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Different faces of (un)controllability: Control restoration modulates the efficiency of task switching

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Abstract

Uncontrollability has been often associated with impaired or rigid cognitive processing. However, perceived stability of uncontrollable events modulated some of these detrimental effects on cognition. We investigated whether the experience of sequential control loss and restoration can enhance cognitive flexibility. We manipulated uncontrollability using a concept formation procedure that entailed either only unsolvable tasks (control deprivation condition), unsolvable tasks followed by solvable ones (control restoration condition) or only solvable tasks (control condition). To assess cognitive flexibility, we used a task-switching procedure that incorporated social categories. In Experiment 1 participants categorized people based on gender or age, and in Experiment 2 and 3 based on gender or social roles. Participants showed more flexibility in control restoration than in control deprivation condition. Additionally, in Experiments 2 and 3 this effect was mainly pronounced in the condition where the task evoked more cognitive conflict. We discuss the motivational underpinnings of unstable experiences of control loss and restoration.

Keywords Control deprivation · Cognitive flexibility · Task switching · Social categories

Decades of research on control deprivation leave us with an image of the control-deprived person as a passive victim of threatening circumstances. Jack Brehm (1993), when questioning the generalizability of learned helplessness effects, used the example of how animals adapt to their natural habitat, when basic resources such as food are threatened. According to Brehm, this observation reveals that when necessary, animals and humans can act flexibly to restore control. We can draw parallels with this observation to our everyday experiences, where a complete lack of control, so a situation in which the outcomes of our actions do not depend at all upon our intentions, seems like an exception rather than the rule. People are able to maintain their perception of control even in situations that objectively and largely restrain their control over the environment (Langer 1975). Even amongst the healthy majority of individuals, their sense of control is often lost and regained many times a day, and across multiple domains of life. Such fluctuations of control loss and restoration might not only influence our thinking about possible sources of uncontrollability but also the way we perceive and categorize the world and other people. Taking this dynamic view of control deprivation, in the present research we ask how the sequence and duration of one's control depriving and enhancing experiences influences cognitive flexibility particularly applied in a socially relevant domain.

Cognitive flexibility, understood as the ability to shift between mental sets, plays a key role in people's lives (Meiran 2010). Flexibility is not only essential for effective self-regulation, goal pursuit and individual well-being, but it is also considered fundamental for socially grounded processes, such as re-categorization, which can favor stereotype change (Dovidio et al. 2006; Gocłowska and Crisp 2013; Kashdan and Rottenberg 2010; Marien et al. 2012). People's flexibility can diminish when such motives as

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personal control or certainty are threatened thereby lowering people's cognitive capacity and activating a defensive and rigid information processing style (Jonas et al. 2014; von Hecker and Sedek 1999). For example, threats to control motivation were shown to increase rigidity, operationalized as increased reliance on ethnocentric beliefs and ingroup biases (Fritsche et al. 2013).

While there is empirical evidence showing that threats to control can decrease flexible thought, to the best of our knowledge, no research has examined the effects of control restoration on flexibility. This issue is important since real-life occurrences of control deprivation are often followed by instances of control restoration. Thus, studying such unstable situations (vs. stable situations of control deprivation) captures people's everyday experiences and might help to explain why despite repeated failures, people do not generally give up when task conditions become increasingly difficult. Also, aiming to understand if and how control restoration can reestablish flexible thinking, paves way for interventions aimed at control-deprived individuals (e.g. unemployed people). Finally, we claim that studying the potentially beneficial effects of control restoration on switching between social categories is important and ecologically valid in the context of a diverse social environment. To address these important issues, we explored whether restoring control could prevent the detrimental effects of control deprivation on cognitive flexibility.

(Un)controllability and cognitive performance

In his pioneering work, Martin Seligman (1975) described the destructive impact of control deprivation on cognitive performance. In situations of control deprivation, he observed, when behavioral outcomes are no longer contingent upon actions taken, organisms suffer from cognitive deficits (ability to discover new response-outcome contingencies), motivational deficits (decreased tendency to initiate new behaviors) and affective deficits (arousal and negative emotions). Consequently, stable and prolonged situations of control deprivation lead to the development of learned helplessness (Seligman 1975). Later work by Sedek and Kofta (1990; also see Kofta and Sedek 1999) demonstrated that prolonged uncontrollability experiences increased feelings of uncertainty that cannot be reduced, and create a state of cognitive exhaustion, accompanied by impaired learning to avoid aversive stimuli. In follow up studies, experiences of control deprivation diminished people's ability to integrate new information into meaningful mental models (Kofta 1993; von Hecker and Sędek 1999), and impaired attentional control and selectivity (Bukowski et al. 2015; Kofta and Sedek 1998). Bukowski et al. (2015) found that under conditions of prolonged and stable control deprivation, people attended to goal-irrelevant information, which reduced their capacity to apply goal-driven attentional control on a subsequent task. Importantly, their studies also revealed that temporary control restoration experiences could prevent such detrimental effects of control deprivation on attentional control.

Still, some research has shown that control deprivation to a small extent can lead to more effort expenditure, cognitive mobilization, and more systematic information processing (Mikulincer 1994; Pittman and D'Agostino 1989; Wortman and Brehm 1975). In these studies, the effects of control deprivation were moderated by externally provided probability of success, or the subjective expectancy of control in participants (Mikulincer 1988; Pittman and Pittman 1979; Roth and Kubal 1975). In addition, the precondition of those beneficial effects was that the control deprivation experience was very short (i.e. one unsolvable task) which led to greater accuracies on Raven task matrices and more efficient cue utilization on other problem-solving tasks, including anagrams, and digit-letter substitution (Mikulincer et al. 1989). However, in other studies short periods of uncontrollability did not change the level of performance in comparison to controllable conditions, whereas prolonged uncontrollability exposure reduced performance accuracy, but not effort expenditure, thus representing the motivational component of behavior (Ric and Scharnitzky 2003).

Based on previous research we know that prolonged and stable control deprivation experiences impair cognitive performance. But to the best of our knowledge, a lot less research has been conducted on the stability of uncontrollability experiences. Some predictions as to how control stability could affect cognitive performance can be retrieved from earlier research on stable vs. unstable attributions of control. Mikulincer (1988, 1990) argued that appraisals of control stability play a key role in predicting how control deprivation affects performance. In his studies, stability was either explicitly manipulated, by encouraging participants to attribute the outcome of their activity to stable or unstable causes, or people's dispositional attribution style (stable or unstable attributions of failure) was measured. Mikulincer (1988) found that following a helplessness training procedure (used as a control deprivation manipulation) participants who made stable (vs. unstable) attributions of their failures (independently of whether these attributions were based on their individual attributional style or induced by the experimenter) were worse at problem solving. These findings revealed the importance of stability appraisals for cognitive performance and suggest that performance decrements due to control deprivation may depend on the perception of possible change in the chain of uncontrollable events directed towards control restoration.

Hence, it can be asserted that *attributions* of stability influence problem solving abilities. However, can an experience of *unstable uncontrollability* by itself produce beneficial effects for cognitive processing? To answer this question, it is important to investigate how control restoration experiences that follow control deprivation, impact performance relative to stable control deprivation experiences. Therefore, in our research we will focus on the consequences of control deprivation and control restoration on cognitive flexibility, which enables people to adapt to new situations and to change existing habits of thought.

Control restoration and cognitive flexibility

Why would the control restoration experience influence cognitive flexibility? We will now refer to two potential basic motivational and cognitive mechanisms that could account for this type of effect. One possible explanation refers to the impact of an unstable and uncertain environment on people's cognitive processing. Recent findings in basic research on attention and perception show that unexpected changes in ongoing events that induce some degree of difficulty and uncertainty can also trigger additional processing and boost performance (Rosner et al. 2015; Swallow and Jiang 2010). Random and unpredictable task settings also enhanced involvement of cognitive control in a task-switching paradigm (Tornay and Milan 2001). Another strand of research (longitudinal) revealed that people who grew up in unpredictable social environments performed better in tasks involving shifting abilities (i.e. switching) but worse at tasks involving cognitive inhibition (Mittal et al. 2015). Therefore, it seems that rapidly changing environmental conditions that induce some degree of subjective uncertainty can boost a form of cognitive adaptation related to greater alertness, attentional orienting to changes and more flexible switching between tasks or mental sets.

