN) decreased with age but had not disappeared by the end of secondary school (10th grade): over 20% of the students used this reasoning in congruent items (leading students to produce correct answers) and in incongruent ones (leading them to produce incorrect answers). The drop in the use of this reasoning coincided with an increase of correct answers in incongruent items from 5th to 9th grade and a decrease of correct answers in congruent items from 5th to 8th grade (Figure 5).

Regarding gap thinking (GT) reasoning, there was a notable appearance of this type of reasoning in 8th grade (17.28% in CS, 18.52% in CD, 18.52% in IS, and 17.28% in ID) while it was much less present before this grade. In 9th grade, this reasoning only appeared in items with a different gap (19.30% in CD and 15.79% in ID), where gap thinking leads to the correct answer. The increase of the use of this reasoning with regard to the natural number bias could explain why differences in students' success levels between congruent and incongruent items were smaller in 8th and 9th grade (Table 2). Therefore, gap thinking influenced differences between students' success levels in congruent and incongruent items in 8th and 9th grade. This reasoning allows students to achieve a correct answer in items with a different gap but leads students to an incorrect answer in items with the same gap. However, the use

of gap thinking reasoning dropped considerably from 8th to 10th grade.

Discussion and Conclusions

We conducted a cross-sectional study on 5th to 10th grade students examining their answers and reasoning in fraction comparison items, pursing two objectives. The first objective was to verify hypotheses inferred from previous quantitative studies by analyzing students' reasoning (congruency effect); the second objective was that of studying the effect of *gap* as a main condition and in interaction with *congruency.* We searched for evidence both in terms of accuracy and in students' written justifications. Generally, our results showed that both primary and secondary school students have difficulties with fraction comparison items, the *natural number bias* (Ni & Zhou, 2005; Vamvakoussi et al., 2012; Van Dooren et al., 2015) being the main reason students fail in fraction comparison.

As in previous studies, better performance was observed in congruent comparison items than in incongruent comparison items (DeWolf & Vosniadou, 2011). The qualitative analysis of students' reasoning supported the fact that in many cases, students think that a fraction is larger if the numerator and denominator are bigger (Behr et al., 1984; DeWolf & Vosniadou, 2011; Moss & Case, 1999). This reasoning is based on the knowledge of natural numbers, since students consider the numerator and denominator as two independent numbers (Behr et al., 1984; Stafylidou & Vosniadou, 2004) and apply natural number ordering knowledge to compare fractions. Therefore, our results support the hypotheses inferred from previous studies in relation to congruency effects. Our data collection method, however, was different since we used four fraction comparison items and asked students to describe their reasoning, instead of using a large number of items in multiple-choice questionnaires.

Interestingly, although students were significantly more successful in congruent items than in incongruent items in each grade, differences between congruent and incongruent items became smaller with age. In fact, differences in 8th and 9th grade between congruent and incongruent items were the smallest. This result is discussed later in interaction with the gap effect. Furthermore, the number of students' correct answers decreased in congruent items from 5th to 8th grade and then increased from 8th to 10th grade. Our qualitative analysis showed that this was explained by a drop in the frequency of student reasoning based on knowledge of natural numbers compatible with these items. At the same time, there was an increase in the number of correct student answers from 5th to 9th grade, which also came with a decrease in reasoning based on natural numbers, which is incompatible with these items. However, although the use of the reasoning based on the order of natural numbers decreases with age, it does not entirely disappear by the end of secondary school education (10th grade), since over 20% of the students used this reasoning in each item.

Furthermore, fraction comparisons with a different gap obtained better results than fraction comparisons with the same gap, and this effect was greater in congruent items than in incongruent items. Therefore, the gap condition influenced students' responses since gap thinking (Pearn & Stephens, 2004) leads to a correct answer in comparisons with a different gap, while it suggests that both fractions are the same in items with the same gap. This result was also supported by the qualitative analysis of students' reasoning where students reason that a fraction is larger when the gap between numerator and denominator is smaller. Gap thinking could be a suitable way of thinking when students notice that there is an identical gap in terms of absolute number but the size of each gap is smaller. For instance, 5/6 and 7/8 have a gap of one, but the second fraction has eighths as a gap, therefore the one missing in the second fraction makes the second fraction larger. However, students considered the absolute difference, and gap thinking thus led to an incorrect answer. That condition affected primary and sec-

ondary school students' responses in our study, in accordance with the study of Gómez et al. (2017), which found that gap-related conditions significantly affected participants' responses (undergraduate students of Engineering).

Differences between items with a different and same gap were significant from 5th to 9th grade but not in 10th grade. However, the biggest difference was found in 8th grade. In fact, 8th grade students obtained the lowest percentages of accuracy in items with the same gap, which are items where gap thinking leads to the incorrect answer. Furthermore, the use of a reasoning based on gap thinking decreased at the end of secondary school.

Interestingly, in relation to differences in students' correct answers in 8th and 9th grade between congruent and incongruent items, differences in these grades were smaller and not significant. Our qualitative analysis provided an explanation: although there is a decrease of the reasoning based on the order of natural numbers in these grades, there was a noticeable increase in the use of gap thinking in 8th grade in all items, persisting in 9th grade in items with a different gap. Therefore, the gap condition influences differences between congruent and incongruent items in 8th and 9th grade. As Gómez et al. (2017) showed with mathematically-trained individuals, our data supports the claim that the gap effect could explain differences between congruent and incongruent items, extending this result from primary to secondary school. However, it seems that this effect decreases (in Spanish students) at the end of Secondary Education.

This result seems to indicate that as Spanish secondary school students start to leave behind their reasoning based on properties of natural numbers when working with rational numbers, they do not necessarily replace this type of reasoning by the correct kind of reasoning. Some of them begin to use a reasoning based on gap thinking instead of a correct reasoning. The difference between the use of a reasoning based on the natural number properties or a reasoning based on gap thinking is that, in the former, students regard the numerator and denominator as independent from one another, and in the latter, students believe there is an additive relationship, rather than a multiplicative one, between numerator and denominator. It could be argued that this is already a step forward in the development of rational number understanding, as a rational number is already conceived as a relation between two natural numbers. But a further step needs to be taken to understand that relation in a multiplicative way. This finding is not only theoretically important; it may also have practical implications. Teachers attending students, who reason about fractions in terms of natural number knowledge should be aware that these students may not necessarily develop a correct understanding once natural number-based understanding is addressed. New, qualitatively different misunderstandings may start to occur.

We believe our study has produced important conclusions, such as the influence of gap and the interaction effect between congruency and gap that explains non-significant differences between congruent and incongruent items in certain grades. There are, however, some limitations to our study. Firstly, future studies should include more items in order to obtain further information about the interaction between congruency and gap conditions, including items with a different gap where gap thinking leads to an incorrect answer. Because we focused on students' reasoning, our study, however, included four items only; with more items, students would be reluctant to verbalize their reasoning. Secondly, the qualitative data was self-reported. Students may have verbalized their reasoning differently from what they actually thought. Therefore, further research is needed in this line, for example, conducting interviews where students have to solve fraction comparison items in real time.

Acknowledgements

This research was carried out with the support of Conselleria d'Educació, Investigació, Cultura i Esport (Generalitat Valenciana, Spain) (PROMETEO/2017/135) and with the

support of University of Alicante (UAFPU2018-035).

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Studia Psychologica, Vol. 62, No. 2, 2020, 123-137
https://doi.org/10.31577/sp.2020.02.795

Personal Impulsivity Mediates the Effects of Neuromodulation in Economic Intertemporal Choices: A Pilot Study

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The involvement of the prefrontal cortex in intertemporal choices has been long recognized. Using neurostimulation techniques, recent studies have indicated that the left dorsolateral prefrontal cortex (DLPFC) influences performance on intertemporal choice tasks. The present pilot study is aimed to explore further the DLPFC's role in intertemporal choices by assessing the influence of individual levels of impulsivity on modulating the stimulation's effects. Thirteen subjects participated in a within-subjects experiment. During the three sessions, participants received 20 minutes of transcranial direct current stimulation (tDCS; either sham, anodal, or cathodal) and were administered the Intertemporal Choice Task. Then, they completed the Barratt Impulsivity Scale and the Dickman Impulsivity Inventory. Using a repeated-measure generalized linear model, we explored the effects of stimulation on intertemporal choice (either immediate or delayed reward) on impulsive responses, defined as quick answers. The individual level of impulsivity was included in the model as a covariate. According to the results, participants made a greater number of impulsive choices favoring immediate rewards after cathodal stimulation of the left DLPFC. Additionally, a moderating role of individual impulsivity emerged. This study provides support for the involvement of the left DLPFC in intertemporal choices. We contend that the role of individual differences should be further explored to obtain a better understanding of intertemporal choice behavior.

Key words: intertemporal choice, neuromodulation, transcranial direct current stimulation, individual differences, impulsivity, delay discounting

Introduction

Intertemporal Choices in Neuroscience Research

Intertemporal choices, that is decisions involving consequences at different points in time (for a review, see Becker, Walker, & McCord, 2017; Berns, Laibson, & Loewenstein, 2007; Frederick, Loewenstein, & O'Donoghue, 2002), have been studied from various perspectives within the fields of economics, psychology, and neuroscience. Evidence from the research literature suggests that when asked to choose between an immediate and a delayed reward (and not only when economic behavior is targeted; see Eikemo & Leknes, 2019), people

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Received April 17, 2019

tend to undervalue the postponed reward (Lempert & Phelps, 2016; Loewenstein & Prelec, 1992; Myerson & Green, 1995; Raineri & Rachlin, 1993). The delayed reward is generally preferred when it is substantially higher than the proximal one. Choosing the second alternative depends on several factors: the length of the delay, the amount of money, and the devaluation rate of the postponed reward. This last factor, known as the temporal discounting effect, has become the principal framework used in psychology to explain how people make intertemporal choices (e.g., Benzion, Rapoport, & Yagil, 1989; Bickel, Koffarnus, Moody, & Wilson, 2014; Charlton et al., 2013; Green, Fristoe, & Myerson, 1994; Story, Vlaev, Seymour, Darzi, & Dolan, 2014). This paradigm assumes that delayed rewards are discounted more as the length of delay increases, and the rate at which delayed consequences lose value is referred to as the discount rate. Discount rates are sometimes used as a measure of impatience (Marzilli Ericson, White, Laibson, & Cohen, 2015).

Within the field of neuroscience, functional magnetic resonance imaging (fMRI) studies have shown that several interacting neural systems are involved in the process of making intertemporal choices (McClure, Laibson, Loewenstein, & Cohen, 2004; McClure, Marzilli Ericson, Laibson, Loewenstein, & Cohen, 2007; Tanaka et al., 2004; Xu, Liang, Wang, Li, & Jiang, 2009; Wittmann, Leland, & Paulus, 2007). McClure and colleagues (2004) observed that the possibility of receiving immediate rewards instead of deferred alternatives elicits greater activation of some paralimbic structures, such as the ventral striatum, orbital frontal cortex, and medial prefrontal cortex. Frontoparietal areas, such as the dorsolateral prefrontal cortex (DLPFC), lateral orbitofrontal cortex (LOFC), and posterior parietal cortex (PPC), are activated by greater amounts of delayed rewards. These areas also play a key role in tasks requiring executive control (Miller & Cohen, 2001; Platt & Glimcher, 1999).

These findings support the hypothesis that the outcome of an intertemporal choice results from an interaction between two competing neural systems (De Martino, Kumran, Seymour, & Dolan, 2006; McClure et al., 2004; Sanfey, Rilling, Aronson, Nystrom, & Cohen, 2003; Sanfey, Loewenstein, McClure, & Cohen, 2006). One system is linked to limbic and paralimbic responses and values immediate rewards, whereas the other one relies on frontoparietal areas and evaluates deferred gratifications. This picture is consistent with the data derived from studying both primates and human patients with lesioned DLPFC and LOFC, as they exhibited lower judgment and temporal planning skills and more frequent impulsive behaviors (Floden, Alexander, Kubu, Katz, & Stuss, 2008; Kalenscher, 2006; Noonan et al., 2010; Wallis, 2012). It also supports the idea that the choice of immediate rewards is associated with and can be interpreted as impulsive behavior.

Neuroeconomic studies based on nonclinical samples often report an online recording of cortical activity while people are making decisions. The main limitation of this approach is that the correlational nature of the findings does not allow researchers to prove causal hypotheses regarding the actual relationships between areas and functions (Stewart & Walsh, 2006). In recent years, neurostimulation techniques have provided a method to overcome this limitation. While brain stimulation is applied, a target area is either inhibited or activated to explore its specific influence on intertemporal choices. More specifically, transcranial direct current stimulation (tDCS) produces a continuous low-intensity electric current on the scalp to increase or decrease cortical excitability by depolarizing or hyperpolarizing, respectively, cortical neurons at a subthreshold level (Paulus, Peterchev, & Ridding, 2013). Overall, anodal stimulation, which increases the spontaneous firing frequency of cortical neurons, has been reported to enhance the performance of cognitive tasks (Fregni et al., 2005; Javadi, Cheng, & Walsh, 2012; Metuki, Sela, & Lavidor, 2012; Straube, Wolk, & Chatterjee, 2011; Wirth et al., 2011), whereas cathodal stimulation causes an inhibition of cognitive processes (Boehringeretal, 2013; Pope & Miall, 2012; Straubeetal, 2011). There-

fore, when a variation in choices is observed, one can presume that the stimulated area is playing a major role within the decision-making process (Stewart & Walsh, 2006). This hypothesis has been confirmed by several studies that used brain stimulation to moderate participants' behavior during decision-making tasks entailing immediate or impulsive responses (Colombo, Balzarotti, & Mazzuchelli, 2016; Iannello, Colombo, & Antonietti, 2014, Oldrati, Patricelli, Colombo, & Antonietti, 2016).

A few studies have used this methodology to examine intertemporal choices. For example, Figner and colleagues (2010) showed that repetitive transcranial magnetic stimulation (rTMS) for 15 minutes at 1 Hz on the left PFC led to a greater frequency of preferences for immediate rewards. These data have been interpreted as being driven by a lower level of self-regulation, i.e., being unable to resist the temptation of an immediate reward. Cho and colleagues (2010) reported that the inhibition of the right DLPFC using continuous theta burst stimulation (cTBS, an rTMS protocol wherein pulses are applied in bursts of three, delivered at a frequency of 50 Hz and with an interburst interval of 200 ms) enhanced impulsive responses. Hecht, Walsh, and Lavidor (2013) found that individuals were more likely to choose smaller immediate gains instead of a larger delayed benefit when the left DLPFC was stimulated and the right DLPFC was inhibited through tDCS, when compared to the sham stimulation. In a recent study, He and colleagues (2016) used anodal high-definition tDCS (HD-tDCS) to investigate the causal role of the left DLPFC in performing the intertemporal choice (ITC) task and showed that HD-tDCS over the left DLPFC lowered the delay-discounting rate (*k*).

These results can be explained by referring to research that supports the key role of the DLPFC in guiding executive processes (for a review, see Tanji & Hoshi, 2008). Many neurophysiological studies on both animals and humans have confirmed that the bilateral DLPFC can be viewed as the neural correlate of the central executive system (Osaka et al., 2007). This information is relevant because it has been argued that several aspects of executive functioning (for example, working memory, inhibition, and task switching) may provide the basis for successful self-regulation (Blair & Ursache, 2011; Hofmann, Schmeichel, & Baddeley, 2012). Following the implications derived from these studies, we can also argue that self-regulation, which involves the inhibition of impulsive tendencies (Baumeister, Bratslavsky, Muraven, & Tice, 1998), may be responsible for the preference for greater distal (i.e., temporally delayed) rewards instead of smaller proximal (i.e., immediate) ones (Fujita & Carnevale, 2012). This pattern provides additional support for the claim that choosing immediate rewards can be interpreted as impulsive behavior because it is associated with a lack of inhibition of impulsive behavior.

Individual Differences in the Level of Impulsivity

Impulsivity has been considered a multifactorial construct and literature provides evidence of multiple varieties of impulsivity (Avila et al., 2004; Dickman, 1990; Evenden, 1999), these varieties being united by a suboptimal way to handle time (Kim & Lee, 2011).

Impulsive decision-making can be viewed as a failure to appropriately consider certain types of temporal factors. Impulsivity may refer to the tendency to weigh immediate outcomes strongly and to discount the value of delayed rewards precipitously (Frederick, Loewenstein, & O'Donoghue, 2002; Kalenscher & Pennartz, 2008). In addition to temporal discounting, impulsivity has been also defined as a lack of inhibitory control, which implies the inability to suppress an action and thus results in a rapid and sometimes premature response (Kim & Lee, 2011). Lack of inhibition of impulsive behavior is linked to what has historically been called "reflection impulsivity," that is, the tendency toward rapid action before sufficient information is gathered (Kagan, Rosman, Day, Albert, & Phillips, 1964). Framing impulsivity according to this perspective leads to assessing impulsivity levels by comparing reaction

times; individuals who are more impulsive will tend to choose an answer quickly and without thinking (Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001). If considering impulsivity as resulting from failures in successfully handling temporal factors in decision making, it implies that individuals may vary substantially in their strategies to deal with time during decision making.