Still, the motivational underpinnings of these effects remain unclear. Control loss and restoration sequences do not merely depict a general change in the environment but they signal goal progress (i.e. restoration of a threatened motive) and provide positive feedback on one's course of action. On the contrary, stable loss of control ought to signal that all efforts to restore control would be futile and could lead to disengagement of cognitive effort (Brehm and Self 1989). A broad range of research related to the motivational intensity theory showed that individuals tend to mobilize exactly the amount of energy that is required to succeed in a particular task and the difficulty of the said task determines energy investment (Wright 2008). Cognitive effort investment is thus minimised when it is impossible to solve the ongoing task or problem despite trying hard to do so. However, in some conditions participants invest more effort than required in a task and do not fully disengage even if task success is impossible; which is inconsistent with the basic idea of energy conservation (Stanek and Richter 2016). When task difficulty is unclear, effort devoted to solve a task might actually increase depending on the importance of success, that is, when, success importance is high and positive mood is induced (Richter 2015; Richter and Gendolla 2009). Thus, it seems possible that even in unstable task conditions (i.e. involving sudden changes in task solvability) cognitive effort devoted to a particular task could potentially increase leading to better cognitive performance.

The next question to address would be why control restoration experiences would specifically impact those functions of cognitive control that are related to cognitive flexibility and task-switching. Control restoration results in a sudden change in perceived controllability (i.e. solvability of the tasks) which could stimulate cognitive effort expenditure and enhance approach motivation. Thus, one explanation of the flexibility-inducing effects of restored perceived control could refer to the motivational mechanism based on low-intensity motivational states that are evoked when prolonged problem-solving activity leads to rewarding results (i.e., goal attainment). The effects of enhanced cognitive control after reward processing were recently more intensively studied, indicating common neural underpinnings of rewards processing, performance monitoring, control execution and action selection related to functioning of the dorsal anterior cingulate cortex (dACC; see Botvinick and Braver 2015; Shenav et al. 2013). In the context of perceived lack of control, the sudden withdrawal of uncertainty related to the missing contingency between intentions and actions, itself could serve as a strong rewarding experience thereby influencing performance on a consecutive switching task. An unexpected goal progress would thus arise from initial negative affect (experienced due to control deprivation) and substituted with positive affect (due to control restoration) (Gable and Harmon-Jones 2011). Since positive affect broadens attention and is beneficial specifically for cognitive flexibility, control restoration experiences might in turn lead to greater flexibility and enhanced ability to switch between task sets (Ashby et al. 1999; Fredrickson and Branigan 2005). Previous research showed that approach motives bolster attentional flexibility (Friedman and Förster 2005), and the cognitive mechanism involved in the boost of flexibility seems to be based on a broadened attentional scope that allows flexible switching between task demands (Friedman et al. 2003). Importantly, approach-based, positive emotional states, related to rewards and incentives were shown to increase cognitive flexibility, assessed via various task-switching paradigms (Aarts et al. 2011; Kleinsorge and Rinkenauer 2012). Thus, a possible explanation of the beneficial effects of control restorative experiences on cognitive flexibility and task-switching refers to approach-based motivation and positive affective states that occur when a sense of personal control is restored (Harmon-Jones et al. 2013).

In sum, those two types of empirical findings directed us to develop the assumption that control restoration could enhance cognitive flexibility due to increased attention to changing environmental (task) conditions and enhanced approach-based motivational states. On a subjective level, on one hand, these experiences should be accompanied by a moderate level of perceived difficulty, uncontrollability and uncertainty in task pursuit, and on the other hand, by enhanced approach-based positive affect after control restoration.

The current research

In this research we investigate the effects of different uncontrollability experiences on cognitive flexibility assessed in the context of social categorization. Control experiences were experimentally induced and later on perceptions of personal control were assessed. Perceived personal control is operationalized by us as the extent to which the self can produce desired (or prevent undesired) outcomes (Skinner 1995). Across three experiments we manipulated control deprivation and restoration using a modified version of a well-established uncontrollability inducing procedure, in which participants are exposed to a series of solvable or unsolvable concept formation tasks (Kofta and Sedek 1999; Sedek and Kofta 1990; von Hecker and Sedek 1999). In the control deprivation condition, we administered a series of unsolvable tasks, whereas in the control restoration condition a series of unsolvable tasks was followed by a series of solvable tasks. We also introduced a control enhancing condition that only consisted of a set of solvable tasks. It is important to notice that we focused primarily on the temporarily activated accumulating experiences of control or lack of control that were evoked by the exposure to solvable vs. unsolvable tasks. Previous research showed that such experimental manipulations of uncontrollability can produce carry over effects to other cognitive processes due to changed perceptions of personal control (Bukowski et al. 2015; Kofta and Sedek 1998). It is not a one-time experience that later influences cognitive flexibility, but rather the change in performance is due to an accumulative experience of several attempts to solve the tasks. In control restoration conditions the dynamics resulting from an unexpected switch from unsolvable to solvable tasks would result in a changed motivational state and broadened cognitive scope.

Cognitive flexibility was measured using a task switching paradigm, which is widely used to explore this process (Monsell 2003). Specifically, we applied a procedure that required participants to switch between two different social categories, which in previous research served as a valid measure of participant's cognitive flexibility (Kossowska et al. 2014; Marzecová et al. 2013). We used a switching task that contains socially relevant material (such as human faces) because processing of social stimuli is strongly automatized and at the same time involves complex inferential processes regarding social category membership (gender, age, race etc.). These social categories are related to expectancies that can bias information processing, therefore making switching between social categories even more demanding with regard to cognitive flexibility than switching between socially irrelevant stimuli (Fiske and Taylor 2007; Ito 2011). More recent studies additionally proved the validity of using task-switching procedures that involve social stimuli (i.e. emotional faces) to examine cognitive flexibility processes (López-Benítez et al. 2017).

In Experiment 1 participants were switching between categories of age and gender. In Experiment 2 and 3 the categories applied in the switching procedure were gender and social roles. Additionally, the combination of specific gender and social role could either be congruent or incongruent with the existing cultural stereotype. We claim that switching from stereotype congruent to incongruent trials would impose the highest demand on cognitive flexibility because it requires contradicting pre-existing expectancies about social roles.

We predicted that control restoration experiences (that follow prior control deprivation experiences), would be associated with greater flexibility of switching between social categories than conditions of stable and prolonged control deprivation. We also expected that the level of flexibility after control restoration would be comparable to the one after a stable control enhancing experience. In other words, the relatively lower ability to switch between social categories would be observed after uncontrollability experiences, which is the effect of an accumulated and stable (not restored) experience of lack of control.

Experiment 1

In Experiment 1, we investigated the impact of experiences of control deprivation and control restoration on the flexibility of switching between social categories. Uncontrollability experiences were induced via a concept formation procedure that consisted of unsolvable and solvable tasks (Sedek and Kofta 1990). Control restoration was induced by sequentially substituting the set of unsolvable tasks by a set of solvable tasks. Additionally, we examined the effects of different uncontrollability experiences on flexibility while controlling for the role of perceived uncertainty, subjective task difficulty and also positive and negative affective states. The switching task used to assess flexibility included faces that could be categorized based either on their gender or age (Marzecová et al. 2013). Face processing stands apart from other types of information processing due to the fact that the face proves to be a rich source of information about attributes, behavioral intentions or trustworthiness about other people (Asch 1946; Keltner and Ekman 2003; Todorov 2011). Face categorization and inferential processes about traits from facial expressions are at the same time very rapid and efficient (Todorov and Uleman 2003). However, the process of face processing itself is inherently complex and involves several areas of the brain (Bruce and Young 1986; Haxby et al. 2000). Gender and age are fundamental social categories that are especially relevant in face processing and are implicitly processed (Mouchetant-Rostaing and Giard 2003). This high automatization of gender and age processing should thus make it more difficult to rapidly switch between these two categories. In fact previous application of gender and age judgments in a switching task indicated that it allows to reliably assess differences in cognitive flexibility (Marzecová et al. 2013). Thus, in this study we applied the social category switching task to assess how lack of control vs. control restoration experiences will influence task switching efficiency on socially relevant material.