Literature suggests that there are individual differences in self-control (e.g., Paschke et al., 2016) and this is consistent, indicating the appropriateness of assessing self-control as a trait. For example, Tangney, Boone, and Baumeister (2018) developed a scale to measure trait self-control based on the survey of self-control problems and failures. Thus, we can hence assume that individuals have different levels of impulsivity depending on their self-regulation skills. This inference has been also confirmed by findings of a relationship between higher impulsivity and lower self-control, which leads to addiction related behavior (Dahlen, Martin, Ragan, & Kuhlman, 2005; Hair & Hampson, 2006). Moreover, impulsive individuals tend to undervalue delayed rewards more heavily (Crean, de Wit, & Richards, 2000; Hinson, Jameson, & Whitney, 2003; Iannello, Biassoni, Nelli, Zugno, & Colombo, 2015; Wittman & Paulus, 2008).

Present Study

Given the promising results of brain stimulation of the left DLPFC and the interesting insights gained regarding the relationship between the DLPFC and impulsivity, the present study aimed to further explore the DLPFC's role in influencing intertemporal choices and the function of individual levels of impulsivity in modulating the effects of stimulation. We aimed to a) investigate whether people with low impulsivity levels respond to tDCS differently from those with high impulsivity, b) explore the DLPFC's role in influencing intertemporal choices by using tDCS and comparing the effects of anodal and cathodal stimulations to a control (sham) condition, and c) study the specific role of individual impulsivity in modulating the tDCS effect. The data from this initial study enable a preliminary assessment of our hypotheses and procedure; however, the results should be confirmed by a larger study.

To date, within economic temporal discounting literature, impulsivity has been measured as the tendency to discount the value of delayed rewards prematurely (Frederick, Loewenstein, & O'Donoghue, 2002; Kalenscher & Pennartz, 2008). The present study shifts the focus to a slightly different facet of impulsivity, thus introducing in this field of research a measure of speed responses, which correspond to the (in)ability to suppress a premature response.

After reviewing the results reported in the literature, we hypothesized that the subjects would be more impulsive – less able to control their impulsive behavior – and would have faster reaction times (as discussed above) after cathodal stimulation and less impulsive after anodal stimulation, if compared to the sham condition. Given the fact that, to the best of our knowledge, no previous study has explored the moderating role of personal impulsivity in decision-making tasks, this part of the study is exploratory. However, as impulsivity is often associated with intolerance to delay and sensitivity to immediate rewards (e.g., Robbins, 2007; Whiteside & Lynam, 2003), we can hypothesize that a higher level of individual impulsivity should enhance the effect of cathodal stimulation and decrease the effect of anodal stimulation.

Method

Participants

Thirteen participants (6 men and 7 women, mean age = 24.3; *SD* = 5.9) joined the study. A Power analysis aimed at assessing the achieved power (using G*Power software), considering the sample size, the within subject design and 24 measurements for the 3 conditions returned a power ($1 - \beta$) of .97. The power analysis calculation dealt with the main effects and was based on expected effect size of Cohen's $f = .25$.

The participants included undergraduate and graduate students recruited through advertising on university message boards. All participants were right-handed and had no metallic implants. Individuals affected by attention deficit hyperactivity disorder (ADHD) or neuropsychiatric disorders as well as smokers, alcoholics, and people with substance abuse – all of whom usually display atypical preferences for immediate gratification (Wittman & Paulus, 2007) – were excluded.

Procedure

The IRB of the Catholic University approved the research project. Each participant read and signed an informed consent form prior to the experiment. Information concerning the reward system for participants was included in the informed consent form.

The design procedure, a within-subjects design, consisted of sessions lasting 40 minutes, which occurred once a week for three consecutive weeks.

Each session had the same structure, which is as follows:

1. Twenty minutes of tDCS stimulation in three conditions and in counter-balanced sequence for each of the three sessions (i.e., sham, anodal, cathodal);
2. ITC task;
3. The third session had two additional phases:
   a. Application of the impulsivity inventories;
   b. Reward (one reward among the ones selected by the participants during the three section was randomly sorted and awarded to the participant)

Self-report impulsivity inventories were administered during the last session – rather than at the beginning of the entire experiment – to avoid the possibility that the participants' explicit and conscious answers about their own level of impulsivity might affect their performance on the subsequent behavioral task (functioning as a prime) by causing them to reflect on their impulsivity.

Tools

Transcranial Direct Current Stimulation. tDCS was delivered through two saline-soaked sponge electrodes (25 cm^2) using a constant-current stimulator (HDC Series by Newronika S.r.l). The active electrode was placed over the F3 position of the EEG 10-20 System (corresponding to the left DLPFC), and the control electrode was placed over the right triceps muscle.

As part of the experiment, participants underwent three different stimulation conditions – anodal, cathodal, and sham – on three different days (once a week) in a counterbalanced manner. To prevent subjects from differentiating between real and sham stimulations, the current was slowly increased to 1.5 mA over a period of 30 seconds. For real stimulation (i.e., either cathodal or anodal), after 30 seconds, the current was maintained at 1.5 mA for 20 minutes, whereas during the sham stimulation, the current was slowly decreased back to zero over 30 seconds.

Intertemporal Choice Task (ITC). We used the task proposed by McClure et al. (2004). Participants were presented with a series of 24 binary choices. Each pair consisted of two alternative monetary outcomes, which differed in both specific amounts (5–80 €) and times of availability (ranging from the day of the experimental session to six weeks later). Specifically, in each trial, participants had to choose between a smaller amount of money that would be immediately available and a larger amount that would be received after some time delay. The earlier rewards could be 5 € or 40 €, and the latter could exceed the former by 15%, 25%, 30%, or 50%. The second reward could be delayed by two, four, or six weeks.

The task was administrated using a laptop computer, and the two alternatives were presented on the two sides of the screen. Participants indicated their responses by clicking the mouse to select their chosen reward, and there was no time limit. In accordance with our definition of impulsivity as discussed in the Intro-

duction, the response time (RT) was recorded. The lower the RT, the more impulsive the subjects.

At the end of the experiment (i.e., the conclusion of the third weekly session), participants were given a reward. One of the trials from the three sessions was randomly selected, and the participant received the reward according to the choice he or she had made in that trial. If the subject had chosen the immediate reward, the corresponding amount of money was given before he or she left the session; if the participant had chosen the delayed reward, he or she was asked to come back to the lab two, four, or six weeks later (according to the time interval specified in that delayed option) to receive the corresponding amount of money. Participants were informed about how the rewards would be assigned when they signed the informed consent form.

Barratt Impulsivity Scale. At the end of the last session, the Italian version of the 30-item Barratt Impulsivity Scale Version 11 (BIS-11; Fossati, Di Ceglie, Acquarini, & Barratt, 2001) was administered. Related to impulsivity, it measures six primary factors (attention, motor, self-control, cognitive complexity, perseverance, and cognitive instability) as well as three secondary factors (attentional, motor, and nonplanning). All items are rated on a 4-point scale (1 = rarely or never; 2 = occasionally; 3 = often; 4 = almost always or always). The BIS-11 has demonstrated an acceptable level of internal consistency (Cronbach's alpha = .79). We computed scores for each of the three subscales assessing secondary factors (attentional impulsivity: Cronbach's alpha = .73; motor impulsivity: Cronbach's alpha = .78; nonplanning impulsivity: Cronbach's alpha = .70).

Dickman Impulsivity Inventory. Individual impulsivity was also assessed by using the short version of the Dickman Impulsivity Inventory (DII-S; Claes, Vertommen, & Braspenning, 2000; Dickman, 1990). We translated the original scale into Italian using a standardized procedure including two independent translations, followed by determination of a consensus translation by an expert panel. The translated scale demonstrated good internal consistency in the present study (Cronbach's alpha = .75). This inventory was designed to assess the personality trait of impulsiveness by using 23 true-false items organized into two subscales: functional impulsivity (the tendency to act with relatively little forethought when doing so is optimal; Cronbach's alpha = .70) and dysfunctional impulsivity (the tendency to act with relatively little forethought when doing so causes problems; Cronbach's alpha = .71).

Results

Statistical Analyses

All statistical analyses were performed using IBM SPSS software (IBM, Armonk, NY, USA, version 20). The level of significance was set at $\alpha = 0.05$. We used the Kolmogorov–Smirnov test to check for the normal distribution of data. A repeated-measures generalized linear model (GLM) was used to explore the within-subjects effects of the type of stimulation on the different dependent variables (see below). Follow-up regressions were used to explore the specific role of individual differences.

Main Effect of Stimulation

We first tested for possible gender differences. As no significant difference emerged within our sample, we did not add gender as a between-subjects variable in the subsequent analyses. We then ran a repeated measures ANOVA aimed at exploring possible differences among tDCS conditions depending on the type of reward (immediate vs. postponed): results (non significant but coherent with previous literature findings) are reported in the supplementary materials.

Because we were interested in exploring different impulsive behaviors, as reflected by RTs, we used a repeated-measures GLM to explore the effects of the type of stimulation (independent within-subjects variable) and the kind of reward chosen (immediate versus postponed reward) on the RT (faster responses were considered as more impulsive) for the different choices (small or big reward – we

retained this distinction when looking at RTs because we were interested in exploring the differences in behavior depending on the choice). All the BIS-11 and DII-S main subscales were included in the model as covariates.

No main effects of the stimulation ($F_{2;14}$ = 1.243; p = .27; η^2 = .17) or the type of reward ($F_{1;7}$ = 1.66; p = .24; η^2 = .19) on RT emerged. However, the results highlighted an interaction effect of the stimulation, the kind of reward, and functional impulsivity: $F_{2;6}$ = 8.27; p < .05; η^2 = .73. An interaction effect among stimulation, kind of reward, and attentional impulsivity emerged: $F_{2;6}$ = 10.95; p < .01; η^2 = .78. A third interaction effect among stimulation, kind of

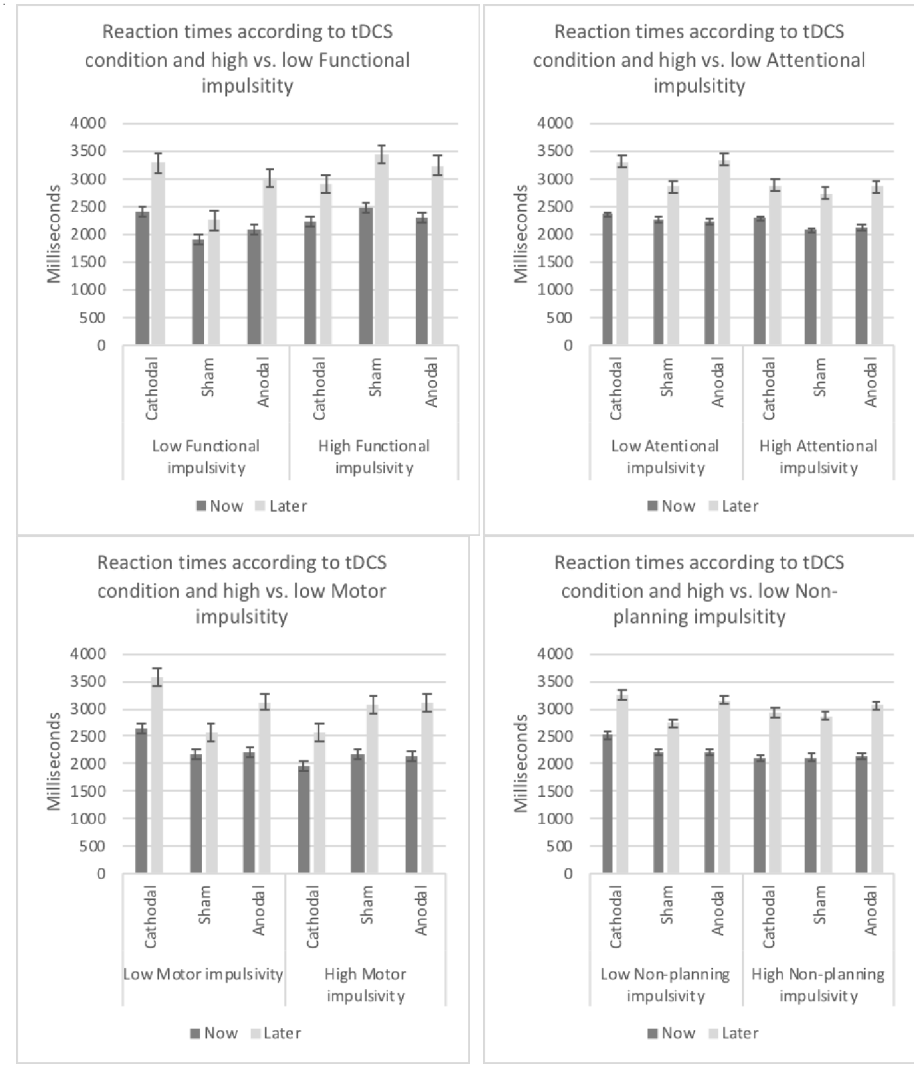

Figure 1 Response Time depending on tDCS condition, the type of reward and level of impulsivity. Errors bars show Standard Errors.

Table 1 *Follow-up regressions using impulsive responses as the criterion*

Predictors			*b*	*SEb*	*β*
BIS - Motor Impulsivity					
Anodal Immediate Reward		Constant	1.14	8.08	
		BIS MI	.72	.42	.46
	R^2 = .46; p = .11				
Anodal Postponed Reward		Constant	-.13.34	9.13	
		BIS MI	1.28	.47	.64*
	R^2 = .40; p = .02				
Sham Immediate Reward		Constant	-3.68	8.27	
		BIS MI	.89	.46	.50
	R^2 = .25; p = .08				
Sham Postponed Reward		Constant	-8.15	10.72	
		BIS MI	.99	.55	.48
	R^2 = .23; p = .09				
Cathodal Immediate Reward		Constant	-.82	7.45	
		BIS MI	.86	.49	.54*
	R^2 = .54; p = .05				
Cathodal Postponed Reward		Constant	-12.94	9.09	
		BIS MI	1.31	.47	.65*
	R^2 = .42; p = .02				
DII - Functional Impulsivity					
			b	*SEb*	*β*
Anodal Immediate Reward		Constant	6.79	4.44	
		DII – FI	1.96	1.01	.51
	R^2 = .26; p = .08				
Anodal Postponed Reward		Constant	-1.53	5.29	
		DII – FI	3.05	1.20	.61*
	R^2 = .37; p = .03				
Sham Immediate Reward		Constant	5.52	5.29	
		DII - FI	1.89	1.20	.43
	R^2 = .18; p = .14				
Sham Postponed Reward		Constant	-2.35	5.44	
		DII - FI	3.18	1.23	.61*
	R^2 = .38; p = .02				
Cathodal Immediate Reward		Constant	6.51	4.37	
		DII - FI	2.21	.99	.56*
	R^2 = .31; p = .04				
Cathodal Postponed Reward		Constant	.07	5.51	
		DII - FI	2.89	1.25	.57*
	R^2 = .33; p = .04				

Note. *b* represents unstandardized regression weights, SE*b* corresponds to the standard error for the unstandardized regression weights, *β* indicates the standardized regression weights.
* indicates p <.05

reward, and motor impulsivity was observed: $F_{2;6} = 5.66$; $p < .05$; $\eta^2 = .65$. Finally, an interaction effect among stimulation, kind of reward, and non-planning impulsivity emerged: $F_{2;6} = 7.07$; $p < .05$; $\eta^2 = .70$.

Postponed rewards tended to elicit more impulsive (faster) answers. Whereas anodal stimulation appeared to have levelled the difference between immediate vs. postponed rewards, after cathodal stimulation individuals reported faster responses when presented with postponed rewards, and the extent of these differences varied depending on the type of impulsivity (see Figure 1).

A follow-up regression (Table 1) to explore the specific role of functional impulsivity in modulating impulsive responses highlighted a significant effect after the anodal stimulation when the reward was delayed ($b = 3.05$; $SEb = 1.20$; b = .61; $p < .05$). The same effect emerged in the sham condition for delayed rewards ($b = 3.18$; $SEb = 1.23$; b = .61; $p < .05$). After the cathodal stimulation, functional impulsivity appeared to modulate impulsive answers both when the reward was immediate ($b = 2.21$; $SEb = .99$; b = .56; $p < .05$) and when it was postponed ($b = 2.90$; $SEb = 1.25$; b = .57; $p < .05$).

To better understand the role of attentional impulsivity in modulating impulsive responses, we ran a follow-up regression. No significant effect emerged.

A follow-up regression to explore the specific role of motor impulsivity in moderating impulsive responses showed a significant effect after anodal stimulation when the reward was delayed ($b = 1.28$; $SEb = .47$; b = .64; $p < .01$). After cathodal stimulation, motor impulsivity appeared to moderate impulsive answers both when the reward was immediate ($b = .86$; $SEb = .40$; b = .54; $p = .05$) and when it was postponed ($b = 1.31$; $SEb = .47$; b = .65; $p < .01$). No effect emerged under the sham condition.

A follow-up regression focusing on non-planning impulsivity found no significant effect.

Discussion

The within-subjects pilot study presented in this paper explored the effect of tDCS on the left DLPFC in moderating impulsive intertemporal choice by considering a possible moderating effect of individual levels of impulsivity.

Findings previously reported in the literature (Hecht, Walsh, & Lavidor, 2013) indicated that a greater number of choices favoring immediate rewards occurred after cathodal stimulation of the left DLPFC. Our results are in line with these findings, even if we focused on a different facet of impulsivity, as measured through response speed (reaction time). Specifically, even if a main effect of the stimulation did not emerge – possibly because of our small sample size – we noted the participants' tendency to report more impulsive (faster) responses after cathodal stimulation when presented with immediate rewards.

Our study added a further level of complexity by including the role of individual impulsivity in the model. We found significant interaction effects, thereby supporting the notion of a moderating role played by individual differences in impulsivity. Especially, we found that motor impulsivity (the tendency to act without thinking) and functional impulsivity (the tendency to act with little forethought in situations where such behavior is beneficial) moderated the effect of cathodal stimulation (by way of increasing its effect), both when the reward was immediate and when it was postponed. The same two types of impulsivity also moderated the effect of anodal stimulation (again increasing the effect of stimulation), but only for delayed rewards. These data suggest that when the DLPFC is inhibited, people become more impulsive, favor immediate rewards, and make faster and less mediated decisions; moreover, this effect is enhanced for individuals who already tend to act without thinking.

By contrast, when the activity of the DLPFC was enhanced, people tended to ponder their decision longer and chose delayed rewards more often. The fact that being more impulsive increased the effect of anodal stimulation for delayed rewards implies that people, who are more impulsive, tend to change their behavior significantly and become more reflective after anodal stimulation but only in case of delayed rewards. In other words, the tendency

to delay discounting per se is not affected, but if an impulsive person considers the delayed rewards, then he or she is more likely to give more thought to the decision and eventually choose the delayed reward option after anodal stimulation. These results confirm previous findings suggesting that impulsive people tend to have an altered sense of time (Wittman & Paulus, 2007), implying that they opt for smaller and immediate rewards because they overestimate the duration of time intervals. This finding explains these individuals' tendency to discount the value of delayed rewards and prefer immediate benefits. In short, time seems to take longer for them and is thus perceived as a higher cost, leading them to choose the immediate reward. The fact that after anodal stimulation people are more likely to choose the delayed rewards and spend a longer time making their decision could be explained as a possible effect of the anodal stimulation, which leads individuals to consider more carefully the exact weight of time when evaluating the value of the rewards.

An additional consideration related to these results, which should be addressed further in future studies, concerns the age of our subjects. Steinberg and colleagues (2009) reported that teenagers tend to be less oriented toward the future and prefer to focus on the immediate present. This perspective would lead to a stronger preference for immediate rewards, regardless of any other consideration. Although our participants were older than teenagers, the mean age of 24 could justify the possibility that a stronger-than-average cognitive focus on the present might still play a role in their reasoning strategies.

Interestingly enough, no effect of individual levels of impulsivity was found when we considered impulsive responses under the sham condition. This result partially contradicts previous findings indicating that personal impulsivity was associated with a preference for proximal reward in temporal discounting tasks (Kirby & Hernstein, 1995; Pine, Shiner, Seymour & Dolan, 2010). One possible explanation could lie in the nature of self-report scales, which assess what individuals believe about their own behavior. Specifically, individuals' beliefs about their tendency to behave in certain ways have been formed through numerous experiences over time. When participants are asked to complete a questionnaire about their level of impulsivity, they refer to these consolidated and established beliefs about their own impulsivity. Apparently, the manner in which individuals tended to rate their own behavior was affected by the stimulation, leading them to be more focused on actual behavioral performance beyond the immediate task-related experience, whereas the same pattern did not arise in the sham condition. This is an interesting discovery that should be explored in depth in future studies.

Another possible explanation of this conflict between our results and previous findings could be due to the different scales used to assess impulsivity. We used fine scales that were probably able to discriminate quite extensively among different kinds of impulsivity, thus providing more sophisticated results. This fact highlights an interesting interaction effect that should be investigated in depth in future studies. Overall, our data suggest that the effect of brain stimulation alone cannot explain individuals' behavior; rather, we must consider individual differences as well to acquire a better understanding of the complicated mechanisms underlying intertemporal choices.

Limitations

The present study, which constitutes a first promising step toward understanding the role of individual differences in modulating the effect of brain stimulation on specific cognitive tasks, has some limitations that should be addressed in future studies. First, the small sample size of the pilot study represents an obvious limitation and may limit the generalizability of the results. This study, however, should be considered an initial exploratory inquiry; we recognize that replication with a larger sample would be needed to further corroborate these preliminary, though encouraging, findings. Replication should also occur with

different age cohorts to examine the possible effect of age.

A second limitation concerns the exclusive reliance on self-reported rating scales to measure individual impulsivity. Although literature on individual differences has relied mainly on self-reported measures, integrating other types of measures (such as direct observations or behavioral measures) could provide a more comprehensive and multifaceted picture of the construct. Future research could address this issue by combining different methods of measuring individual impulsivity.

Conclusion

The findings of the present study, although they will have to be confirmed in follow-up studies, offer several interesting implications. Low behavioral inhibition and high reward sensitivity are generally considered major predictors of risk-taking behavior (Gullo & Dawe, 2008). Conversely, there is a positive correlation between the ability to resist impulsive reactions and the achievement of positive life outcomes (Keough et al., 1999). Taken together, these findings suggest that delay-discounting behavior is influenced by brain stimulation, but not in a direct and deterministic manner. What seems crucial is the interaction between stimulation and individuals' impulsivity levels, which indicates that behavior is affected by different factors that pertain to distinct domains. Our data, by highlighting how the tDCS affected behavior differently depending on the individual level of impulsivity, suggest an important role of individual impulsivity that should be further explored to better understand the effect of tDCS itself. Our results suggest that a tDCS-based protocol could potentially be used both in research activity and as a form of support for populations prone to risk-taking behavior. However, the protocol and the expected outcomes should be calibrated according to individual levels of impulsivity. This recommendation is in line with a growing body of research within the tDCS literature that emphasizes considering individual differences, such as gender, physiological differences, and cognitive abilities (Jones & Berryhill, 2012; Krause & Kadosh, 2014), to thoroughly understand the differential effects of stimulation on participants.

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Appendix

We ran a repeated measures ANOVA aimed at exploring possible differences among tDCS conditions depending on the type of reward (immediate vs. postponed). No effect of the tDCS condition emerged ($F_{2;\ 24} = 2.41$; $p = .11$). This could be due to our small sample size. If we consider the trend of answers, people tended to choose the immediate reward more often. This was enhanced by anodal stimulation – confirming the general trend previously reported in literature (see table below).

		Mean	*SD*
Cathodal	Postponed	11.31	6.97
	Immediate	14.77	6.88
Sham	Postponed	10.23	7.53
	Immediate	14.00	7.33
Anodal	Postponed	12.08	7.34
	Immediate	15.69	6.45

Preference for Postponed vs. Immediate reward according to tDSC condition

Studia Psychologica, Vol. 62, No. 2, 2020, 138-147
https://doi.org/10.31577/sp.2020.02.796

The Predictive Importance of Selected Protective Factors against Different Types of Antisocial Behavior Manifested by Adolescent Boys and Girls

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The study aims to identify protective factors against antisocial behavior of adolescents. Data from the SAHA project (The Social and Health Assessment), obtained from a16-year-old juvenile cohort, were used to analyze antisocial behavior of adolescent boys (*N* = 733) and girls (*N* = 1110). Subsequently, levels of the predictive importance of the protective factors of the family environment, school environment, fulfilled leisure time and individual factors were tested through multinomial regression analysis in the groups of boys and girls. Slightly different paths to the absence of antisocial behavior were identified for adolescent boys and girls. Key predictors for adolescent boys with non-problem behavior are prosocial beliefs, prosocial behavior, leisure time, expectations of goal attainment, parental involvement, and teacher support. For adolescent girls, positive school environment, feelings of safety at school, parental warmth, parental supervision, prosocial beliefs, optimistic beliefs, and leisure time contribute to non-problematic behavior.

Key words: antisocial behavior, protective factors, adolescence

Introduction

Adolescence is perceived as a period of increased risk of manifestations of problem behavior (Modecki, 2016). Researchers are increasingly interested in identifying protective factors that reduce the likelihood of antisocial behavior, not only in the absence of risk factors but also in their presence, through a specific interaction between them (Morrison, Brown, D'Incau, O'Farrell, & Furlong, 2006; Portnoy, Chen, & Raine, 2013).

Research supports the importance of protective factors such as attachment to parents, social skills, internalized moral beliefs, interaction and engagement in close relations with prosocial peers, and rewarding of prosocial expressions, not only in terms of reducing antisocial behavior and alcohol use but also in relation to lower incidence of depressive symptomatology (Connell, Cook, Aklin, Vanderploeg, & Brex, 2011; Monahan, Oesterle, Rhew, & Hawkins, 2014). Protective factors lead to positive developmental manifestations, even when an individual is confronted with risk factors.

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Received June 2, 2019

Furthermore, a connection has been identified between these factors and a lower occurrence of problem behavior during pubescence and early adolescence (Morrison et al., 2006; Pollard, Hawkins, & Arthur, 1999).

The importance of protective factors in relation to antisocial behavior can be studied at the interpersonal level (family, school, and leisure time activities) and at the individual level (intrapersonal context). At the interpersonal level, important factors include relationships with parents and other significant adults (including teachers). The importance of effective parenting in relation to the deviant behavior of adolescents is documented by extensive research (Torrente & Vazsonyi, 2008). Key parenting methods involve parental support (Ritakallio, Luukkaala, Marttunen, Pelkonen, & Kaltiala-Heino, 2010), effective communication (Steinberg & Silk, 2002) and psychological control (Barber, Bean, & Erickson, 2002). In the school environment, the relationship between the child and the teacher (McCurdy, Mannella, & Eldridge, 2003) and the overall school climate (McEvoy & Welker, 2000) are important. During adolescence, peers become more important for fulfilling the need for belonging; numerous studies have demonstrated the harmful effect of peer-to-peer rejection on adolescent development, and this experience is assessed as a risk factor for later maladjustment (Sentse, Lindenberg, Omvlee, Ormel, & Veenstra, 2010). On the other hand, the experience of acceptance by peers has a positive effect (Ladd & Burgess, 2001). Furthermore, a child (or an adolescent) may also experience acceptance and success by engaging in extracurricular activities (Mahoney, 2000), especially in highly complex and cooperative ones. Peer social networks created based on shared goals and interests could work as a possible supportive agent.

With regard to personality characteristics, protective factors in the form of prosocial involvement and internalized moral beliefs appear to be highly functional (Kaufmann, Wyman, Forbes-Jones, & Barry, 2007). Malti and Krettenauer (2013), in a meta-analysis based on 42 studies involving more than 8,000 participants, showed that moral emotions are related to both prosocial and antisocial behavior.

A protective factor may be gender itself (Morrison et al., 2006). Moffitt and Caspi (2001) report the ratio of boys to girls' antisocial behavior as 1.5 to 1 during adolescence. In general, risk factors have a stronger relationship to problem behavior in girls, while protective factors are more relevant for the inhibition of undesirable activities in boys (Monahan et al., 2014).

There is an obvious trend of strengthening research orientation towards protective factors against antisocial behavior (Connell et al., 2011; Monahan et al., 2014; Morrison et al., 2006). However, numerous studies exploring protective factors in relation to the inhibition of antisocial behavior have focused on one or several selected variables. We assume that the simultaneous focus on a wider spectrum of potential antecedents will enable the identification of those that contribute most to the prediction of the extent of antisocial behavior and that specifically have the strongest inhibitory potential against it.

The identification of protective factors for antisocial behavior is undoubtedly more effective when the specifics of those who report this behavior are taken into account. Person-centered approach has the potential to provide a more structured view, and it is important for practical application in the form of interventions or educational programs and psychological counseling (Blatný, Jelínek, & Hrdlička, 2016). In this way, it is possible to consider whether a certain group of adolescents can be characterized by the simultaneous occurrence of specific behavioral manifestations to create a differentiated profile (Modecki, 2016). We assume that the use of a person-centered approach in the research will allow us to preserve sensitivity to the context of particular expressions and identify their concurrent incidence, characterizing specific types of adolescents depending on the extent and severity of the manifested antisocial behavior.

Studies on this topic (Blatný, Jelínek, & Osecká, 2009; Vassallo, Smart, Sanson, Dussuyer, & Victoria, 2002) demonstrate different representations of girls and boys among

adolescents with non-problem behavior as well as those characterized by a higher degree of antisocial expression. Different extents of the manifestation of antisocial behavior based on gender have been confirmed by the creation of two separate typologies, one for a group of adolescent boys and the second for a group of adolescent girls (Selecká, Václaviková, Blatný, & Hrdlička, 2017). Despite the fact that, at the basic level, similar predictors for life-long manifestations of antisocial behavior appear to be important for both men and women, some risk and protective factors are identified as more crucial in relation to specific behavioral expressions of boys or girls (Monahan et al., 2014; Torrente & Vazsonyi, 2008).

Consequently, the simultaneous use of person-centered and variable-centered approaches provides a more comprehensive understanding of the context of protective factors and the extent of adolescent involvement in antisocial behavior.

The main objective of the current study is to identify the most important protective factors while focusing on a wider spectrum of possible antecedents. Thus, the aim is to identify which protective factors contribute most to the prediction of the extent of antisocial behavior.

Furthermore, the current study focuses on the simultaneous examination of the significance of protective factors with regard to the severity of the antisocial behavior in the typologies created (Selecká et al., 2017) separately for adolescent boys and girls. More specifically, the aim is to identify which protective factors are most relevant for the inclusion of adolescent boys in type 1, non-problem behavior (compared to the types exhibiting 2, conduct problems, 3, conduct problems with drug and alcohol abuse and consequences from formal authorities, and 4, antisocial behavior) and for the inclusion of adolescent girls in type 1, non-problem behavior (compared to type 2, conduct problems and 3, antisocial behavior).

Methods

Sample

The research was conducted on a representative sample of juveniles from urban areas in the Czech Republic (Prague and 12 regional cities) in three age cohorts (12-year-old, 14-year-old and 16-year-old). Participants were selected through the procedure of stratified random sampling (see Blatný, Hrdlicka, Ruchkin, Vermeiren, & Schwab-Stone, 2006; Blatný et al., 2016).

The results of this study are based on data obtained from the 16-year-old juvenile cohort, which contains data from 1,843 adolescents (733 boys and 1110 girls). This age cohort was chosen because of the most prevalent manifestations of antisocial behavior (e.g., forms of aggressive behavior, drug-related crime) and the assumption of greater personality and behavioral stability (e.g., prosocial behavior, a higher level of internalization of moral beliefs).

Based on the results of the Blatný et al. (2016) studies, we created a typology of antisocial behavior in an earlier study (Selecká et al., 2017). Using a non-hierarchical cluster analysis on SAHA's items, reflecting different manifestations of antisocial behavior separately for groups of boys and girls. The separate computations for the groups of boys and girls led to the formation of different typologies. In the case of boys, four types of antisocial behavior were identified (Table 1).

Table 1 *The typology of antisocial behavior in boys*

Type	*N*	%
Non-problem behavior	416	56.75
Conduct problems	188	25.65
Conduct problems with drug and alcohol abuse and with consequences from formal authorities	82	11.20
Antisocial behavior	47	6.41

Table 2 *The typology of antisocial behavior in girls*

Type	*N*	%
Non-problem behavior	682	61.44
Conduct problems	313	28.20
Antisocial behavior	115	10.36

In the case of girls, a slightly different typology was created. Conduct problems and conduct problems with current prevalence of alcohol/drug abuse constitute one type, and the result of the cluster analysis is three types of antisocial behavior for girls (Table 2).

Measures

Social and Health Assessment (SAHA); (Schwab-Stone et al., 1999) is a thematically broad-based questionnaire survey dealing with risk and protective factors in the social development and health of school youth. The questionnaire consists of 65 structured questions divided into 375 items. The questions and scales are divided into two large domains. The first domain consists of questions focused on sources of risk and protective factors, and the second domain is represented by questions on the impacts on behavior and mental health. In the present study, the following scales from SAHA were used:

The Antisocial Behavior Scale (α = .788) identifies conduct problems of varying severity (Schwab-Stone et al., 1999) in the following main domains (subscales): 1) conduct problems/norms violation, 2) property offenses and 3) violent behavior, including items focused on 4) disciplinary and legal consequences of antisocial behavior (disciplinary proceedings at school, arrest). Participants score on a 5-point scale how many times they have been involved in one of the types of antisocial behavior in the last year (0 = not at all, 1 = once, 2 = twice, 3 = three to four times, 4 = five times or more). Item example: “In the last year, how many times did you steal in the store?”