Method

Participants

Based on previous research that involved similar experimental procedures we sought to recruit 75 participants (Marzecova et al. 2013; Bukowski et al. 2015). Seventy-six participants (undergraduate students) took part in the experiment in exchange for course credits. Data of two participants could not be recorded due to technical problems and had to be excluded from the sample (randomly assigned to the control and control deprivation conditions). Two participants failed to follow the instructions in the social category switching task and obtained an accuracy rate close to chance (52% of accurate responses) and were therefore also excluded (randomly assigned to the control restoration condition). Thus, in the final analyses, seventy-two people were included (59 women and 13 men, M_{age} 20.0; $SD = 1.49$), twenty-five participants in the control condition, twenty-three in the control deprivation condition and twenty-four in the control restoration condition. A priori power analyses were not performed. Therefore, we conducted a sensitivity analysis using G*power (Faul et al. 2007). Results showed that with this sample size (N = 72) the minimum effect size that could have been detected for $\alpha = 0.5$, and $1 - \beta = 0.80$, for 3 groups (experimental conditions) is f = 0.37 (minimum detectable effect).

Materials and measures

Control manipulation

To induce experiences of uncontrollability and control we used the *Informational Helplessness Training* (*IHT*). The training was based on the original procedure developed by Sedek and Kofta (1990), in which informational helplessness (uncontrollability) was evoked via a concept-formation procedure. The IHT procedure consisted of a series of six discrimination problems presented one after another. Each problem was composed of 12 trials each, and on each trial one figure was presented on the screen. Across all trials, figures varied on five dimensions: (1) size (small or large), (2) shape (triangle or circle), (3) surface (plain or striped), (4) position of a line (at the top or bottom of the figure), and (5) size of the letter ‘r’ in the middle of the figure (small or large). The participants’ task was to identify the diagnostic feature of the figures in each discrimination problem. For example, in one set of 12 trials, the common feature might be a small “r” and in the other, a line on the top of the figure. Participants were informed that all tasks were solvable and that they could resolve the tasks, that is, identify the diagnostic feature of the figures to be discovered (e.g., the small “r” or the line on the top in the above examples) by using the information (i.e., ‘yes’ or ‘no’) accompanying the figure presented on the screen. The instructions explained that ‘yes’ means presence (e.g., the presented circle with the small “r” letter has the diagnostic feature), whereas ‘no’ means absence of the target feature in the figure (e.g., the triangle with the large “R” letter does not have the diagnostic feature). After each problem completion, a list of ten features (i.e., possible solutions) was presented to participants, and participants were asked to indicate the solution by pressing the corresponding key on the computer keyboard, thereby identifying the target feature. Importantly, participants were *not* informed about their success/failure after the completion of consecutive problems in either condition. In the control deprivation condition, the sequence of ‘yes’ and ‘no’ was arranged in such a way that each possible hypothesis of a problem solution received 50% confirmatory and 50% nonconfirmatory evidence. Therefore, in the control deprivation condition, it was not possible to solve any of the tasks (i.e., control deprivation). In the control condition participants received information that allowed them to solve the tasks accurately, that is, ‘yes’ appeared when the target feature was present in the figure (i.e., when the figure had the small “r” in our example) and ‘no’ appeared when the opposite feature (i.e., large “R”) was present. Hence, all the tasks were potentially solvable. After a sample task, participants were asked by the program whether they understood the instructions and continued. Participants were assigned to one of the three conditions. In the control condition, all six concept-formation tasks presented to the participants were solvable; in the control deprivation condition, none of the six tasks were solvable; and in the control restoration condition, the first three problems were unsolvable and the second sequence of three problems was solvable. In neither condition participants received feedback on their performance (success or failure). Lack of feedback is a specific feature of this informational helplessness induction procedure, which was developed based on the classical Hiroto and Seligman behavioral helplessness training (1975), in order to examine the impact of irreducible uncertainty on task performance (Kofta and Sedek 1999). The informational helplessness procedure was proven to strongly affect cognitive performance, as well as motivational and emotional processes (Kofta and Sedek 1998; Sedek and Kofta 1990). Since we were interested in the effects of accumulating experiences of uncontrollability related to the inability to formulate and verify the accuracy of predictions, we decided to incorporate this procedure to test this process since it was most applicable to our research. Also, in the control restoration condition we studied the role of a rewarding experience that followed the introduction of solvable tasks on cognitive performance. Including additional feedback to the procedure might disrupt those sequential effects because random feedback might be perceived as rewarding in some circumstances. Excluding feedback in the manipulation allowed us to omit this confound and control for the externally rewarding stimuli.

Manipulation check

Three questions measured perceptions of accuracy, difficulty and control after the manipulation (*How accurate do you think you were in doing the tasks? How difficult did you find the tasks? To what extent did you feel that you had control over your performance?*). Participants answered using a 7-point scale (e.g., from 1—absolutely no control, to 7—full control).

Emotions and uncertainty

After the control manipulation task, we measured participant's mood using the *Multiple Affect Adjective Check List-Revised* (*MAACL-R*; Zuckerman and Lubin 1985), which measures positive (happy, joyful, pleasant, merry; *Cronbach's alpha* = 0.89) and negative emotional states (Cronbach's alpha = 0.96). The scale differentiates negative emotional states in depression (e.g., sad, depressed; 8 items, Cronbach's alpha = 0.93), anxiety (e.g., worried, anxious; 4 items, Cronbach's alpha = 0.88), and hostility (e.g., angry, hostile; 4 items, Cronbach's alpha = 0.94). Additionally, we measured uncertainty using two items (uncertain, disoriented; Cronbach's alpha = 0.78).

Social category switching task (SCST)

To test participant's ability to switch between different social categories, we introduced the *social category switching task*. This task was previously used to assess differences in cognitive flexibility (Marzecová et al. 2013). In this task, participants categorized pictures of human faces according to one of two social categories: gender (female vs. male) or age (young vs. old). Eight black-and-white photographs, depicting a young female, an older female, a young male, and an older male (two pictures for each category) were selected from *The center for vital longevity face database* (Minear and Park 2004). All of the photographs had the same properties (7.41 cm width and 6.74 cm height) and were displayed in the center of the screen. An additional cue, in the form of a colored frame surrounding the picture (green or purple), appeared in the middle of the screen. The cue informed participants what categorization rule (either gender or age categorization) is applicable on a given trial. The color-categorization rule combination was counterbalanced.

Each trial in the procedure began with the presentation of a fixation cross for 1000 ms. Afterward, the target picture, framed with either the green or the purple colored frame, was presented in the middle of the screen. The cue and the target remained on the screen until the participant responded or for a maximum duration of 3000 ms. After incorrect responses, a beep was presented and the next trial followed after 1500 ms (see Fig. 1). Participants responded using both hands. The "z" and "m" keys were used to respond to the gender task, whereas the age task was performed with "x" and "n" keys. The matching of keys to category exemplars was also counterbalanced across participants. Participants task was to categorize the target as man/woman or young/old in each case. They were given written instructions on the screen explaining the matching of keys and the tasks. The task contained 8 practice trials, followed by four experimental blocks of 80 trials each. The stimuli were presented in a random order to each participant. RTs and accuracy were recorded in order to calculate switching costs as dependent variables.

Questionnaire data was gathered before the manipulation and a test version of an open-ended social categorization measure was administered at the very end of the study.[1]

[1] A need for cognitive closure scale was applied before the manipulation to control for its moderating impact on our variables of interest. No moderating effects were found. Additionally, an open-ended, paper–pencil measure of social categorization (participants were asked to list all the ways they could think of categorizing others and write them down on a blank sheet of paper) was administered as the last measure in the study. It did not have any impact on the procedure and the results were non-conclusive, thus they are not reported in the text.