The potential protective factors, based on the SAHA method, were examined as follows:

Conventional Involvement Scales: conventional involvement/extracurricular activities (α = .507), leisure time (α = .411). Participants are asked, for example, how many hours per week they spend engaging in particular extracurricular activities or how they spend their free time (e.g., watching TV, reading, …).

School Environment and Academic Motivation Scales: attachment to school (α = .813), school environment (α = .720), perceived teacher support (α = .711), academic motivation (α = .577). Participants score on a 4-point scale (from “not true at all” to “absolutely true”), for example, if they like going to school, if they feel safe in the school environment, if they perceive teachers as being supportive, and if the education seems to be important for them.

Parenting Scales: parental involvement (α = .725), parental supervision (α = .718), parental warmth (α = .796). Above mentioned scales represent items as follow: “My parents ask me how my life is going.”, “My parents want to know, who I am spending time with.”, and “My parents are proud of me.” Participants score on a 4-point scale (from “never” to “often”).

Prosocial Attitudes and Behavior: prosocial beliefs (α = .816), expectations of the future (α = .786), happiness (α = .862), and prosocial behavior (α = .598). Area of the questionnaire represented by the mentioned scales contains, for example, following items: “How bad is it to steal in a store?”, “What are your chances of happy family life?”, or “Usually, I share with others.”.

Results

Through a multinomial regression analysis, we tested the predictive importance of selected protective factors such as family environment, school environment, leisure activities, and individual factors leading to the inclusion of an

individual into a particular type based on manifested antisocial behavior.

Tabachnick et al. (2001) stated that multinomial logistic regression is more robust to violations of assumptions of multivariate normality and equal variance-covariance matrices across groups. On the other hand, multicollinearity can violate the informative value of the results. Therefore, we tested the multicollinearity of the predictors with tolerance and VIF statistics. The predictors have proven not to be biased by multicollinearity.

Model of regression analysis in boys: the predicted values were not significantly different from the values of the analyzed model (Pearson = 1921.787, p =.994), and the model decreased the proportion of unexplained variance significantly (χ^2 = 295.654, df = 45, p =.000). In the group of boys, significant protective factors were identified (Table 3). For inclusion in the group of unproblematic boys, the most prominent predictor is the acquisition of prosocial beliefs. Further, the incidence of prosocial behavior, engaging in extracurricular activities and positive expectations for the future are identified as being significant predictors. Last but not least – parental involvement and supervision, as well as teacher support, contribute to the inclusion in the group without problem behavior.

Table 3 *Results of a multinomial logistic regression analysis of a group of non-problem adolescent boys against the groups of boys with antisocial behavior*

1 vs 2	*B (SE)*	*P*	*Lower*	*Odds Ratio*	*Upper*
Conventional involvement	.094 (0. 40)	.017	1.017	1.099	1.187
Teacher support	-.088 (0.034)	.008	.857	.915	.978
Parental supervision	.068 (0.026)	.010	1.017	1.070	1.126
Prosocial beliefs	-.147 (0.023)	.000	.825	.863	.903
1 vs 3	*B (SE)*	*P*	*Lower*	*Odds Ratio*	*Upper*
Leisure time	.082 (0.038)	.032	1.007	1.086	1.170
Prosocial beliefs	-.192 (0.029)	.000	.779	.825	.874
1 vs 4	*B (SE)*	*P*	*Lower*	*Odds Ratio*	*Upper*
Leisure time	.136 (0.064)	.035	1.010	1.146	1.300
Prosocial behavior	.317 (0.137)	.021	1.049	1.373	1.797
Parental involvement	-.216 (0.101)	.032	.661	.806	.982
Future expectations	-.140 (0.067)	.037	.763	.870	.991
Prosocial beliefs	-.369 (0.044)	.000	.634	.691	.754

Note. R^2 = .340 (Cox & Snell), R^2 = .385 (Nagelkerke)

Table 4 *Results of a multinomial logistic regression analysis of a group of non-problem adolescent girls against the groups of girls with conduct problems*

1 vs 2	*B (SE)*	*P*	*Lower*	*Odds Ratio*	*Upper*
Leisure time	.081 (0.036)	.026	1.010	1.084	1.164
Prosocial beliefs	-.242 (0.027)	.000	.745	.785	.828
1 vs 3	*B (SE)*	*P*	*Lower*	*Odds Ratio*	*Upper*
School attachment	-.067 (.032)	.035	.879	.935	.995
School environment	.066 (.030)	.028	1.007	1.068	1.132
Safety at school	.058 (0.026)	.028	1.006	1.060	1.116
Parental supervision	.076 (0.019)	.000	1.039	1.079	1.120
Parental warmth	-.073 (0.033)	.026	.871	.929	.991
Happiness	-.077 (0.040)	.050	.856	.926	1.000
Prosocial beliefs	-.124 (0.019)	.000	.852	.884	.917

Note. R^2 = .219 (Cox & Snell), R^2 = .263 (Nagelkerke)

In the group of girls, the regression analysis model also appears to be appropriate (Pearson = 2203.902, p =.157), and the model significantly reduced the proportion of unexplained variance (χ^2 = 268.135, df = 30, p =.000). In the group of girls, some different protective factors were identified (Table 4). Here, the school climate or the feeling of safety in school play significant role as predictors for the inclusion in the group of unproblematic girls. Further, parental supervision and perceived expressions of parental warmth are important predictors. In terms of the individual, prosocial beliefs remain in the position of a prominent predictor.

Discussion

The importance of a separate approach to analyzing conduct problems among adolescent boys and girls was discussed in a paper that aimed to verify the suitability of a typology based on the extent and severity of this behavior (Selecká et al., 2017). Because the typologies for adolescent boys and girls proved to be valid, we proceeded to analyze the protective factors against antisocial behavior separately for each particular type.

In general, for inclusion in the group of unproblematic boys, individual factors appear to be the most important ones. Specifically, the most prominent predictor is the acquisition of prosocial beliefs, in agreement with Kaufmann et al. (2007). The extent of moral internalization distinguishes non-problem boys from all other types. Therefore, it is crucial in terms of the development of (im)moral behavioral tendencies (Hoffman, 2000; Malti & Latzko, 2010).

The incidence of prosocial behavior, where higher scores mean a lower likelihood of belonging to the non-problematic group of boys rather than the group that exhibits antisocial behavior, may appear paradoxical. However, the prosocial behavior of an individual may be aimed at a member of his/her own social group (Sobotková, Blatný, & Hrdlička, 2007) and may potentially have antisocial manifestations. This may be how a group of adolescents evaluates itself as a prosocial group.

Boys who do not exhibit problem behavior are more likely to engage in extracurricular activities, where they may develop their potential and have less free time to spend on unfocused activities. In accordance with the abovementioned findings, Mahoney (2000) notes the relationship between participation in extracurricular activities organized by the school and a lower probability of early school dropout or arrest among high-risk boys and girls. Social relationships that are associated with participation in such activities play an important role in inhibiting antisocial behaviors. Even high-risk youth can benefit from the social contacts that extracurricular activities may involve. These include values that are consistent with the values of society and consequently lead to a reduction of antisocial behavior.

With regard to assuming goal achievement (e.g., academic success, future work success and personal fulfillment), boys with a higher level of positive expectations for the future are most likely to be in the first type (without conduct problems) when compared to the group of boys exhibiting a significant extent of antisocial behavior. Future expectations are perceived as fundamental, a developmental change occurs in the effort to adapt to the demands of the future (Seginer, 2008). Non-problematic adolescents assume the least difficulty in fulfilling developmental tasks and achieving future successes. This finding supports the identified association of risk behaviors and future expectations (Sipsma, Ickovics, Lin, & Kershaw, 2012).

In the interpersonal context, the parent-child relationship appears to be crucial. For inclusion in the group of unproblematic boys, parental involvement is particularly important (Torrente & Vazsonyi, 2008). Additionally, parental control is identified as a significant factor. Specifically, boys belonging to the non-problem behavior type do not receive parental control to such an extent. We can consider whether a certain level of rebellion against adult authority and an effort not to comply with requirements is the adolescent's response to a stricter educational style or whether increased parental control follows committed offenses.

In terms of the school environment, the position of the teacher is significant. In boys, perceived teacher support decreases with manifestations of antisocial behavior. This finding can be explained in several ways: antisocial behavior may be the result of a sensitively felt support deficit; alternately, due to the problem behavior of the adolescent, the teacher may provide little favor.

Girls' inclusion in the non-problem behavior type compared with the group with more pronounced antisocial expression takes a slightly different path than that of boys. It appears that environmental factors (the school climate or the feeling of safety in school) play a more important role in the development of girls in a socially desirable way. Because these factors can be considered interconnected, this result also reflects the emotional accent in the form of a positive relationship with the school environment. The unproblematic group of girls exhibits more positive emotions in relation to school, associated with a lower degree of negative evaluations of the school environment. It can be explained in two ways: antisocial behavior may be conditioned by a negative school environment, or the school environment may be experienced as more unfavorable as a result of perceived problems at school.

For the inclusion of girls in the unproblematic group, the importance of parenting is confirmed. An emotional relationship with parents is crucial, especially perceived expressions of parental warmth. These conclusions are supported by Lorincová (2014), who evaluates parental warmth as a protective factor against mental disorders in general and aggressive behavioral tendencies in particular. A lack of support and warmth can result not only in antisocial behavior (Peiser & Heaven, 1996) but also in depressive manifestations (Ritakallio et al., 2010). Although the importance of the family gradually decreases during adolescence, social support from parents consistently appears to be most effective in preventing the development of depressive symptomatology. According to some studies (e.g., Garnefski, 2000), girls are more vulnerable to a lack of social support. Among them, peers and significant others could be subjectively even more important for fulfilling their needs.

While parental supervision (Formoso, Gonzales, & Aiken, 2000) and effective communication (Barber et al., 2002) are reported as significant factors for healthy adolescent development, excessive parental control can lead to inclusion in the antisocial girls' group. The question remains whether increased parental supervision is followed by defiant behavior and adolescent girls, through negative behavior, build their own position to find independence or whether this involves a more intense reaction of parents to behavioral changes and occasional fluctuations related to the development period.

We can confirm that the level of internalized moral beliefs is a prominent predictor in terms of the individual. The stronger prosocial beliefs are, the more likely it is that a particular girl will belong to a non-problem behavior type. We can conclude that a set of internalized beliefs about how a person should behave and which behavioral acts are inappropriate or even reprehensible may represent an inhibitory factor for antisocial impulses (Hoffman, 2000; Malti & Latzko, 2010). As Malti and Krettenauer (2013) state, the degree of moral emotion in adolescents represents an important predictor of prosocial and antisocial behavior. The personality context may be a key because personality traits, agreeableness, and conscientiousness predict the degree of moral emotions achieved (Krettenauer, Asendorpf, & Nunner-Winkler, 2013).

A specific aspect of the typology of adolescent girls involves subjectively perceived feelings of happiness. As noted by Cook et al. (2015), depression appears to be comorbid with manifestations of antisocial behavior more often in girls than in boys. Thus, feelings of happiness are perceived as opposed to depression and could potentially be considered a protective factor against antisocial expressions.

Limitations and Implications

The main limitation of this research is the use of a research design based exclusively on self-

evaluation corresponding with the serious disadvantage of the possible tendency to alleviate existing antisocial behavior by adolescents themselves or to present false increases under the influence of conformity.

The creation of the types of adolescent boys and girls based on reported manifestations of antisocial behavior and subsequently identified factors leading to inclusion in particular types suggest further possibilities for research as well as potential implications for practice. In terms of research, there is an urgent challenge to conduct longitudinal studies that consider not only the numerous risk and protective factors of antisocial behavior but also a sufficient range of their potential internalized and externalized expressions. In terms of practice, key emphasis should be placed on strengthening resources that are effective in inhibiting undesirable activities, such as providing emotional warmth and social support, recognizing the importance of moral beliefs gained at an early age and the process of their internalization, and the ability of the individual to develop his/her potential and experience success. Interventions targeted along this line and implemented by professionals could compensate, to a certain extent, for any potential family deficiencies. Additionally, gender-specific prevention programs (Blatný et al., 2006) may be more effective than nonspecific programs given the different typologies of boys and girls.

Conclusions

The differentiation of individual types based on the type and intensity of behavioral expressions allows us to obtain a more detailed understanding of conduct problems. Further analysis can lead to a more precise way of identifying predictors that increase the likelihood of individual inclusion in a certain type, namely, the "non-problem behavior" type vs. the type with a high incidence of antisocial expression.

Additionally, on the basis of previous analyses conducted by the authors of the study (Blatný et al., 2016) that suggested an unequal representation of girls and boys in different types, we implemented the typology for both groups separately. The results confirm the purpose of this step, not only because of the creation of different typologies but also because the results point to differences in the significance of individual predictors (protective factors) leading to inclusion in the non-problematic type for adolescent boys and girls. Based on the identification of variables that are relevant in this respect, more precise testing of their significance will be undertaken in further studies.

Acknowledgements

Publication has been supported by the project "Risk behavior in adolescence, the incidence and influencing factors" of the Scientific grant agency of the Ministry of Education of the Slovak Republic (ME SR) and of Slovak Academy of Sciences (SAS) no. VEGA 1/0042/17.

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Studia Psychologica, Vol. 62, No. 2, 2020, 148-163
https://doi.org/10.31577/sp.2020.02.797

Job Crafting, Work Engagement, Burnout: Mediating Role of Self-Efficacy

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Based on the Job Demands-Resources model (JD-R), the aim of this study was to verify work engagement and burnout prediction models in relation to self-efficacy and the following four job crafting strategies: increasing structural job resources, increasing challenging job demands, increasing social job resources, and decreasing hindering job demands. Data was obtained by using questionnaires. The sample comprised 178 employed participants between 20 and 58 years of age. The results indicated that crafting challenging demands (e.g., seeking extra tasks) and social job resources (e.g., asking for feedback on job performance) was positively associated with work engagement. Behavioral strategies connected with the avoidance of difficulties at work (decreasing hindering job demands), associated with younger age of employees in managerial positions, significantly contributed to burnout. Self-efficacy as a personal source partially mediated the relationship between increasing challenging job demands and work engagement. Participants in managerial positions indicated a higher level of job crafting, work engagement, and self-efficacy as opposed to individual contributors. The results of the study are practically applicable in organizations in the form of stimulations, management, and the support of those job crafting strategies that contribute to benefits on an individual and organizational level.

Key words: job crafting, self-efficacy, engagement, burnout, JD-R model

Introduction

Job crafting is a specific form of proactive work behavior that involves employees actively changing the (perceived) characteristics of their jobs (Tims & Bakker, 2010; Wrzesniewski & Dutton, 2001). As job crafting is initiated by the employees themselves, it has been described as an individualized, bottom-up, and proactive approach to job re-design compared to top-down and "one-size-fits-all" approaches that are initiated by an organization (Demerouti & Bakker, 2014; Parker, 2014; Parker & Ohly, 2008).

Wrzesniewski and Dutton (2001) define job crafting as "physical and cognitive changes done by individuals in their work tasks and relations" (p. 179), whereby these changes are initiated and carried out in a "bottom-up" manner. Crafting work tasks involves changing a set of formal prescribed duties; such as adding or cancelling tasks; changing the nature of tasks; and changing how much time, energy,

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Received August 2, 2019

and attention an individual devotes to different tasks. Relationship crafting involves changing how, when, and with whom individuals cooperate, also reflecting the quality and number of interactions with other colleagues (Berg, Dutton, & Wrzesniewski, 2008).

Employees, therefore, craft their work to create more motivating conditions and control it, confirm its meaningfulness, shape their working identity, and strengthen their work motivation. In addition to the reasons given above, whether or not an individual performs job crafting depends on the person-job fit. It is important to reflect on two aspects of that compliance: a) the match between individual knowledge, skills, and abilities in relation to the job requirements; and b) the correspondence between the needs and desires of the individual and their employment role. If all the factors are in balance, then the employee has a good "compliance" experience with the job. However, if they are not in balance, there is a misfit and disharmony, which can lead to job crafting that will help correct this relationship (Tims & Bakker, 2010; Tims, Derks, & Bakker, 2016).

Tims and Bakker (2010) theoretically framed job crafting in the context of the Job Demands-Resources (JD-R) model, which is a comprehensive theoretical framework for understanding how job design elements influence occupational well-being and work performance. The model describes how job demands and resources influence motivation enhancing (e.g., work engagement) and strain-enhancing (e.g., exhaustion) processes and work performance.

Job demands encompass work characteristics that, if they exceed the adaptive capabilities of employees, can potentially lead to stress, strain, exertion, and burnout. Specifically, these include the physical, social, and organizational aspects of work (e.g., the amount of time to do tasks/time pressure, the amount of work, contact with people, and the physical environment) that require continuous physical or mental effort. Job resources encompass the physical, psychological, social, and organizational aspects of work that help to achieve work goals; reduce job demands; promote personal growth, learning, and development; and activate work motivation. Job resources are the main initiators of engagement and resulting performance of employees. Accordingly, job crafting serves as an important link between work motivation and the cultivation of job and personal resources that in turn help increase the person-job fit (Bakker & Demerouti, 2017).

Based upon a theory presented by Tims and Bakker (2010), Tims et al. (2012) suggested that job crafting consists of four dimensions: increasing structural job resources includes performing behaviors that aim to increase the autonomy, skill variety, and other motivational characteristics of the job; increasing social job resources entails asking for feedback, advice, and support from supervisors and colleagues; increasing challenging job demands involves performing behaviors, such as asking for more responsibilities; and decreasing hindering job demands entails performing behaviors that aim to minimize physical, cognitive, and emotional demands, such as reducing one's workload and work-family conflict. To operationalize job crafting in terms of the JD-R model, Tims, Bakker, and Derks (2012) published a widely-used job crafting scale designed to measure job crafting.

The JD-R model assumes the existence of two basic processes that explain the relationship with work engagement and burnout (Bakker & Demerouti, 2007; Schaufeli & Bakker, 2004a). Firstly, job demands activate the energy depletion process, resulting in increased employee efforts to meet these demands or requirements. When employees encounter job demands, they often resort to different compensation strategies in order to maintain adequate work performance. However, in the long-term perspective, these strategies become ineffective and deplete the mental and physical reserves of employees, which in turn leads to burnout (Trépanier, Austin, Forest, & Vallerand, 2014). On the other hand, job resources activate the motivation process. These resources support employee motivation and work engagement as they help them achieve their goals; promote their growth, edu-

cation and development; satisfy their need for autonomy; and increase their willingness to invest effort into work tasks (Demerouti et al., 2001).

Tims, Bakker, and Derks (2012) report that job resources reinforce work engagement, employee motivation and energy, and subsequent positive organizational outcomes. Job resources also act as balancers of the negative effects of job requirements and can lead to occupational engagement even if job demands are high. For work motivation, it is very important to experience an appropriate level of challenging job demands to stimulate employees to develop their skills or set more ambitious goals for themselves. More demanding job requirements allow the acquisition of valuable experience, which can lead to higher satisfaction and self-efficacy (Gorgievski & Hobfoll, 2008). Macey and Schneider (2008) say that challenging situations encourage work engagement if employees believe that their time and energy investment will be meaningfully rewarded. In a meta-analytical study, Crawford, LePine, and Rich (2010) document the positive relationship of challenging job demands with work engagement even when these have been assessed as stressful. On the contrary, demands that were considered to be hindering by employees correlated negatively with work engagement.

In addition, previous studies revealed that increasing social and structural job resources and increasing challenging job demands were negatively associated with burnout and boredom at work (Tims, Bakker, & Derks, 2012; Van Hooff & Van Hooft, 2014). These findings are consistent with the Conservation of Resources Theory (Hobfoll, 1989), which suggests that stress arises from inadequate job resources and leads to burnout. Individuals with a greater supply of job resources are more likely to cope with job demands whereas individuals with fewer resources are increasingly tense, which may lead to burnout. On the other hand, it was found that hindering job demands are linked to negative aspects of employee mental health such as burnout (Schaufeli, Bakker, & Van Rhenen, 2009; LePine, Podsakoff, & LePine, 2005).

Previous studies on the JD-R model focused on job characteristics, leading to a neglect of personal resources. This is despite the fact that personal resources play a comparable role in occupational life: they lead to increased employee motivation and engagement, are related to stress resistance, and have positive effects on emotional and physical well-being (Schaufeli & Bakker, 2004a). Personal resources such as self-esteem, optimism, and self-efficacy are positively related to work engagement (Xanthopoulou, Bakker, Demerouti, & Schaufeli, 2007; 2009). On the contrary, employees with a low level of self-efficacy have pessimistic ideas about their future success and personal development, which can lead to burnout. Research in this area has shown that self-efficacy acts as a source of prevention from the negative consequences of an excessive and long-term work load (Blecharz, Luszczynska, Scholz, Schwarzer, Siekanska, & Cieslak, 2014), stimulating work-related recovery from stress and helping employees adapt to changes in an organization (Jimmieson, Terry, & Callan, 2004).

Self-efficacy and personality proactivity are among the personality traits that play an important role in job crafting. Tims and Bakker (2010) report that people with a proactive personality are more likely to engage in job crafting willingly: they take the initiative to improve their current work conditions, identify opportunities for change, and start and persevere until they achieve a meaningful change.

In their study, Xanthopolou et al. (2007) found that self-efficacy, self-esteem, and optimism partly served as mediators between job resources and work engagement. Similarly, Luthans, Avey, Avolio, Norman, and Combs (2006) documented that a work resource-rich environment activates employees' psychological capital (i.e., hope, optimism, efficiency, and resilience), which in turn can lead to profits and positive results at work. Huang, Wang, and You (2016) have further shown that self-esteem and optimism are important media-

tors in the relationship between work overload and exhaustion.

The Current Study

Current research, based on Tims and Bakker's (2010) conceptualization of job crafting, has adopted different operationalizations of this construct. Petrou, Demerouti, Peeters, Schaufeli, and Hetland (2012) merged two dimensions of their conceptualization – increasing structural and social job resources – into one increasing job resources dimension and differentiated between only three types of job crafting. Similarly, Nielsen and Abildgaard (2012) identified two factors: decreasing social job demands and increasing quantitative job demands. Because there are a number of alternative operationalizations of job crafting, the first goal of the present study was to examine the structure of the latent factors of the job crafting scale to see whether they could be meaningfully distinguished from each other. Then the relationships between dimension-specific forms of job crafting, work engagement, burnout, and self-efficacy were more closely examined. Several researchers have examined these relationships (Crawford, LePine, & Rich, 2010; Hansez & Chmiel, 2010; Tims, Bakker, & Derks, 2012; Tims, Bakker, & Derks, 2013; Brauchli et al., 2013; Van; Hooff, & Van Hooft, 2014), but self-efficacy as a personal resource has often been neglected. Employees who believe in their self-efficacy choose more demanding tasks, set higher goals, put more effort into their performance, and are more persistent, compared to employees who have a lower level of self-efficacy (Lunenburg, 2011). As mentioned in the Introduction, personal resources play an important role in relation to burnout and engagement. They have a comparable role to work resources as they lead to increased employee motivation and engagement (Schaufeli & Bakker, 2004a; Xanthopolou et al., 2007; Xanthopolou et al., 2009; Huang, Wang, & You, 2016).

The lack of literature led the present authors to the question of whether position level (managerial and non-managerial) contributes to job crafting strategies as a distal antecedent. Karasek (1979) introduced the concept of active jobs, which denotes professions with high demands and a high level of control. These professions encourage employees to actively learn, and they motivate them to new patterns of behavior. Based on this concept, managerial positions represent active jobs with higher autonomy and control, albeit with certain demands. According to the 2016 Employee Engagement Trends (Hackbarth, Harris, & Wright, 2016), engagement increases as employees gain higher-level positions within a company, which might be strengthened in a "feedback loop" level of job crafting (Baker, 2011). In the present study, the aim was to test whether managerial positions increase the likelihood of job crafting strategies through searching for resources and challenges.

Research regarding age and gender differences in job crafting is somewhat equivocal. For example, Petrou, Demerouti, and Xanthopoulou (2016) identified a higher level of job crafting for men, whereas Van Hoof and Van Hooft (2014) documented the opposite. Based upon action regulation theory, it can be argued that older and more experienced employees (i.e., relative to younger and less experienced ones) are more likely to have developed cognitive routines in their work that might lower behavioral changes like job crafting (Zacher, Hacker, & Frese, 2016). On the other hand, several studies document a higher level of work engagement for older employees (e.g., Najung & Seung-Wan, 2017) and a positive influence of work engagement (in the "feedback loop") on job crafting strategies (Baker, 2011). For that reason, there are no specific predictions made on age and gender characteristics and job crafting; however, it is nonetheless useful to understand the nature of such relationships in further research.

Following the abovementioned findings, this study assumes that:

1. self-efficacy will be positively related to increasing structural and social resources, thus increasing challenging job demands

2. self-efficacy will also act as a mediator between job crafting dimensions (increasing

structural and social resources and increasing challenging job demands) and work engagement

3. increasing structural and social job resources, and increasing the challenging job demands, will predict work engagement, whereas reducing the hindering demands will predict burnout

4. managerial positions will strengthen job crafting strategies

Methods

Participants and Procedure

Data was collected using an online questionnaire through social networks and with voluntary participation. A minimum inclusion criterion was used; selected participants indicated that they were in full-time employment for a fixed or indefinite term. Part-time workers and freelancers were excluded from the sample. In total, 178 employees participated in the study. More than half of the sample was female (59%), the average age of the participants was 33.3 (*SD* = 8.45) years, and 35.4% of participants were managers. The educational level of the participants was relatively high: almost 78% of the participants reported having a bachelor's degree or a higher qualification. Thirty-seven percent of employees worked in a medium-sized organization (51–500 employees), 37% in a large one (over 501 employees), and 26% indicated they were employed in a small organization (up to 50 employees). Participants were provided with an informed consent sheet that included information on the purpose of the research, their right to anonymity, and a reassurance that the results would be used exclusively for research purposes.

Measures

Four self-reporting measures and scales were administered in the form of online questionnaires. Two independent translations into Slovak (and then back into English) were done of three questionnaires (measuring work engagement, job crafting, and burnout) to be used in the study, and the final versions were agreed upon after mutual consent between two translators. The self-efficacy questionnaire was adapted to the Slovak population, and there was no need to translate it.

Work engagement was measured with the short nine-item version of the Dutch Utrecht Work Engagement Scale (UWES; Schaufeli, Bakker, & Salanova, 2006) measuring the three dimensions of engagement – vigor, dedication, and absorption. An example item is: "At work, my colleague feels bursting with energy". A 7-point scale was used with answers ranging from 0 (never) to 6 (always). De Bruin and Henn (2013) provided evidence for the presence of a general factor and that the interpretation of a total score is justified and preferable. Internal consistency confirmed the strong reliability (α = .95).

Job crafting was measured with the 21 items of the job crafting scale (Tims, Bakker, & Derks, 2013). The scale measures four basic dimensions of job crafting: increasing structural job resources (e.g., "I'm trying to improve my skills"); increasing social job resources (e.g., "I ask my supervisor to direct me"); decreasing hindering job demands (e.g., "I try to make my work less emotionally intense"); and increasing challenging job demands (e.g., "When an interesting project emerges, I volunteer as a collaborator"). Participants responded on a five-point Likert scale (1 = never, 5 = frequently). Cronbach's alphas were all above the recommended .70.

The Bergen Burnout Inventory (BBI-15) (Näätänen, Aro, Matthiesen, & Salmela-Aro, 2003) was used to measure burnout level. BBI-15 measures the three dimensions of burnout: exhaustion (e.g., "I often sleep poorly because of the situation at work"), cynicism (e.g., "I feel depressed and think about leaving my current work"), and inadequacy (e.g., "I often question the value of my work"). Participants responded on a six-point Likert scale (1 = totally disagree, 6 = totally agree). The score can be calculated separately for each dimension or as a total burnout score. The measured reliability coefficient for the whole scale was high with an alpha value = .90.

The General Self-Efficacy Scale (GSE) (Košč, Heftyová, Schwarzer, & Jerusalem, 1993) was used to measure the level of self-efficacy. The scale contains ten statements (e.g., "I can find a way out of almost every problem if I make the necessary effort"), and participants answered to what extent the statement applied to them on a four-point Likert scale (1 = not at all true for me, 4 = totally true for me). The value of the reliability coefficient alpha = .86.

Demographic variables. The questionnaire provided to the participants also asked them to indicate their position level (managerial/non-managerial), level of education, type of contract, size of organization, gender, and age for use as demographic variables. In line with the goal of the study, only the variables of position level, gender, and age were included.

Statistical Analyses and Procedure

Before completing the statistical analyses and the dimensionality, the latent structure of the 21 items of the job crafting scale was performed. The factor analysis maximum likelihood was used to examine whether four factors of the job crafting scale could be meaningfully distinguished from each other. As a criterion to retain factors, those factors that had an eigenvalue higher than 1 were retained. The loadings in the matrix were meant to be higher than 0.30 in order to decide whether an item was acceptable for the component. A correlation analysis, hierarchical regression analysis, and mediation analysis were conducted in order to investigate how demographic variables, self-efficacy, job crafting dimensions, engagement, and burnout are connected. Two separate hierarchical regression analyses were conducted on each outcome variable (engagement and burnout) in three steps. Previous studies (e.g., Petrou et. al., 2016; Najung & Seung-Wan, 2017; Hackbarth, Harris, & Wright, 2016) linked gender differences (i.e., being a woman), age differences (i.e., older employees), and position level (i.e., managerial) to work outcomes, which emphasizes the importance of controlling the potential effect of those variables in the prediction models. Hence, age, gender, and position level were entered into the model at Step 1. Given the prior findings between self-efficacy and work outcomes, self-efficacy was entered at Step 2 and behavioral job crafting strategies were entered at Step 3. A mediation analysis was used to verify the role of self-efficacy as a mediator between job crafting dimensions, engagement, and burnout. First, the requested conditions that had to be met were tested before the mediation analysis (the relationship between the independent variable and the mediator, the relationship between the independent variable and the dependent variable, and the relationship between the mediator and the dependent variable). The process tool in the SPSS statistical package by Andrew F. Hayes (2013) was used for the mediation analysis. Bootstrapped standard errors were calculated for path coefficients. The indirect effect was also tested using the bootstrapping procedure on 10,000 samples. The completely standardized indirect effect (Preacher & Kelley, 2011) was used as a measure of effect size.

Results

First, the factor structure of the job crafting scale using the factor analysis (maximum likelihood) was examined. An examination of the eigenvalues and the scree plot reflected a four-factor solution in the line with the original instrument. Five items with loadings smaller than 0.30 were removed: "If there are new developments, I am one of the first to learn about them and try them out"; "I try to make my work more challenging by examining the underlying relationships between aspects of my job" (from Increasing Challenging Job Demands); "I decide on my own how I do things" (from Increasing Structural Job Resources); "I look to my supervisor for inspiration" (from Increasing Social Job Resources); and "I make sure that my work is mentally less intense" (from Decreasing Hindering Job Demands).

Following this, a factor analysis was conducted with a maximum likelihood on the remaining sixteen items to identify the final solution. An additional factor analysis showed a

KMO-index of 0.792, and a significant ($p = 0.000$) Bartlett's test of sphericity. The pattern matrix documented that there should be a distinction between four dimensions of the scale, accounting for 48% of the variance. The findings were the following for the number of the items for each factor: the Increasing Structural Job Resources factor was saturated with three items, the Increasing Challenging Job Demands factor had four items, the Decreasing Hindering Job Demands consisted of five items, and four items were identified for the Increasing Social Job Resources factor. In addition, to test the reliability of all scales, Cronbach's alpha (α) coefficient was used and was derived from the reliability analysis. The factor loadings, items, means, standard deviations, and Cronbach's alphas are shown in Table 1.

Following this, Spearman's correlation analysis on testing variables was performed. The means, standard deviations for the studied variables, reliability coefficients for the scales used, and the correlation matrix are presented in Table 2.