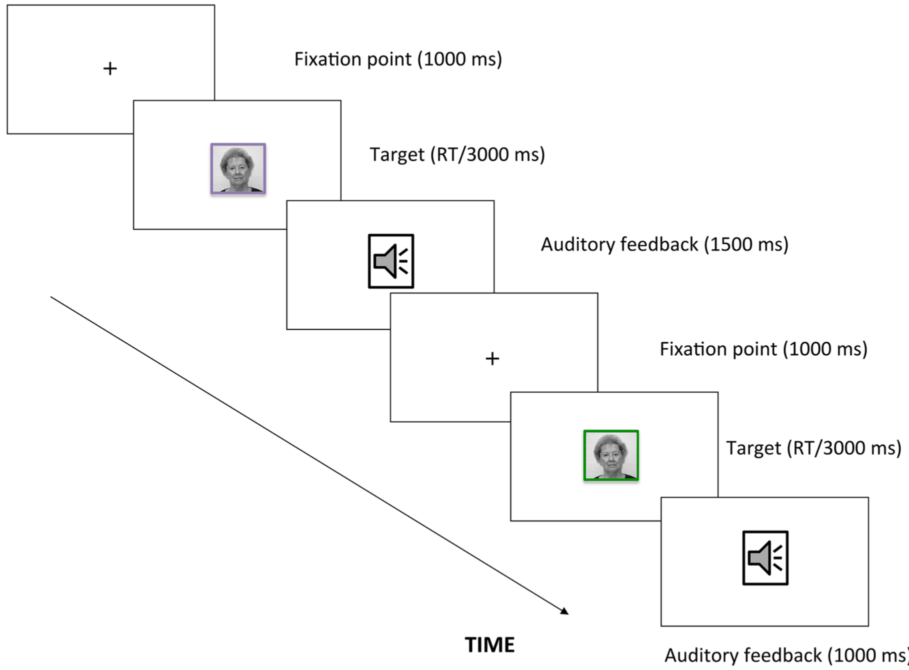

Fig. 1 Schematic illustration of the social category switching task procedure. Sequence of events representative for the complete stimulus repetition and category switch condition. The sample image is reproduced from the center for vital longevity face database (Minear and Park 2004), downloaded from http://agingmind.utdallas.edu/stimuli/facedb

Design and data analysis

Our main hypothesis was related to the impact of different uncontrollability experiences on the efficiency of switching between social categories. Therefore, firstly we calculated switching costs, that is the difference in reaction times and response accuracies between switch vs. no switch trials (i.e. when the task on the previous and the current trial is different vs. when the task repeats) as an index of cognitive flexibility (Monsell 2003). Further on, we analyzed the differences between the three experimental conditions (control deprivation, control restoration and control) with regard to switching costs.

It was also possible to apply more intricate level of analysis to the task-switching procedure which not only takes into account whether the same or different task was performed as in the previous trials (e.g., whether participants must respond to age on the previous and to gender on the current trial, or they have to respond to age on both), but also the changes in the attributes of the target stimulus (e.g. young woman on the previous trial and old woman in the current one, or young woman in both). In line with the feature binding approach (Hommel 1998), we propose to analyze jointly the effects of task repetition and stimulus repetition (indicated by the repetition of stimulus attributes). This allows us to differentiate between the cost in switching responses for the same stimulus (complete repetition) and switching responses to a partially different stimulus (partial repetition), or a completely different stimulus (complete alternation), which provide an additional test for our hypothesis (Schmidt and Liefooghe 2016). Taking this distinction into account allows us not only to check for the task switch effects but look more specifically into those task conditions requiring larger flexibility. Note that changing (vs. repeating) response will be more demanding when exactly the same stimulus is repeated (e.g., a young woman), but in the previous trials participants must give a response (e.g., "young"), and in the current trial a different one (e.g., "woman"). Since those trials are especially demanding in terms of cognitive flexibility, they constitute an important additional test of our hypothesis. Therefore, we checked for the effects of condition on switching costs in interaction with the task and stimulus repetition type. Thus, we conducted a full repeated measure ANOVA (rANOVA) within a 3 (uncontrollability) × 2 (task) × 3 (stimulus repetition) mixed design with personal control experience manipulated between participants (control deprivation vs. control restoration vs. control), and task (gender vs. age categorization), and stimulus repetition (complete alternation vs. complete repetition vs. partial repetition) manipulated within-participants. The task variable refers to whether participants had to categorize the stimuli based on its gender (male, female) or age (young, old). The stimulus repetition refers to the repetition of features across trials such that complete alternation implied that the trial differed from the previous one (e.g., $Trial_{n-1}$ = young woman; $Trial_n$ = old man). Complete repetition implies that the two category dimensions repeated (e.g., $Trial_{n-1}$ = young woman; $Trial_n$ = young woman). Finally, partial repetition implies that

Table 1 Means (and standard deviations) for manipulation checks and other experiential measures (emotions and uncertainty)

Experiment	Condition	Manipulation checks			Phenomenal experiences				
		Perceived control	Perceived accuracy	Perceived difficulty	Uncertainty	Negative emotions	Positive emotions	Positive high-approach	Positive low-approach
Experiment 1	Control	5.64 (1.25)	5.88 (0.93)	2.60 (1.50)	2.32 (1.23)	1.68 (1.26)	4.06 (1.38)	–	–
	Control deprivation	1.83 (0.89)	1.78 (0.95)	5.91 (1.31)	4.52 (1.79)	2.61 (1.36)	2.52 (1.03)	–	–
	Control restoration	4.50 (1.10)	4.25 (0.90)	3.63 (0.92)	2.50 (1.34)	1.87 (0.98)	3.55 (1.39)	–	–
Experiment 2	Control	6.33 (0.82)	6.15 (1.09)	1.94 (1.68)	1.44 (0.68)	1.2 (0.31)	3.35 (0.68)	3.27 (0.80)	3.09 (0.69)
	Control deprivation	1.84 (0.81)	1.97 (0.97)	5.53 (1.27)	2.65 (1.17)	1.9 (0.76)	2.9 (0.62)	2.7 (0.79)	2.83 (0.80)
	Control restoration	4.52 (1.12)	4.26 (1.06)	3.87 (1.45)	1.66 (0.66)	1.42 (0.37)	3.4 (0.53)	3.23 (0.50)	3.34 (0.79)
Experiment 3	Control	5.37 (1.28)	5.53 (1.26)	2.82 (1.50)	1.50 (0.78)	1.3 (0.37)	3.28 (0.68)	3.19 (0.81)	3.05 (0.90)
	Control deprivation	1.88 (0.97)	1.64 (1.03)	5.83 (1.03)	2.80 (1.26)	1.84 (0.82)	2.81 (0.62)	2.44 (0.77)	2.92 (0.75)
	Control restoration	3.74 (1.16)	3.84 (1.23)	4.38 (1.04)	2.05 (1.19)	1.62 (0.79)	2.89 (0.75)	2.55 (0.85)	3.01 (0.89)

In experiment 1, 2 and 3

one category dimension changed whereas the other repeated across two trials (e.g., Trial_{n-1} = young woman; Trial_n = old woman).

Results

Manipulation checks

The three manipulation check questions were analyzed separately. An univariate ANOVA test revealed a significant effect of control manipulation on perceived control ratings ($F(2,69) = 75.51$, $p < .001$, $\eta^2_p = 0.69$). Planned comparisons using Bonferroni correction for multiple comparisons revealed that perceived control was higher in the control restoration group, compared with the control deprivation condition ($p < .001$, $d = 2.68$), and they both scored lower compared to the control condition ($p = .002$, $d = -0.97$; $p < .001$, $d = -3.56$, respectively), which proved that the uncontrollability manipulation worked well. There was also a significant effect of manipulation on perceived accuracy ($F(2,69) = 118.53$, $p < .001$, $\eta^2_p = 0.78$). Perceived accuracy ratings were higher for the control restoration condition than for the control deprivation condition ($p < .001$, $d = 2.67$) and both differed significantly from the control condition ($p < .001$, $d = -1.78$; $p < .001$, $d = -4.36$, respectively). Perceived difficulty of the task was also significantly affected by the manipulation ($F(2,69) = 42.27$, $p < .001$, $\eta^2_p = 0.55$). Perceived difficulty scores were lower for the control restoration condition than for the control deprivation condition ($p < .001$, $d = -2.01$), and again they were both significantly different from the control condition ($p = .019$, $d = 0.83$; $p < .001$, $d = 2.35$, respectively) (for descriptive statistics see Table 1).

Emotions and uncertainty

We also analyzed the differences in experienced emotions using univariate ANOVA analyses. We found significant effects of the control manipulation on negative emotions ($F(2,69) = 3.86$, $p = .026$, $\eta^2_p = 0.10$) as well as positive emotions ($F(2,69) = 8.84$, $p < .001$, $\eta^2_p = 0.20$). The results showed that the control restoration and control deprivation condition did not differ in terms of experienced negative emotions ($p = .125$, $d = -0.62$) and positive emotions ($p = .023$, $d = 0.84$), showing more positive emotions in the control restoration vs. control deprivation condition. In the control deprivation condition participants experienced more negative emotions ($p = .030$, $d = 0.71$), and less positive emotions ($p < .001$, $d = -1.26$), compared to the control condition. In the control restoration condition, participants did not differ significantly from the control condition in terms of experienced negative or positive emotions. Additionally, we found a significant effect of control manipulation on uncertainty ratings ($F(2,69) = 16.32$, $p < .001$, $\eta^2_p = 0.32$). In the control deprivation condition participants experienced a higher level of uncertainty in comparison to control restoration ($p < .001$, $d = 1.19$) and control conditions ($p < .001$, $d = 1.43$). The difference between control restoration and control was non-significant (for descriptive statistics see Table 1).

Social category switching task (SCST)

Trials with erroneous and missed responses (i.e., trials in which no response was given), or reactions shorter than 200 and higher than 2000 ms were excluded from the analysis of response times to normalize the data distribution (see Ratcliff 1993). [2] The first trial of each block was not included in the RT and accuracy analyses, since it cannot be coded as switch or no switch trial (see Marzecová et al. 2013). Accuracy (ACC, mean proportion of correct responses) and mean RTs were calculated from all the remaining trials.

Effects of control manipulation

To test for the differences in flexibility of categorization as a function of experimental condition, we calculated switching costs for response times (mean RTs for switch—no switch trials) and accuracy and conducted a one-way ANOVA with uncontrollability as the between-subjects factor (control deprivation, control restoration and control). The main effect of condition was significant, $F(2,69) = 3.73$, $p = .029$, $\eta^2_p = 0.10$. Pairwise comparisons indicated that participants in the control restoration condition had lower switching costs ($M = 100$, $SD = 65$) than participants in the control deprivation condition ($M = 145$, $SD = 63$), $p = .016$, $d = -3.46$. Participants in the control deprivation condition revealed higher switching costs than those in the control condition ($M = 103$, $SD = 62$), $p = .025$, $d = 3.23$. The difference between the control restoration and control conditions was non-significant ($p = .85$). The effect of condition on switching costs was not significant in the accuracy measure ($F(2,69) = 1.01$, $p = .37$, $\eta^2_p = 0.03$). We also calculated a reversed efficiency index which is a form of analyzing the response time—accuracy trade-off by dividing the RT data by accuracy scores and performed an univariate ANOVA on this dependent variable. However, no significant effects were found here as well ($F(2,69) = 1.34$, $p = .27$, $\eta^2_p = 0.04$).

As described above, in the Social Category Switching Task we also analyzed the effects of control manipulation as a function of stimulus repetition to obtain a stronger test for our predictions regarding the impact of control deprivation vs. restoration on cognitive flexibility. Accordingly, we checked for the effects of condition in interaction with the task type and repetition type. To do that, we conducted a full repeated measures ANOVA with the 3 (uncontrollability) × 2 (task) × 3 (stimulus repetition) design for RT switching costs as the dependent variable. We found a significant three-way interaction ($F(2,69) = 4.08$, $p = .021$, $\eta^2_p = 0.11$). Pairwise comparisons for differences between the control restoration vs. control deprivation condition revealed significantly lower switching costs in the gender categorization task (i.e., when participants switched from age to gender) only for complete repetition ($p = .045$) or partial repetition trials ($p = .017$). Additionally, when switching from gender to age and in complete alternation trials, participants in the control deprivation condition showed higher switching costs relative to the control condition ($p = .033$).

The 3 (uncontrollability) × 2 (task) × 3 (stimulus repetition) interaction was not significant for the accuracy measure ($F < 1$).

Discussion

Experiment 1 revealed that a stable control deprivation experience decreases cognitive flexibility, but when control deprivation changes and initial lack of control is substituted with a sense of exerted control, then participants behave in a more flexible way. This beneficial effect in the form of decreased switching cost (changing between gender and age as a categorization rule) could be observed in the control restoration (vs. control deprivation) condition. Ancillary analyses revealed that the difference between unstable and stable control deprivation conditions was most strongly pronounced in more demanding task settings, in which participants had to subsequently categorize the same face based on two different rules (e.g., when participants saw the same young woman twice and had to categorize her as a young person first, but then, following a rule switch on the following trial, they had to categorize her as a woman). Prolonged, control enhancing experience produced the same effects as the control restoration experience in terms of assessed flexibility. Thus, the results of this experiment confirmed our prediction that control restoration, as well as control enhancement, buffer against the cognitively harmful effects of lacking control. Additional, subjective measures applied after control manipulation showed that participants in the control restoration condition experienced a moderate level of perceived difficulty and uncontrollability, and lower uncertainty relatively to the control deprivation condition. Thus, a high level of irreducible uncertainty may be a crucial factor leading to decreased cognitive performance after prolonged and stable control deprivation (Kofta and Sedek 1999). Additionally, our control restoration manipulation effectively reduced uncertainty to a level comparable with the control condition. Control restoration was also accompanied by more positive and less negative affective states relative to the control deprivation condition (but similar as in the control condition). Therefore, it seems plausible that the lack of differences in performance between control restoring

[2] RT data in the social category switching task was normally distributed, as indicated by the Kolmogorov–Smirnov test for the switching cost measure, $D(74) = 0.061$, $p = .20$. Tests performed for each experimental and task condition separately also confirmed a normal distribution of the results ($p > .05$).

and control enhancing conditions could be due to decreased uncertainty and more positive, approach related affect. Still, the type of affect measure applied in this experiment did not allow us to distinguish between high and low approach affective states.

Experiment 2

The results of Experiment 1 indicated that prolonged control deprivation lowers the ability to flexibly switch between categorization levels, whereas a control restoration experience successfully eliminates this deteriorative effect. In Experiment 2 we aimed at replicating and extending this finding by applying a more complex switching procedure as a dependent measure, which would not only require to change categorization rules but also would incorporate stereotype congruent and incongruent information. Research on processing of stereotypical information reveals that stereotype incongruent information engages executive control and elicits cognitive conflict based on stimulus—response incompatibility (Bartholow and Dicker 2008; Kleiman et al. 2014; Payne 2005). Perception of people in gender counter-stereotypical roles (vs. stereotypical roles) evoked greater activity of the right dorsolateral prefrontal cortex (DLPFC; Quadflieg et al. 2011). The DLPFC is generally engaged in complex cognitive tasks that require maintaining task objectives and overcoming a habitual or dominant response (Knutson et al. 2007). Inhibitory control is engaged during person perception when participants were asked to ignore stereotypic associations evoked by stereotypical gender roles (Quadflieg et al. 2011). Based on this research, we assumed that switching between stereotype congruent and incongruent gender—social roles pairings will constitute the highest demands on cognitive conflict resolution processes. Since control deprivation affects the efficiency of attentional control, we expected that a stable experience of uncontrollability will also influence the flexibility of switching between social categories and would mostly be observed on stereotype incongruent trials, that is, when highest levels of cognitive conflict are induced. However, control restoration experience would diminish those detrimental effects on switching abilities. Since the overall difficulty of the task has been increased in comparison to the task-switching procedure used in Experiment 1, we focused here more directly on the accuracy and efficiency measures of performance related to the resolution of the speed—accuracy trade-off.

As in Experiment 1, we measured perceived uncertainty and difficulty in order to assess the role of uncertainty reduction as a potential mechanism modulating the efficiency of switching between social categories. Additionally, we assessed low and high approach positive and negative affect to examine whether motivational intensity (i.e. approach-based positive affect; Harmon-Jones et al. 2013) accounts for the predicted higher flexibility of social categorization after control restoration (vs. control deprivation).