Table 1 *Items, means, standard deviations, Cronbach's alphas, and factor loadings of the job crafting scale (N = 178)*

					Factor			
	Item wording	*Mean*	*SD*	Alpha	1	2	3	4
	Increasing structural job resources			*.84*				
1	I try to develop myself professionally	4.24	0.85		.79			
2	I try to develop my capabilities	4.11	0.92		.74			
3	I try to learn new things at work	4.23	0.86		.63			
	Increasing challenging job demands			*.78*				
4	When there is not much to do at work, I see it as a chance to start new projects	3.44	1.09			.77		
5	I regularly take on extra tasks even though I do not receive extra salary for them	3.52	1.18			.69		
6	I make sure that I use my capacities to the fullest	3.59	1.01			.52		
7	When an interesting project comes along, I offer myself proactively as project co-worker	3.26	1.01			.46		
	Decreasing hindering job demands			*.74*				
8	I manage my work so that I try to minimize contact with people whose problems affect me emotionally	3.12	1.14				.83	
9	I organize my work so as to minimize contact with people whose expectations are unrealistic	3.00	1.25				.70	
10	I organize my work in such a way to make sure that I do not have to concentrate for too long a period at once	3.01	1.15				.48	
11	I try to ensure that I do not have to make many difficult decisions at work	2.59	1.09				.46	
12	I try to ensure that my work is emotionally less intense	3.05	1.09				.38	
	Increasing social job resources			*.72*				
13	I ask whether my supervisor is satisfied with my work	2.66	1.23					.86
14	I ask others for feedback on my job performance	3.12	1.14					.59
15	I ask colleagues for advice	3.37	0.95					.42
16	I ask my supervisor to coach me	2.58	1.05					.42

Table 2 *Means, standard deviations, reliability coefficients, and the correlation matrix for the studied variables*

	M	*SD*	Alpha	1	2	3	4	5	6	7	8	9
1 Gender				1								
2 Positions level				-.099	1							
3 Age	33.30	8.44		-.041	-.376**	1						
4 Self-efficacy	31.69	4.48	.86	.126	-.293**	.332**	1					
5 Work engagement	37.28	10.57	.94	-.016	-.244**	.259**	.364**	1				
6 Burnout	43.62	15.44	.90	-.029	-.136	-.112	-.041	-.258**	1			
7 Increasing structural JR	12.67	2.29	.84	.062	-.166*	.050	.253**	.396**	-.017	1		
8 Decreasing hindering JD	6.12	2.12	.74	-.021	.118	-.085	.117	-.052	.201**	.053	1	
9 Increasing social JR	14.80	3.97	.72	-.068	-.191*	-.079	.075	.347**	.011	.377**	.031	1
10 Increasing challenging JD	17.35	3.92	.78	.013	-.315**	.182	.422**	.615**	.118	.569**	.031	.458**

Note. M – Mean, SD – standard deviation, Alpha – reliability coefficient, JR – job resources, JD – job demands, Position level (1 = managerial position, 2 = individual contributor), Gender (1 = woman, 2 = man), * $p < 0.05$; ** $p < 0.01$.

The expected positive relationship between job resources (social and structural) and work engagement was confirmed (r = 0.396, p = 0.000; r = 0.347, p = 0.000). Apparently, if employees have the opportunity to increase their social and structural resources, this strongly supports their work engagement. A similar principle existed for the positive relationship between increasing challenging job demands and work engagement (r = 0.615; p = 0.000). Furthermore, the findings showed a significant positive correlation between decreasing hindering job demands and burnout (r = 0.201; p = 0.001). The relationships of the variables regarding increasing job resources (both social and structural) and increasing challenging job demands and burnout were non-significant (Table 2).

Self-efficacy as a personal resource was significantly related to work engagement (r = 0.364; p = 0.000), participating in the increase of structural resources (r = 0.253; p = 0.001) and in increasing challenging job demands (r = 0.422; p = 0.000). Self-efficacy does not significantly contribute to an increase in social resources (r = 0.075) or to decreasing hindering job demands (r = 0.117) (Table 2).

As expected, participants in managerial positions indicated a higher level of job crafting in the area of increasing structural resources (r = -0.166; p = 0.027) and increasing challenging job demands (r = -0.315; p = 0.000) as opposed to individual contributors. These participants also showed higher levels of work engagement and self-efficacy (Table 2). In terms of background variables (age and gender), the results indicated only weak and insignificant connections with job crafting strategies; a higher level of self-efficacy (r = 0.332; p = 0.000) and engagement (r = 0.259; p = 0.000) was shown for older employees.

Two separate hierarchical regression analyses were conducted to evaluate prediction models on each of the outcome variables (engagement and burnout) in three steps. Age, gender, and position level were entered into the model at Step 1, self-efficacy was entered at Step 2, and behavioral and job crafting strategies were entered at Step 3. The models and results are presented in Table 3.

In the regression model for engagement, independent variables accounted for 39.6% of the variability (Table 3). Significant predictors for work engagement identified: increasing challenging job demands (β = 0.46, p = 0.000), increasing social job resources (β = 0.17, p = 0.022), and age (β = 0.15, p = 0.031. Other variables that exhibited significant correlation with work engagement (Table 2) – self-efficacy, increasing structural job resource and position level – lost their predictive power in mutual linear combination. Higher age, imple-

Table 3 *Hierarchical regression analyses on engagement and burnout*

	Overall model		Predictors/Beta							
Step	R^2	F	gender	age	position	Self-efficacy	IStrJR	DHJD	ISocJR	ICHJD
Engagement										
1.	.08	5.09**	.01	.17*	-.18**					
2.	.12	5.93**	-.03	.13	-.14	.21*				
3.	.39	13.87**	.02	.15*	.04	.12	.01	-.08	.17*	.46**
Burnout										
1.	.04	2.59	-.07	-.18**	-.18**					
2.	.04	1.96	-.07	-.17*	-.18*	-.02				
3.	.14	3.29**	-.07	-.19*	-.19*	-.09	-.01	.24**	-.16	.21*

Note. IStrJR = Increasing structural job resources, DHSJD = Decreasing hindering job demands, ISocJR = Increasing social job resources, ICHJD = Increasing challenging job demands; gender (1 = female, 2 = male), position (1 = managerial, 2 = non- managerial); * p < 0.05, ** p < 0.01.

menting strategies to increase social job resources (working with colleagues), and challenging job demands (workload and cognitive demands) contribute to work engagement.

Regarding the prediction model for burnout regression, the analysis (Table 3) showed that the combination of inserted variables accounted for 14% of variability. A combination of variables were identified as the strongest predictors of burnout: decreasing hindering job demands (β = 0.24, p = 0.001), increasing challenging job demands (β = 0.21, p = 0.041), position level (β = -0.19, p = 0.017), and age (β = -0.19, p = 0.017). Burnout is significantly contributed to by a combination of younger respondents in managerial positions, the implementation of strategies decreasing hindering demands (e.g., making difficult decisions), and increasing social job resources (e.g., asking feedback from supervisors and colleagues).

The assumption about the role of self-efficacy as a mediator in the relationship between job resources, job demands, and work engagement was tested by a mediation regression analysis using the Process tool in the SPSS statistical package by Andrew F. Hayes (2013). Requested conditions for mediation were met for testing two mediation models: 1) increasing challenging job demands–self-efficacy–work engagement–self-efficacy–work engagement and 2) increasing structural job resources–self-efficacy–work engagement. The aim of the mediation was to identify the size of the indirect effect (self-efficacy) by controlling the direct effect of a) increasing challenging job demands on work engagement and b) increasing structural job resources on work engagement.

Figure 1 shows that self-efficacy partly mediates the correlation between increasing challenging job demands and work engagement. The results documented that the increase in challenging job demands significantly predicts self-efficacy (β = 0.315, p = 0.002), and self-efficacy significantly predicts work engagement (β = 1.489, p = 0.000). Also, challenging job demands was a significant predictor of work engagement (β = 1.580, p = 0.000).

After incorporating the mediator of self-efficacy into this relationship, the effect of challenging job demands on work engagement was partially reduced (β = 1.489, p = 0.000), but the direct effect of increasing structural job resources on work engagement remained statistically significant. In practice, this means that self-efficacy as a personal resource contributes only minimally to the explicability of work engagement. The size of the resulting indirect effect (after mediator control) was ES = 0.0908, 95% CI [0.019, 0.2689] (Figure 1).

When testing the second mediation model (increasing structural job resources–self-efficacy–work engagement), the results showed no mediation effect between crafting structural job resources and work engagement via self-efficacy (CI [-0.012, 0.493]).

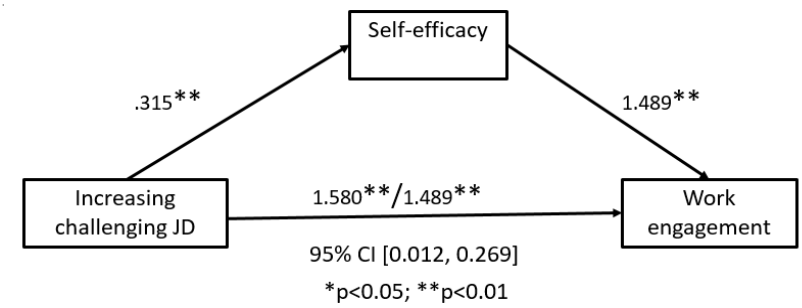

Figure 1 Mediation analysis: increasing challenging job demands–self-efficacy–work engagement

Discussion

Based on Tims and Bakker's (2010) conceptualization of job crafting, the first aim of the study was to examine whether the four-factor structure of the job crafting scale could be replicated. The next aim was to test how personal resource self-efficacy contributes to job crafting strategies and how job crafting dimensions vary as a function for predicting different work outcomes (engagement and burnout). The relationship between managerial positions and job crafting strategies was also examined.

Using the factor analysis (maximum likelihood) to verify the latent structure of the job crafting scale, a four-factor solution was identified with some differences in the number of items and in the factor loadings when compared to the original instrument. Although the present results are consistent with the initial findings of Tims, Bakker, and Derks (2012), previous research has been ambiguous in the results (e.g., Petrou et al., 2012; Nielsen & Abildgaard, 2012). For this reason, the present study sees the importance of contributing to this issue with the present results and confirms the number of dimensions of job crafting.

Findings concerning the relationship between self-efficacy and job crafting dimensions were partially as expected, but there were also some unexpected results. Research has shown that self-efficacy plays an important role in relation to working life as one of the personal resources. Respondents who showed a higher level of self-efficacy were more engaged at work and carried out job crafting at a much higher level, namely for structural job resources and challenging job demands. Decreasing hindering job demands and increasing social job resources had weak associations with self-efficacy. Rudolph, Katz, Lavigne, and Zacher (2017) in their study documented associations of self-efficacy with all of job crafring strategies except for decreasing hindering job demands. Explanation for our findings might be that employees with higher level of general self-efficacy direct more attention to "growth-oriented" job crafting behaviors than to decreasing hindering demands and "people-oriented" crafting strategies (e.g., communication, cooperation with colleagues). In addition, older people showed higher levels of self-efficacy and engagement. This may be due to the fact that older employees have more work experience, are more mature, and value their work. This can lead to more positive self-esteem and commitment to work.

In general, the results emphasize the importance of self-efficacy, which has often been neglected as a personal resource in research. It is important to say that personal resources are comparable to work resources, as they lead to increased employee motivation, performance, and engagement (Schaufeli & Bakker, 2004a; Xanthopolou et al., 2007; Xanthopolou et al., 2009; Huang, Wang, & You, 2016). Various research in this area has shown that self-efficacy acts as a source of prevention against the negative effects of excessive and long-term stress (Blecharz et al., 2014), stimulates recovery from work-related stress, and helps employees adapt to organizational changes (Jimmieson, Terry, & Callan, 2004).

On the other hand, when incorporating self-efficacy into regression models, the abovementioned correlations did not work. Self-efficacy became a non-significant variable in work engagement prediction. The significant predictors in this relationship were increasing challenging job demands, age, and increasing social job resources. The combination of a higher age, strategies to increase social job resources (social support, working with colleagues), and challenging job demands (seeking new projects, taking on extra tasks) contributed to work engagement. In the other words, in case of "supportive environment" at work, behavioral strategies play a more important role in shaping positive work outcome (engagement) than personal resources (self-efficacy). Crawford et al. (2010) also found a positive correlation between challenging job demands and work engagement, even when these were assessed as stressful. In terms of the prediction of burnout, self-efficacy was com-

paratively non-significant. A lower age, managerial position, decreasing hindering job demands, and increasing challenging job demands significantly contributed to burnout. It seems, age is one of the important predictors of an employee´s well-being. Considering the so-called structural model (Maslach, Jackson, & Leiter, 1996), responsibilities associated with managerial position, expected strategies in seeking new challenges in those positions, and strategies connected with regulation of the presence of specific demands (i.e., work overload, personal conflicts) together with younger age and the absence of specific resources (i.e., experience) can lead to long-term discomfort, uncertainty, and often burnout.

A study by Huang, Wang, and You (2016) has shown that personal resources, including self-efficacy, also act as mediators in the relationship between work conditions and outcomes (behavior and attitude). The present study tested the size of the indirect effect of self-efficacy by controlling the direct effect of increasing structural job resources on engagement and increasing challenging job demands on engagement. One finding was that self-efficacy partially explains the relationship between challenging job demands and work engagement. This result contradicts previous findings, which have shown that satisfaction is one of the personal resources that mediated the relationship between job demands and exhaustion and between job resources and energy (Van den Broeck et al., 2008). Previous studies only focused on verifying the relationships between job demands, job resources, and outcomes in general (Huang, Wang, & You, 2016; Van den Broeck et al., 2008; Xanthopolou et al., 2007). This study focused in more detail on job resources and demands, examining social job resources and challenging job demands in relation to work engagement. There was an assumption that the differences in job resources and job demands ought to be taken into consideration in future research. As mentioned above, for some people time pressure can be perceived as a challenging job demand, whereas for others it is a hindering job demand.

Findings for job crafting and work engagement were largely as expected based upon theoretical considerations and consistent with meta-analytic findings for other forms of proactive behavior (Tornau & Frese, 2015). The results of our study illustrate that job crafting in the area of increasing social, structural, and challenging job demands contributes positively to employee engagement and refers to the functioning of the motivational potential of the job resources that improve person-job fit which, in turn, positively impacts job attitudes, and occupational well-being.

Regarding the connection between the distal variable and job position (managerial and non-managerial), it was proposed that managerial positions would increase the likelihood of job crafting strategies through the search for resources and challenges. The present findings confirmed this expectation and showed that a managerial position was significantly associated with the job crafting dimensions of increasing structural and social job resources and increasing challenging job demands. The only job crafting dimension, where there were insignificant associations, was in decreasing hindering job demands. One explanation may be that in job crafting, employees voluntarily change their work themselves in a meaningful way. These characteristics distinguish job crafting from top-down approaches, whereby employees are checked by their supervisor as to how they should perform their work (Grant & Parker, 2009). However, a problem may arise in working conditions where job crafting cannot be performed. Indeed, some jobs have a well-defined structure and require strict rules and procedures that are contrary to any attempt to change working conditions. Job crafting may be also affected by superiors who require work to be performed in a prescribed manner. On the other hand, managers are not usually under strict scrutiny and can do their jobs in the way they choose.

The above findings point to a greater significance of job resources and challenging job demands, compared to personal resources, in terms of both work engagement and burn-

out; the personal resources in the presented research acted more as distal variables in relation to behavior (job crafting), attitudes (engagement), and experience (burnout) as opposed to proximal job resources. The fact that self-efficacy has been assessed as a general characteristic has contributed to the documented findings, thus, in the future there should be a focus on the specific and direct assessment of work self-efficacy. Also, specific job crafting dimensions are differentially associated with both antecedents and work outcomes. In particular, decreasing the hindering demands dimension appears to differ markedly from the other three job crafting dimensions, and this observation deserves further attention in future research.

In summary, the present study contributes to the enhanced understanding of the nature of the job crafting construct, its unique relationships between each job crafting dimension, and work outcomes (engagement and burnout). It investigated the role of individual difference (self-efficacy) and demographic characteristics (type of position) as antecedents of job crafting and mediators (self-efficacy) between dimensions of this proactive behavior and work outcomes (engagement and burnout).

Limitations

The present study took into account a number of limitations related to behavioral science research that may have influenced the presented results (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). The research design was based solely on self-assessment methodology. The predictor and criterion variables were measured using the same tools (self-assessment Likert scales) at the same time and place, which could be a source of "false" covariance, independent of the content of the constructs themselves. The cross-sectional design of the research was another limiting factor; data was obtained only in one measurement. Job crafting is not an isolated and one-time affair; it is a continuous process influenced by the career path and context within which individuals perform their work and by changes to the conditions in which work is performed (Fried, Grant, Levi, Hadani, & Slowik, 2007). The presented measurements did not allow for a study of the reciprocity between job crafting variables and the work engagement presented by several studies. Another study limitation is the size of the sample and the non-random and occasional selection of participants. Furthermore, the sample was not representative of employees in Slovakia in terms of sample size, the uniform distribution of some of the studied variables, or economic segments. The participants were approached through social networks instead of directly, which could have resulted in the research participation of only those individuals, who are active users of social networks.

Practical Implications

Looking at job crafting and the implications based on the presented research, it is important to note that employees should have the opportunity to change their working conditions within their organization. Job crafting is a way that employees can change their lives at work and make a valuable contribution to their organization. Each employee is different, and it is very difficult to create optimal working conditions for each employee individually. This is why employees should be allowed to adjust their working conditions at their discretion, as this may affect their subsequent working behavior. Moreover, organizations and employers can invest in various programs designed to develop and improve personal resources. As one of the personal resources, self-efficacy can affect the way employees perceive job characteristics and help them overcome difficulties at work.

Acknowledgement

This research was carried out with the support of the Slovak grant agency VEGA, grant scheme VEGA 1/0273/18.

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Studia Psychologica, Vol. 62, No. 2, 2020, 164-177
https://doi.org/10.31577/sp.2020.02.798

Emotional Creativity Across Adulthood: Age is Negatively Associated with Emotional Creativity

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Previous research has shown that cognitive creativity decreases in older adulthood. However, the impact of age on emotional creativity remains unknown. The main aim of the present study was to explore how emotional creativity differs across adulthood. A total of 407 participants (251 women, 156 men) consisting of older, midlife and younger adults were administrated the Emotional Creativity Inventory (ECI). A hierarchical multiple regression was used to determine whether emotional creativity differed with age. Age was negatively associated with the ECI total score and two components of the ECI, emotional novelty and emotional preparedness. In contrast, emotional effectiveness/authenticity did not differ significantly across adulthood. The results indicate that the tendency to think about one's emotions and to evaluate them as novel and unique decreases with age, whereas the ability to respond effectively in situations requiring novel emotional responses remains relatively intact across adulthood.

Key words: emotional creativity, creative cognition, divergent thinking, aging, emotion regulation

Introduction

Emotional creativity (EC) is very important for healthy emotion regulation and thus also contributes to well-being (Morgan & Scheibe, 2013; Schutte, Manes, & Malouff, 2009), higher life satisfaction (Limonero, Tomas-Sabado, Fernandez-Castro, Gómez-Romero, & Ardilla-Herrero, 2012), better relationship satisfaction (Bloch, Haase, & Levenson, 2014; Vater & Schröder, 2015), effective coping with stress (Averill, 1999; Frolova & Novoselova, 2015) and healthy aging (Hopp, Troy, & Mauss, 2011). In contrast, ineffective emotional processing has been found to be linked with depression (Joormann & Quinn, 2014), decreased job satisfaction (Blatný, Květon, Jelínek, Šolcová, Zábrodská, Mudrák, & Machovcová, 2018) and a variety of psychiatric disorders, such as anxiety, post-traumatic stress disorder or obsessive-compulsive disorder (Banich, Mackiewicz, Depue, Whitmer, Miller, & Heller, 2009).

The present study aims to explore the relationship between EC and age. The peak and decline model (Lindauer, 1998) suggests that creative cognitive abilities peak in early adulthood, and their decline starts when people are

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Received September 3, 2019

in their 30s or 40s. However, very little is known about age-related changes in EC. EC is a pattern of cognitive abilities related to originality and appropriateness in emotional experience (Averill, 1999; Ivcevic, Brackett, & Mayer, 2007). It involves one's ability to experience novel emotional experiences, think creatively about past emotional reactions and experiences or respond appropriately in situations requiring new or unusual emotional responses.

When comparing EC to standard definitions of creativity (Runco & Jaeger, 2012), the first difference is that EC is related to the novelty of the subject's emotions, whereas the standard understanding of creativity is related to the novelty of the subject's ideas or products. However, regarding the basic principles, EC shares the criteria of originality as well as effectiveness with standard definitions of creativity. The criterion of originality in emotional experience is included directly in the basic definition of EC, because EC, like creativity, is suggested to benefit from flexible cognitive structures relating to the development of new ideas and products. EC has also been found to be related to the increased involvement of participants in creative leisure-time activities, e.g. creative writing, painting, composing music, dance improvisation, theatrical improvisation and do-it-yourself activities (Trnka, Zahradnik, & Kuška, 2016).

Regarding the criterion of effectiveness, novel emotional reactions should also be effective and appropriate, because emotionally creative reactions should meet the demand of responding appropriately in interpersonal situations (Averill, 1999). Through this demand, EC also meets the criteria of practicality, relevance and adaptiveness to reality, which are closely related to standard definitions of creativity (Runco & Jaeger, 2012). In contrast, it seems that cognitive abilities related to EC do not necessarily require a problem-finding ability, because emotional processes are highly spontaneous and emergent in nature.

EC is related to both exploratory and generative cognitive processes (Finke, Ward, & Smith, 1992). The experience of an unusual combination of discrete emotions, a variety of different emotions at the same time or responding to emotional situations in a unique manner requires cognitive flexibility in generative processes. This includes the generation of unique and unusual emotional experiences and reactions. In contrast, thinking about past emotional reactions and experiences requires processes such as memory retrieval, but also attribute finding and conceptual interpretation of past emotional events.

EC is a complex phenomenon and links both cognitive and emotional processes. As mentioned above, there is a lack of evidence concerning age-related changes and EC (but see Trnka, Cabelkova, Kuška, & Nikolai, 2019). To formulate working hypotheses for the present study, two fields of related research were stimulating: research on age-related changes in the cognitive processing of emotions and research on age-related changes in creativity.

Age-Related Changes in the Cognitive Processing of Emotions

Research on age-related changes in the cognitive processing of emotions shows inconsistent results. One branch of this research has focused on age-related changes in emotional complexity, a construct that involves simultaneous experiencing of different emotions, fine-grained differentiating of one's emotions, distinguishing between one's own emotions and those of others, and expressing a varied and nuanced set of feelings (Grühn, Lumley, Diehl, & Labouvie-Vief, 2013). Older adults showed less overall fluctuation in affect over time (Grühn et al., 2013) and less variability in negative affect over time (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000; Grühn et al., 2013), compared to younger adults. In contrast, Charles (2005) brought evidence about greater emotion heterogeneity in older age.

Hay and Diehl (2011) investigated age-related differences in two facets of emotional complexity: the co-occurrence of positive and negative affect and emotional differentiation

(the ability to describe one's own emotions in a detailed fashion). Age was found to be negatively associated with emotional differentiation, as older adults showed lower emotional differentiation than younger adults. In contrast, the co-occurrence of positive and negative affect was not related to age.

Furthermore, Wurm (2011) brought empirical evidence supporting a hypothesis of the narrowing of affective space with increasing age. The narrowing of affective space refers to a reduction of the dimensionality of complex emotional situations and to a worsening of the ability to maintain complex representations with increasing age. The results of this study showed that participants of older age had less complex lexical representations than younger participants. These results indicate a kind of age-related worsening of lexical access to mental representations.

Research focused on exploration of the intensity of emotional experience has brought inconsistent results. On one hand, age has been found not to diminish the subjective intensity of both positive and negative affect in everyday life (Carstensen et al., 2000). On the other hand, older adults showed a more intense emotional experience when viewing acts of injustice compared to younger adults (Phillips, Henry, Hosie, & Milne, 2008).

Interestingly, older adults showed improvements in the cognitive control of emotions, specifically in habitual use of problem-solving as an emotion-regulation strategy (Le Vigouroux, Pavani, Dauvier, Kop, & Congard, 2017), in using positive reappraisal (Lohani & Isaacowitz, 2014; Shiota & Levenson, 2009), in habitual reappraisal use (John & Gross, 2004; Le Vigouroux et al., 2017; Masumoto, Taishi, & Shiozaki, 2016), in down-regulating feelings of disgust (Scheibe & Blanchard-Fields, 2009) or in habitual suppression use (Brummer, Stopa, & Bucks, 2014; Eldesouky & English, 2018; Nolen-Hoeksema & Aldao, 2011). These improvements are often ascribed to the benefits arising from the accumulation of experience with processing various emotions during the life course (Blanchard-Fields, 2007, 2009).

Age-Related Changes in Creativity

As mentioned above, EC is related to both generative and exploratory cognitive processes. Past research has revealed age-related decline in both generative and exploratory phases of the creative process (Roskos-Ewoldsen, Black, & McCown, 2008). In contrast, linking EC with the construct of divergent thinking, otherwise frequently used as an indicator of creative potential, is not so easy.

Divergent thinking is generally defined as an open-ended mental process oriented toward finding new, appropriate and different solutions to a given problem (Guilford, 1967). This group of cognitive processes is activated during the handling of objects or during various creative performances. However, empirical studies seeking links between EC and divergent thinking have shown inconsistent results (Ivcevic, Brackett, & Mayer, 2007; Martsksvishvili, Abuladze, Sordia, & Neubauer, 2017; Zenasni & Lubart, 2008). To explore possible conceptual similarities between EC and divergent thinking, a more detailed look at the structure of EC is needed.

EC consists of three different components: novelty, preparedness and effectiveness/authenticity (Averill, 1999). For example, emotional preparedness, including thinking about one's emotional reactions or seeking reasons for one's own feelings, cannot be expected to require the imagining of an alternative use for common objects, which is an important component of divergent thinking. Similarly, emotional novelty, denoting how a person perceives his or her emotions as being original, unique or uncommon, is much more linked to a self-oriented processing of emotions than to cognitive processes that facilitate finding new solutions to a problem. The third component of EC, emotional effectiveness/authenticity, includes effective responding in situations requiring new or unusual emotional responses and the tendency to believe that emotions may help a person achieve his or her life goals. This component could be considered to be interrelated with divergent thinking, in part be-

cause appropriate responding in situations requiring novel emotional responses may also be expected to include the requirement of seeking novel experiential solutions to a given emotional situation.

For divergent thinking, a curvilinear age pattern with a peak before the age of 40 and a later decline with age have been found (Palmiero, 2015; Reese, Lee, Cohen, & Puckett, 2001). However, some studies also did not find any age-related difference in divergent thinking (Palmiero, Di Giacomo, & Passafiume, 2014; Roskos-Ewoldsen, Black, & McCown, 2008) or found that the ability of older adults to think divergently is comparable to younger adults, but occurs at a slower rate (Foos & Boone, 2008).

The Present Study

The main purpose of the present study was to explore EC in participants of different ages. Very little research has been conducted on the relationship between EC and age in recent times. Therefore, the insights from related research were used for the development of working hypotheses.

Emotional complexity shares some features with EC, for example, the simultaneous experience of different emotions or the expression of a varied set of feelings. Therefore, it may be used as a referential model when searching for a hypothetical age-related pattern. In emotional complexity, curvilinear age patterns with a peak in late middle adulthood and a decline in older age were found (Labouvie-Vief, Chiodo, Goguen, Diehl, & Orwoll, 1995; Labouvie-Vief, Diehl, Jain, & Zhang, 2007). Based on these findings, it can be hypothesized for the purposes of the present study:

Hypothesis 1. EC has a curvilinear age pattern with a peak in late middle adulthood and a decline in older age.

One of the three components of EC, emotional preparedness, is closely linked to thinking about one's emotional reactions and seeking reasons for one's own feelings. This construct seems to be related to emotional understanding, in other words, to how a person subjectively understands his/her own emotions. Subjective emotional understanding, similarly to emotional complexity, has been found to show curvilinear age patterns with a peak in late middle adulthood and a decline in older age (Labouvie-Vief, DeVoe, & Bulka, 1989). Therefore, it can be hypothesized for the purpose of the present study:

Hypothesis 2. Emotional preparedness has a curvilinear age pattern with a peak in late middle adulthood and a decline in older age.

Furthermore, emotional novelty is linked with experiencing a great variety of emotions at the same time, experiencing uncommon combinations of emotions, undergoing unusual emotional reactions and responding to emotional situations in a unique manner (Averill, 1999). This construct shares some aspects with the person's overall variability in emotional experience and fluctuation in affect over time. In past research, older adults showed less overall fluctuation in affect over time (Grühn et al., 2013) and less variability in negative affect over time (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000; Grühn et al., 2013), in comparison to younger adults. Based on these findings, it can be hypothesized that:

Hypothesis 3. Age is negatively related to emotional novelty.

The third component of EC, emotional effectiveness/authenticity, includes effective responding in situations requiring new or unusual emotional responses and the tendency to believe that emotions may help a person achieve his or her life goals. This component can be considered to share some aspects with divergent thinking, in part because responding in situations requiring unusual emotional responses may also be expected to include the requirement of seeking novel experiential solutions to a given emotional situation. Divergent thinking showed a curvilinear age pattern with a peak before the age of 40 and a later decline with age (Palmiero, 2015; Reese, Lee, Cohen, & Puckett, 2001). Therefore, it can be hypothesized that:

Hypothesis 4. Emotional effectiveness/authenticity has a curvilinear age pattern with a peak before the age of 40 and a decline in older age.

Methods

Participants

A total of 407 participants (251 women, 156 men) participated in the present study. All were citizens of the Czech Republic. They ranged from 15 to 64 years of age (M_{age} = 39 years; *SD* = 16). The quota sampling method was used, thus assuring approximately equal proportions of genders and age groups. Given the fact that cognitive decline has been found to influence EC (Trnka et al., 2019) as well as emotional diversity in older adulthood (Ram, Gerstorf, Lindenberger, & Smith, 2011), only adults younger than 65 were included in the present study to eliminate the bias that could occur due to different levels of cognitive decline in very old adults. Participants were asked about their current medication and chronic diseases by means of an anamnesis questionnaire during the contact phase. Those suffering from mental illnesses or psychiatric disorder that could potentially influence their emotionality (depression) were excluded from the sample. In addition, participants medicated by drugs that influence their emotionality (psychopharmaceutic drugs or antiepileptic drugs) were excluded from the sample.

The research design was approved by the institutional ethics committee. All participants provided signed informed consent with participation in the study. Signed parental informed consent was obtained in cases of participants younger than 18 years. Participants were assured about protecting the confidentiality of the research data.

Measures

At the beginning, each participant filled in the basic demographic characteristics. Afterwards, participants were administrated with a self-report questionnaire measuring EC.

EC was measured using the Emotional Creativity Inventory (ECI) (Averill, 1999), a self-report questionnaire. The ECI consists of 30 items rated on a 5-point scale, with anchors of 1 (*strongly agree*) and 5 (*strongly disagree*). The total score ranges from a low of 30 to a high of 150. Two of the 30 items are reversely coded. The ECI has three subscales that reflect different facets of EC: Preparedness (items like *"I think about and try to understand my emotional reactions"*), Novelty (items like *"My emotional reactions are different and unique"*) and Effectiveness/Authenticity (items like *"I respond well in situations that call for new or unusual emotional responses"* or *"My outward emotional reactions accurately reflect my inner feelings"*). The ECI is a widely accepted and used measure. The studies of Humphreys, Jiao, and Sadler (2008); Ivcevic, Brackett , and Mayer (2007); and Gutbezahl and Averill (1996) have provided evidence of the good construct and discriminant and incremental validity of the ECI. Thus, the validity of this self-report questionnaire is considered acceptable for the purpose of the present study.

Data Analysis

To determine whether EC and its three components differed with age, a series of hierarchical multiple regression analyses that regressed emotional creativity and its component estimates onto age, controlling for differences in gender and education, was conducted. In order to estimate the effects of age after education and gender were entered, the first two steps of the hierarchical regression included gender and education (the first step, Formula 1) and gender, education and age (the second step, Formula 2). This enabled us to estimate the age contribution to variance explained in addition to that explained by gender and education. Then the possible U-shaped relationship of EC and its three components and age was tested by adding the squared term and moderating effects of demographic variables of education and gender by adding the interaction terms to the hierarchical regression framework (the third stage is depicted in Formula 3). Given that neither the age squared nor the interaction terms added significant explanatory power to the model and that the extended model showed significant multicollin-

earity, the results of the third part of hierarchical regression are not reported here and only the results of the first two steps of hierarchical regression are presented.

$$ECI_i = b_0 + b_1 Gender + b_2 Edu + \xi \quad (1)$$

$$ECI_i = b_0 + b_1 Gender + b_2 Edu + b_3 Age + \xi \quad (2)$$

$$ECI_i = b_0 + b_1 Gender + b_2 Edu + b_3 Age + b_4 Age^2 + b_5 AgeGender + b_6 AgeEdu + \xi \quad (3)$$

Where:

- ECI_i denotes the ECI components *Effectiveness/Authenticity* (ECI_{ea}), *Preparedness* (ECI_p), *Novelty* (ECI_n) and subsequently the Emotional Creativity Inventory in total (ECI).
- *Gender* and *Age* stand for the gender and age of the participants
- *Edu* stands for education (primary, secondary, and higher). The variable was included as an ordinal variable as opposed to a series of dummy variables in order to maintain the character of ordinal data, though at the expense of possibly unequal differences between the categories (primary and secondary education, secondary and higher).

The 25th version of the SPSS was employed to analyze the data. In order to increase the reliability of the results, a two-tailed 5% level of significance was chosen. Based on the central limit theorem, a normal distribution of the data was assumed.

Results

Our primary interest was to determine whether EC differed with age. To do so, the reliability of the questionnaire was estimated and Cronbach's alphas were computed for ECI and its three subscales: Novelty, Preparedness and Effectiveness/Authenticity. The Cronbach's alpha for ECI was .877, and for the subscales of Novelty and Preparedness it was .821 and .801, respectively, which represents very good consistency. The Cronbach's alpha for the Effectiveness/Authenticity subscale was .711, which represents good consistency (see Table 1).