Method

Participants

Based on previous research that used the same control deprivation manipulation (Bukowski et al. 2015) and the Social Category Switching Task (Marzecova et al. 2013) we determined the expected effect size at f = 0.31. Sample size was determined using G*Power (Faul et al. 2007), α-error probability was set on 0.05. According to this analysis a minimum sample size of 105 participants was required to obtain a 0.80 power effect.[3] We recruited a sample of one hundred-and-three participants. Undergraduate students, who took part in this experiment, received financial compensation of 10 PLN (approximately $2.50) for participation. One participant failed to complete the manipulation. Five participants were excluded before the analyses, based on the manipulation checks, which revealed that they were either aware that the tasks were unsolvable in the control deprivation condition (three participants), or did not follow the instructions and failed to resolve any of the three solvable tasks in the control restoration condition (two participants). On the gender-role switching task, one participant obtained an accuracy rate that was not different from a chance level response tendency (52% of accurate responses) and was also excluded from further analyses. The final sample size was therefore ninety-six (61 females and 35 males, $M_{age} = 21.91$, $SD = 1.89$) that included thirty-three participants in the control condition, thirty-two in the control deprivation condition and thirty-one in the control restoration condition.

Materials and measures

Control manipulation

We used the same *IHT* procedure as in Experiment 1 to induce experiences of control deprivation, control restoration or to enhance control.

Manipulation check

The effectiveness of manipulation was measured by the same three questions as in Experiment 1 plus two additional

[3] We also conducted sensitivity analysis. Results show that with this sample size (N = 96) the minimum effect size that we can detect for α = 0.5, and 1 − β = 0.80, for 3 groups (experimental conditions) and 2 number of measurements is f = 0.33 (minimum detectable effect).

questions that assessed threat or challenge appraisals (*Did you find this task challenging? Did you find this task threatening?*), which participants answered using a 7-point scale (ranging from 1—not at all to 7—very much).

Emotion measurement

The participants' current emotional state after the control manipulation was measured using the PANAS scale (Watson et al. 1988). Since we were not only interested in the valence of the emotions, but also in their motivational intensity (especially related to approach vs. avoidance motivation), we conducted a factor analysis for positive and negative emotions that revealed a three-factor solution for positive affective states and a two-factor solution for negative states. The results of the factor analysis confirmed the division proposed by Harmon-Jones et al. (2009) differentiating between low- and high approach affective states. Hence, we calculated separate indexes for low-approach positive affect (interested, inspired, excited, Cronbach's alpha = 0.73), high-approach positive affect (active, strong, enthusiastic, proud, determined, Cronbach's alpha = 0.81) and two positive affective states related to alertness (alert, attentive, Cronbach's alpha = 0.79). For negative affective states, one index included high-avoidance negative affect (jittery, hostile, scared, nervous, afraid) and the other, low-avoidance negative affect (guilty, ashamed, distressed).

Gender role switching task (GRST)

Participants were instructed to categorize pictures of people based on their gender (male or female) or profession (prototypical male or female). Each picture showed a man or a woman in a specific work context (that could be inferred based on the target person's clothes or tools), thereby creating stereotypical or counter-stereotypical gender-social role combinations. We selected 32 gender stereotypical and counter-stereotypical pictures from the base created by Quadflieg and colleagues (Quadflieg et al. 2011). We used 16 pictures of males and 16 pictures of females, with 8 pictures of stereotypical roles and 8 of counter-stereotypical roles within each gender category. Additionally, we used four different pictures for the practice session. The task consisted of 8 practice trials of social role categorization (they were asked to indicate typically male or female professions), 8 practice sessions for the gender categorization (male vs. female categorization), 8 combined categorization trials (switching between social role and gender) and four experimental blocks of 64 trials each (combined categorization rules), resulting in 256 trials overall.

Each trial in the procedure began with the presentation of a gray background in the place where the target picture was going to appear for 1000 ms. Afterward, the target picture, framed with either the green or the purple colored frame, was presented in the middle of the screen. The cue and the target remained on the screen until the participant responded or for a maximum duration of 3000 ms. After incorrect responses, a beep was presented and the next trial followed after 1500 ms. Participants were instructed to press "m" and "z" for one categorization rule or "n" and "x" keys for the other. The meaning of a particular rule was indicated by the color of the frame around the picture (green or purple). The color-categorization rule matching, as well as the response mapping, were counterbalanced across participants.

Questionnaire data was gathered before the manipulation and an open-ended social categorization measure was administered at the end of the study.[4]

Design and data analysis

As in Experiment 1. That is, the response times and accuracy rates were analyzed in an ANOVA with a repeated measures design. Additionally, switching costs (the difference between switch vs. repetition trials) were calculated and analyzed for each condition. We mainly focused on the comparisons between the control deprivation and restoration group, also taking into account the effects of control deprivation and restoration in contrast to the control group.

The experiment employed a 3×2 mixed design with type of uncontrollability experience manipulated between subjects (control deprivation vs. control restoration vs. control) and congruency (congruent vs. incongruent gender—role pairings) measured as a within-subject variable. Switching costs were the dependent measure. The Congruency factor referred to whether the person appearing in each trial had a gender congruent (e.g., male firefighter) or incongruent (e.g., female firefighter) role based on socially shared gender stereotypes.

Results

Manipulation checks

There was a significant effect of control manipulation on perceived control ($F(2,93) = 193.93$, $p < .001$, $\eta^2_p = 0.81$). Participants in the control restoration condition perceived having significantly more control than in the control deprivation condition ($p < .001$, $d = 2.74$) and less than in the control condition ($p < .001$, $d = -1.84$). We also compared

[4] Gender identification and system justification scales were applied before the manipulation to control for their moderating impact on our variables of interest. No moderating effects were found. Additionally, an open-ended, paper–pencil measure of social categorization was administered at the end of the study. No effects of manipulation were found.

the control deprivation with the control condition and found lower scores of perceived control ($p < .001$, $d = -5.51$). There was a significant effect of manipulation also on perceived accuracy ($F(2,93) = 130.94$, $p < .001$, $\eta^2_p = 0.74$) and perceived difficulty of the task ($F(2,93) = 46.06$, $p < .001$, $\eta^2_p = 0.51$). Participants in the control restoration condition reported higher perceived accuracy ($p < .001$, $d = 2.25$) but more difficulty ($p < .001$, $d = -1.22$) than in the control deprivation one. Control deprivation manipulation generated a lower perceived accuracy in comparison to control condition ($p < .001$, $d = -4.05$) but higher scores of perceived difficulty ($p < .001$, $d = 2.41$). In the control restoration condition participants also rated their perceived accuracy as lower than in the control condition ($p < .001$, $d = -1.76$, respectively) and assessed the perceived difficulty of the task as higher ($p < .001$, $d = 1.23$). The results proved the efficiency of the uncontrollability manipulation.

Emotions and uncertainty

We focused on comparing control restoration with deprivation conditions with respect to emotional states induced by the manipulation, since our predictions mainly concerned differences between those two groups. The main effect of manipulation on negative emotions ($F(2,93) = 14.82$, $p < .001$, $\eta^2_p = 0.24$) as well as on positive emotions was significant ($F(2,93) = 6.29$, $p = .003$, $\eta^2_p = 0.12$). Participants in the control restoration condition experienced less negative, and more positive emotions in comparison to the control deprivation condition ($p = .002$, $d = -0.80$ and $p = .006$, $d = 0.87$, respectively). Importantly, participants in the control restoration condition scored higher than the control deprivation condition in low-approach positive emotions ($p = .012$, $d = 0.64$) as well as in high-approach positive emotions ($p = .013$, $d = 0.80$). Additionally, we found that experienced uncertainty was lower in the control restoration than in the control deprivation condition ($p < .001$, $d = -1.04$) (for all descriptive statistics see Table 1).

Gender role switching task (GRST)

As in the SCST trials with erroneous and missed responses (i.e., trials in which no response was given), or reactions shorter than 200 and higher than 2000 ms were excluded from the analysis of response times (see Ratcliff 1993).[5] The first trial of each block for RT and accuracy measures was excluded, since it cannot be coded as switch or repetition trial for further analyses (see Marzecová et al. 2013). Accuracy and RT scores were means calculated from all the remaining trials.

Effects of control manipulation To test the specific hypothesis regarding differences in flexibility of social categorization as a function of uncontrollability, we conducted a one-way ANOVA with uncontrollability as the between-subjects factor and switching costs as the dependent variable. The effect of control manipulation on reaction times switching costs was not significant ($F(2,93) = 1.08$, $p = .344$, $\eta^2_p = 0.02$), similar to the two-way interaction between uncontrollability and congruency ($F(2,93) = 1.04$, $p = .358$, $\eta^2_p = 0.02$). However, there was a significant main effect of control manipulation on switching costs for the accuracy measure ($F(2,93) = 4.65$, $p = .012$, $\eta^2_p = 0.09$). Planned comparisons revealed that switching costs were significantly lower in the control restoration condition ($M = 0.016$, $SD = 0.027$), in comparison to the control deprivation one ($M = 0.046$, $SD = 0.056$; $p = .007$, $d = -3.75$). Participants in the control deprivation condition revealed higher switching costs than those in the control condition ($M = 0.020$, $SD = 0.039$; $p = .015$, $d = 3.46$). Moreover, the switching costs for accuracy of responses were not significantly different in the control condition in comparison to the control restoration condition ($p = .74$). The two-way interaction between uncontrollability and congruency was not significant for accuracies ($F(2,93) = 1.42$, $p = .248$, $\eta^2_p = 0.03$). Thus, the same pattern of results observed with RT in Experiment 1 could be observed with the accuracy measure in Experiment 2.

Reversed efficiency analysis As in Experiment 1, we wanted to test the possibility of a trade-off between response time and accuracy that could have occurred in the GRST. We calculated an index of reversed efficiency by dividing average reaction times for each task condition, by the corresponding accuracy rates. This index allowed us to estimate how well participants dealt with conflict between trying to be accurate while responding fast at the same time. The main effect of uncontrollability on switching costs was not significant ($F(2,93) = 2.41$, $p = .09$, $\eta^2_p = 0.05$). However, we found a significant uncontrollability × congruency interaction, $F(2,93) = 3.53$, $p = .033$, $\eta^2_p = 0.07$; see Fig. 2. To check whether the efficiency analyses indicated different switching costs between uncontrollability conditions as a function of stereotype congruency, we performed planned comparisons analyzes. For the stereotype-incongruent trials participants in the control restoration condition showed lower switching costs in comparison to the control deprivation condition ($M = 139$, $SD = 128$ vs. $M = 240$, $SD = 256$), $p = .025$, $d = -3.26$. Participants in the control deprivation condition revealed higher switching costs than those in the control condition ($M = 122$, $SD = 98$, $p = .008$, $d = 3.87$).

[5] RT data in the gender role switching task was normally distributed, as indicated by the Kolmogorov–Smirnov test performed for each experimental and task condition (all p's > .18).

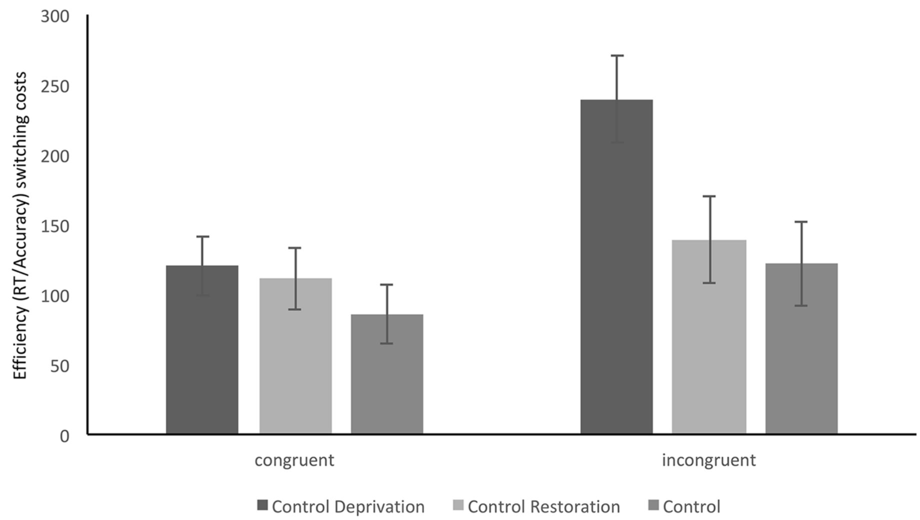

Fig. 2 Switching costs in experiment 2 (reversed efficiency index in ms) as a function of uncontrollability and stereotype congruency. Error bars represent 1 standard error

Performance in the control and control restoration conditions did not differ significantly from each other ($p = .694$). No significant interaction was observed for congruent trials ($F(2,93) = 0.71$, $p = .49$, $\eta^2_p = 0.01$).

Discussion

In Experiment 2, using a modified switching paradigm to study cognitive flexibility, we replicated the main finding from Experiment 1 wherein the control restoration experience lead to higher levels of flexibility in comparison to control deprivation. Additionally, in this experiment, participants were exposed to two types of cognitive conflict, one related to switching between social categories, and the other related to congruency between those categories and social roles. Thus, the overall task difficulty increased in comparison to the first experiment. This was reflected in a greater variability in the accuracies of responses and differences between controllability conditions. Importantly, we observed less accurate performance and higher switching costs for the accuracy measure in the control deprivation group, in comparison to the control restoration group. An efficiency index that accounts for the trade-off between response times and accuracies revealed the same pattern of results, additionally showing the role of stereotype congruency. Namely, the benefit from a control restorative experience was most pronounced in task conditions that involved double cognitive conflict, that is, when participants were asked to switch between tasks and when they were presented with stereotype incongruent targets. In fact, after experiencing control restoration participants were coping more effectively with cognitive conflict, i.e. categorized comparably well when exposed to congruent and incongruent gender roles.

As in Experiment 1 we checked the role of reduced uncertainty and affective states as factors that are related to enhanced flexibility of social categorization. We found the same pattern of results for uncertainty assessment, which was similar to the control enhancing group that revealed a decreased level of experienced uncertainty after control restoration. Reduced uncertainty was also accompanied by motivational states characteristic for goal completion (i.e. low approach positive affect; Gable and Harmon-Jones 2011).[6]

Experiment 3

In Experiment 2 we found that control restoration can increase cognitive flexibility in comparison to stable control deprivation. However, one could argue that since in the control restoration (vs. prolonged control deprivation) condition uncontrollability was experienced only for a short time (3 vs. 6 uncontrollable tasks), the lack of control experience in that condition may simply not have been strong enough. As a consequence, the obtained effects could be due to the length of the uncontrollability experience, rather than the control restoration sequence itself. To resolve this, we designed a third experiment, in which the uncontrollability experience was equally

[6] We performed an additional mediation analysis to tested whether experiencing more positive low-approach emotions in the control restoration condition might account for lower switching costs in the accuracy measure. To perform this mediation that includes a multi-categorical independent variable, we used the MEDIATE procedure for testing indirect effects (Hayes and Preacher 2014). Bootstrapping analyses with 10,000 samples revealed a significant indirect effect of control restoration (vs. deprivation) via low-approach positive affect on switching costs ($IE = 0.003$, $SE = 0.002$, bias-corrected bootstrap intervals for 95% level of confidence, CI: 0.001, 0.009). The indirect effect of control deprivation vs. control condition contrast was not significant ($IE = 0.000$, $SE = 0.001$, bias-corrected bootstrap intervals for 95% level of confidence, CI: −0.003, 0.003). Separate mediation analyses for positive high-approach emotions and for negative high- and low-approach emotions did not reveal any significant indirect effects.

long in both the control restoration and control deprivation condition, but the control restoration condition contained additional control enhancing trials. This design implicates that the duration of uncontrollability in control deprivation and control restoration conditions is equal but the overall duration of the control restoration manipulation is longer. We claim that if performance improvement would be observed in this control restoration condition, relative to the control deprivation one, then it could be argued that this is due to the sequential switch from lack of control to control that enhances flexibility, rather than due to the uncontrollability experience itself.