The correlation and descriptive statistics for all continuous and categorical variables are listed in Table 1. Age proved to be significantly correlated with ECI and two of its components. The components of ECI itself were also sig-

Table 1 *Descriptive statistics, reliability and correlations for all continuous variables*

	Age	ECI	ECI_n	ECI_p	ECI_{ea}	Education
ECI	-.217***	1				
ECI_n	-.238***	.874***	1			
ECI_p	-.216***	.796***	.537***	1		
ECI_{ea}	.024	.714***	.386***	.476***	1	
Education	-.103*	-.010	-.044	.061	-.022	1
Mean	39.46	97.01	41.83	25.39	29.74	2.50
Std. deviation	15.53	16.39	9.29	5.45	5.51	.55
Range	14–64	43–146	18–70	7–35	13–45	1-3
N	407	398	403	406	401	407
Cronbach's alpha (*N* of Items)		.877 (30)	.821 (14)	.801 (7)	.711 (9)	

Note. Statistical significance for correlations: * p < .05; ** p < .01; *** p < .001 (2-tailed). ECI – ECI total score; ECI_n – Novelty component; ECI_p – Preparedness component; ECI_{ea} – Effectiveness/Authenticity component. Education categories: 1 – elementary; 2 – secondary; 3 – higher.

nificantly correlated. The relationship of ECI and components with the categorical variable (gender differences) is presented in Table 2. According to the *T*-test results presented in Table 2, women reported higher average emotional creativity scores in ECI and its components Preparedness and Effectiveness/Authenticity.

The standardized *β* coefficient estimates, standard errors, *p*-values and Variance Inflation Factors (VIF) for the statistically significant steps of hierarchical regressions are listed in Tables 3, 4, 5, and 6. The plots of associations between ECI and its three components – Novelty (ECI_n), Preparedness (ECI_p) and Effectiveness/Authenticity (ECI_{ea}) – on the y-axes and Age of the respondents on the x-axes are presented in Figure 1. Tables 3-6 show that none of the VIF exceeds 5; thus, the multicollinearity was not high. The statistical significance of all four presented models was acceptable at 5% significance levels. The *β* coefficients for age were negative and statistically significant in three out of four cases, showing that the ECI total score ($\beta = -0.219$, $p < .001$) and its components Novelty ($\beta = -0.244$, $p < .001$) and Preparedness ($\beta = -0.211$, $p < .001$) were negatively associated with the age of the participants. In other words, the older the participants were, the lower EC and specifically lower emo-

Table 2 *Gender differences in ECI total score (ECI), Novelty component (ECI_n), Preparedness component (ECI_p) and Effectiveness/Authenticity component (ECI_{ea})*

	N women	*N* men	Mean women	Mean men	Mean Difference (women-men)	*t*-value	*P*-value
ECI	243	155	98.69	94.37	4.32*	2.58	.010
ECI_n	247	156	42.46	40.84	1.62	1.71	.088
ECI_p	251	155	25.97	24.46	1.50**	2.72	.007
ECI_{ea}	245	156	30.25	28.94	1.31*	2.34	.020

Note. Levene's test of homogeneity of variances did not reject the null hypothesis of variance equality for all the variables. Statistical significance for mean differences: * p < .05; ** p < .01; *** p < .001 (2-tailed). The Ns vary across the subscales due to missing or unreadable responses in several cases.

Table 3 *Association of ECI total score with age, controlling for gender and education*

Dependent variable	ECI	Step1		ECI	Step2	
	β	Sig.	VIF	*β*	Sig.	VIF
Gender	-.129*	.010	1.00	-.124*	.011	1.00
Education	-.013	.800	1.00	-.036	.459	1.01
Age				-.219***	.000	1.01
R^2	.017			.064		
ΔR^2	.017			.047		
ΔF	3.354*	.036		19.858***	.000	
N	397			397		

Note. Statistical significance: * p < .05; ** p < .01; *** p < .001 (2-tailed). Reference variables: women, higher education. The coefficients *β* are standardized. We also tested the U-shaped model of the ECI-age relationships. Age squared did not prove to be statistically significant in any of the regression, so we report the linear model only.

tional novelty (the tendency to perceive their own emotions as being original, unique, uncommon and improbable), as well as lower emotional preparedness (the tendency to think about one's own emotional reactions and experiences), they reported. Thus, Hypothesis 3, predicting a negative relationship of emotional novelty to age, was confirmed. However, the age patterns found for ECI total score and two components, Preparedness and Effectiveness/Authenticity, did not confirm the hypothesized curvilinear age pattern.

To test Hypotheses 1, 2, and 4, the possible U-shape relationships of EC with age by adding the quadratic term to the regression were specifically tested. However, the quadratic U-shape relationship was not statistically significant for ECI total score, nor for its three com-

Table 4 *Association of the Novelty component of the ECI (ECI_n) with age, controlling for gender and education*

Dependent variable	ECI_n	Step1		ECI_n	Step2	
	β	Sig.	VIF	*β*	Sig.	VIF
Gender	-.086	.086	1.00	-.081	.096	1.00
Education	-.045	.369	1.00	-.071	.148	1.01
Age				-.244***	.000	1.01
R^2	.009			.068		
ΔR^2	.009			.059		
ΔF	1.862	.157		25.112***	.000	
N	402			402		

Note. Statistical significance: * p < .05; ** p < .01; *** p < .001 (2-tailed). Reference variables: women, higher education. The coefficients *β* are standardized. We also tested the U-shaped model of the ECI-age relationships. Age squared did not prove to be statistically significant in any of the regression, so we report the linear model only.

Table 5 *Association of the Preparedness component of the ECI (ECI_p) with age, controlling for gender and education*

Dependent variable	ECI_p	Step1		ECI_p	Step2	
	β	Sig.	VIF	*β*	Sig.	VIF
Gender	-.133**	.007	1.00	-.132**	.007	1.00
Education	.059	.233	1.00	.037	.450	1.01
Age				-.211***	.000	1.01
R^2	.021			.065		
ΔR^2	.021			.044		
ΔF	4.425*	.013		18.897***	.000	
N	405			405		

Note. Statistical significance: * p < .05; ** p < .01; *** p < .001 (2-tailed). Reference variables: women, higher education. The coefficients *β* are standardized. We also tested the U-shaped model of the ECI-age relationships. Age squared did not prove to be statistically significant in any of the regression, so we report the linear model only.

Table 6 *Association of the Effectiveness/Authenticity component of the ECI (ECI_{ea}) with age, controlling for gender and education*

Dependent variable	ECI_{ea}	Step1		ECI_{ea}	Step2	
	β	Sig.	VIF	*β*	Sig.	VIF
Gender	-.117*	.020	1.00	-.116*	.020	1.00
Education	-.024	.630	1.00	-.026	.597	1.01
Age				-.024	.628	1.01
R^2	.014			.015		
ΔR^2	.014			.001		
ΔF	2.844	.059		.235	.628	
N	400			400		

Note. Statistical significance: * p < .05; ** p < .01; *** p < .001 (2-tailed). Reference variables: women, higher education. The coefficients *β* are standardized. We also tested the U-shaped model of the ECI-age relationships. Age squared did not prove to be statistically significant in any of the regression, so we report the linear model only.

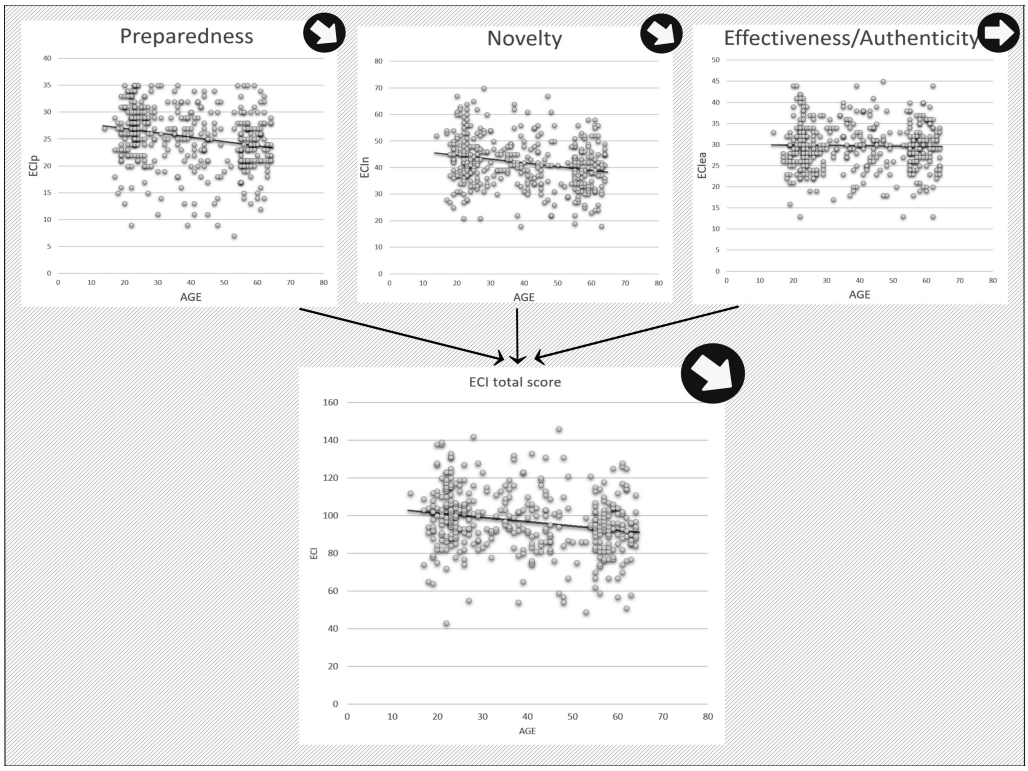

Figure 1 Plots of associations between ECI and its three components: Novelty, Preparedness and Effectiveness/Authenticity

ponents, Novelty, Preparedness, and Effectiveness/Authenticity. Thus, Hypotheses 1, 2, and 4 were not confirmed, and neither EC nor any of its three components showed a curvilinear age pattern. Given that the U-shape was not statistically significant, and for the sake of conciseness of the paper, the results of U-shape relationships are not presented here.

Out of all the independent variables listed in Tables 3-6, age proved to explain the highest share of variability in the dependent variables. In the case of ECI, age explained 4.7% of the variability, which is a statistically significant change from the 1.7% that was explained by gender and education altogether (Table 3). Similarly, in the case of Novelty, age was responsible for 5.9% of the variability, which is a significant shift from the 0.9% explained by education and gender only (Table 4). For Preparedness, age was responsible for 4.4% of the variability, which is a statistically significant increase from the 2.1% explained by gender and education only (Table 5). In the case of Effectiveness/Authenticity, age did not bring a statistically significant increase in R^2 and was not statistically related ($\Delta R^2 = .001$, $\Delta F = .235$, $p = .628$, Table 6).

Of the control variables, men proved to be less emotionally creative in ECI ($\beta = -0.124$, $p = .011$) and its Effectiveness/Authenticity ($\beta = -0.116$, $p = .020$) and Preparedness component ($\beta = -0.132$, $p = .007$) than women. Education did not prove to be significantly related to EC.

Discussion

The results of the present study showed that age was negatively associated with the ECI total score and two components of ECI, emotional novelty and emotional preparedness. Despite the present study not being a longitudinal one, the cross-sectional results indicate a linear decrease of EC with age, including a linear decrease of emotional novelty and emotional preparedness (Figure 1).

Interestingly, past cognitive developmental research has revealed curvilinear age patterns in emotional complexity, showing a clear peak in late middle adulthood and a decline in older age (Labouvie-Vief, Chiodo, Goguen, Diehl, & Orwoll, 1995; Labouvie-Vief, Diehl, Jain, & Zhang, 2007). Similarly, subjective emotional understanding also shows curvilinear age patterns, with a peak in late middle adulthood and a decline in older age (Labouvie-Vief, DeVoe, & Bulka, 1989). In contrast to these findings, the results of the present study indicate a linear decrease of EC with age, despite the fact that a possible U-shaped relationship of EC with age was tested for (see the Results section). Contrasting the results of the present study with previous research indicates that EC shows a different, linear age pattern compared to the nonlinear age patterns found in emotional complexity and subjective emotional understanding.

The results of the present study showed that the older the participants were, the weaker was their tendency to evaluate their emotions as novel and unique. Furthermore, the results also indicated a linear decrease of emotional preparedness with age (Figure 1), which suggests a weakening of the tendency to think about one's emotional reactions and emotional experiences and to search for reasons for one's own feelings. These results are in accordance with the assumption suggesting more flexible and emotionally mature functioning in older adulthood due to the accumulation of experience with various emotions during the life course (Blanchard-Fields, 2007, 2009). Participants of older age are suggested to have previous rich experience with various emotional episodes that have occurred during their life courses, and this experience may lead to a tendency to perceive further emotional experiences as less unique, novel or uncommon. At the same time, the accumulation of experience may also cause a repeated experience of similar emotional events. This may be an explanation for the age-related decrease in thinking about one's emotional reactions and experiences and searching for the reasons for one's own feelings. Simply put, repeated experience of similar emotional events may lead to future utilization of patterns and scripts from previously experienced emotional

episodes stored in memory. The decreased thinking about one's emotional reactions and emotional experiences may even be considered to be adaptive, because it can save cognitive resources in older adulthood.

Contrasting the results of the present study with the research of age-related differences in divergent thinking (Palmiero, 2015; Palmiero, Di Giacomo, & Passafiume, 2014) provides further interesting insights into the age-related pattern of cognitive aging. Previous research revealed that verbal divergent thinking seems to be preserved after the age of 40 years without any further decline in older age (Palmiero, 2015). These results are interpreted by the assumption that verbal proficiencies (expressive word knowledge, concept formation, comprehension of text and verbal working memory) remain relatively intact across the lifespan. In contrast, the results of the present study indicated that EC decreases as age increases. We suggest that the decrease of EC in older age is rather unrelated to the quality of verbal proficiencies. Instead, the decreased levels of EC in terms of emotional preparedness are suggested to be closely connected with the decreased cognitive effort to invest attention, time and energy into thinking about past emotional reactions and emotional experiences. Merely the decreased effort to invest the energy into the processing of past emotional events is hypothesized as being responsible for a decline of emotional preparedness with age.

Interestingly, this interpretation is in accordance with previous research on self-perspective that showed an age-related decrease in memory specificity (Piolino et al., 2006). The nature of memories of older adults has been found to be more generic and less specific than the memories of younger adults. The age-related decline in recalling sensory–perceptive, affective and spatiotemporal details may also be responsible for the age-related decrease in emotional preparedness found in the present study. Participants of older age may invest less attention, time and energy into thinking about past emotional reactions and emotional experiences, because their affective memories lack detail and specificity. Thus, the decreased memory specificity may be responsible for lower engagement in thinking about one's own emotional reactions and experiences in older adulthood.

The results of the present study indicate that one of the three components of EC, emotional effectiveness/authenticity, does not change significantly across adulthood (Figure 1). Emotional effectiveness/authenticity did not show any increase, decrease or curvilinear age pattern. This component includes effective responding in situations requiring new or unusual emotional responses and the tendency to believe that emotions may help a person achieve his or her life goals. Contrasting stable emotional effectiveness/authenticity across adulthood with the age-related decrease in EC, emotional novelty as well as the emotional preparedness found in the present study may be inspiring for the formulation of a hypothesis for future research. It seems that the tendency to think about one's emotions and to evaluate one's emotions as novel and unique decreases with age. However, the ability to respond effectively in situations requiring new or unusual emotional responses seems to remain relatively intact across adulthood.

Limitations

The present study was not designed as a longitudinal study. Despite the presented results, the present study cannot show how EC varies during the life of individuals. Future research utilizing a longitudinal design is needed in this field. The obtained results could also be affected by possible cohort effects. For example, it is not clear if older participants experienced different cultural conditions compared to younger participants. Furthermore, our findings are based on the utilization of a self-report questionnaire; thus, the data arises from the participants' own perceptions of their emotionally creative abilities. At present, the Emotional Creativity Inventory (Averill, 1999) is the only available method for measuring emotional creativity. The development of a new, objective measure of emotional creativity is a big chal-

lenge for future methodological development in this field.

Conclusion

Previous research has shown that older adults have decreased cognitive creativity (Palmiero, Nori, & Piccardi, 2017) as well as other decreased cognitive abilities, like working memory, processing speed, reasoning and higher-level executive functions (Salthouse et al., 2003; Salthouse, 2010). The present study contributes to this field and shows that age was negatively associated with the ECI total score and two components of the ECI, emotional novelty and emotional preparedness. In contrast, age was not associated with the third component of EC, emotional effectiveness/ authenticity. Taken together, the results of the present study indicate that the tendency to think about one's emotions and to evaluate one's emotions as novel and unique decrease with age, whereas the ability to respond effectively in situations requiring new or unusual emotional responses does not change significantly across adulthood.

Acknowledgement

The collection, analysis, and interpretation of data as well as writing this manuscript were supported by the Czech Science Foundation (GA CR), project no. 18-26094S "Emotional creativity and cognitive decline in the elderly".

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