Method

Participants

Using the same power calculations as in Study 2 for an expected effect size of f = 0.31, to obtain a 0.80 power effect, the required sample size is 105 (Faul et al. 2007).[7] We recruited one hundred-and-thirty-one undergraduate students. Four participants did not successfully complete the experimental procedure and were not included in the analyses. Five participants were excluded based on manipulation check results, which revealed that they perceived the solvable tasks in the control condition as unsolvable (three participants) or failed to resolve any of the four solvable tasks in the control restoration condition (two participants). On the gender-role switching task, three participants obtained an accuracy rate that was not different from a chance level response tendency (one from control deprivation condition: 55% and two from control restoration condition: 38% and 57% of overall accurate responses) and could not be included in further analyses. The final sample size was therefore one-hundred-nineteen (102 females and 17 males, M_{age} = 21.27, SD = 2.31) and consisted of thirty-eight participants in the control condition, forty-two in the control deprivation condition and thirty-nine in the control restoration condition. All participants, who took part in this experiment, received financial compensation of 10 PLN (approximately $2.50). After completing the procedure, they were thanked and debriefed.

Materials and measures

Control manipulation

The type of procedure applied to induce experiences of controllability and uncontrollability was the same as in Experiment 1 and 2 (*IHT*; Sedek and Kofta 1990). However, in order to maintain an equal number of unsolvable tasks in the control deprivation and control restoration condition, we modified the amount of solvable and unsolvable tasks in each of the conditions. A review of previous literature on experimental methods of control deprivation revealed that applying only three unsolvable tasks is not a common way to induce uncontrollability. Original studies using concept formation tasks applied four unsolvable problems as a way of inducing uncontrollability (vs. one unsolvable task that served as a "low helplessness" comparison group; Mikulincer 1988, 1989). Importantly, the original procedure of *Informational Helplessness Training* applied four unsolvable tasks as a way of inducing uncontrollability (Sedek and Kofta 1990; von Hecker and Sedek 1999). In some experiments, more than four unsolvable problems were introduced in order to examine the effects of prolonged uncontrollability and the role of uncertainty and affect in this process (Kofta and Sedek 1999; Ric and Scharnitzky 2003; Sedek et al. 1993). We also referred to the original studies on control deprivation in defining the number of tasks for the control deprivation group because the manipulation applied on the *IHT* procedure does not contain feedback (unlike the Hiroto and Seligman 1975 procedure, which induced behavioral and not informational helplessness; see; Sedek and Kofta 1990), thus participants need a prolonged period of learning in order to infer the lack of contingency between their attempts and results. Therefore, participants in the control deprivation condition received four unsolvable problems and in the control restoration condition they received the same four problems but followed by four solvable ones. We also added a control condition, in which participants received only four solvable tasks, the same ones that were included in the control restoration condition but after the 4 unsolvable ones.

Manipulation check

The effectiveness of manipulation was measured by the same five questions as in Experiment 2, that concerned the experienced level of certainty regarding the performance in the tasks, perceived difficulty of the tasks, control over one's outcomes, feelings of threat and challenge. Participants answered using a 7-point scale (ranging from 1—not at all to 7—very much).

Emotions and uncertainty

The participants' current emotional state after the control manipulation was measured using the PANAS scale (Watson et al. 1988). We calculated one index for negative affective states (Cronbach's alpha = 0.91) and one for positive affective states (Cronbach's alpha = 0.86). As in Experiment 2, we

[7] We also conducted sensitivity analysis for this. Results show that with this sample size (N = 119) the minimum effect size that we can detect for $\alpha = 0.5$, and $1 - \beta = 0.80$, for 3 groups (experimental conditions) and 2 number of measurements is f = 0.29 (minimum detectable effect).

calculated separate indexes for low-approach positive affect (interested, inspired, excited, Cronbach's alpha = 0.71), high-approach positive affect (active, strong, enthusiastic, proud, determined, Cronbach's alpha = 0.85) and two positive affective states related to alertness (alert, attentive, Cronbach's alpha = 0.75). We also measured the level of experienced uncertainty after the manipulation (two items: uncertain, disoriented, Cronbach's alpha = 0.81).

Gender role switching task (GRST)

We used the same procedure to measure flexibility of switching between stereotype congruent and incongruent gender roles as in Experiment 2. At the end of the experiment, an auxiliary measure was administered in order to assess participant's explicit typicality judgments of different gender—profession associations. Participants were thanked and debriefed.

Design and data analysis

We followed the same analysis strategy as in Experiment 1 and 2, focusing on response times, accuracy rates and reversed efficiency analyses using a repeated measures ANOVA. Again, we mainly focused on the comparisons between the control deprivation and restoration group, as this comparison was critical for our hypothesis regarding the control restorative advantage in flexibility. We also compared the effects of control deprivation and restoration in contrast to the control group, which in the case of this experiment was shorter than in the two previous experiments. The experiment employed a 3 × 2 × 2 mixed design with uncontrollability experience manipulated between participants (control deprivation vs. control restoration vs. control), whereas switching (same vs. different categorization rule) and congruency (congruent vs. incongruent gender—role pairings) were measured as within-participant variables. Again, switching costs were used as dependent variable.

Results

Manipulation checks

The main effect of control manipulation on perceived control ratings was significant ($F(2,116) = 93.83$, $p < .001$, $\eta^2_p = 0.62$). Participants rated their level of perceived personal control as higher in the control restoration than in the control deprivation condition ($p < .001$, $d = 1.74$) and lower than in the control condition ($p < .001$, $d = -1.33$). We also encountered significant effects of manipulation of perceived accuracy and difficulty scores ($F(2,116) = 110.16$, $p < .001$, $\eta^2_p = 0.66$ and $F(2,116) = 62.43$, $p < .001$, $\eta^2_p = 0.52$; respectively). Participants in the control restoration (vs. control deprivation) condition judged being more accurate ($p < .001$, $d = 1.94$) and experiencing less difficulty when doing the tasks ($p < .001$, $d = -1.40$). Additionally, in the control restoration condition people rated their perceived accuracy as lower than in the control condition ($p < .001$, $d = -1.35$, respectively), and assessed perceived difficulty of the tasks as higher ($p < .001$, $d = 1.21$). Comparing the control deprivation with the control condition, we found lower scores of perceived control and perceived accuracy ($p < .001$, $d = -3.07$, and $p < .001$, $d = -3.35$), but higher scores of perceived difficulty ($p < .001$, $d = 2.34$) when participants were deprived of control. The results proved the efficiency of the uncontrollability manipulation.

Emotions and uncertainty

The control manipulation significantly influenced experienced negative and positive emotions ($F(2,116) = 6.09$, $p = .003$, $\eta^2_p = 0.10$, $F(2,116) = 5.30$, $p = .006$, $\eta^2_p = 0.08$; respectively). Firstly, we compared the emotional states induced by the control restoration vs. control deprivation condition and participants did not differ in terms of self-reported emotional states with respect to negative emotions ($p = .49$, $d = -0.27$) nor positive emotions ($p = 1$). Control restoration scores did not differ from the ones obtained in the control condition for negative emotions but were significantly lower on positive emotions ($p = 130$, $d = 0.53$ and $p = .041$, $d = -0.55$; respectively). In the control deprivation condition participants experiences significantly more negative and less positive emotions than in the control condition ($p < .001$, $d = 0.85$ and $p = .002$, $d = -0.72$, respectively). The control restoration and deprivation conditions did not differ between each other with respect to low-approach affect nor high-approach affect ($p = 1$). Still, both groups differed significantly from the control condition in terms of high approach affect (interaction effect: $F(2,116) = 9.91$, $p < .001$, $\eta^2_p = 0.15$), showing less approach related affect after control deprivation ($p < .001$, $d = -0.77$) and control restoration ($p = .002$, $d = -0.96$). The manipulation affected also significantly the level of experienced uncertainty ($F(2,116) = 14.24$, $p < .001$, $\eta^2_p = 0.20$). In the control restoration condition it was significantly lower in comparison to the control deprivation condition ($p = .008$, $d = -0.62$). Additionally, uncertainty was non-significantly lower in the control than in the control restoration condition ($p = .091$, $d = -0.55$) and significantly lower in control vs. deprivation condition ($p < .001$, $d = -1.25$; for all descriptive statistics see Table 1).

Gender role switching task (GRST)

Trials with erroneous and missed responses (i.e., trials in which no response was given), or reactions shorter than 200

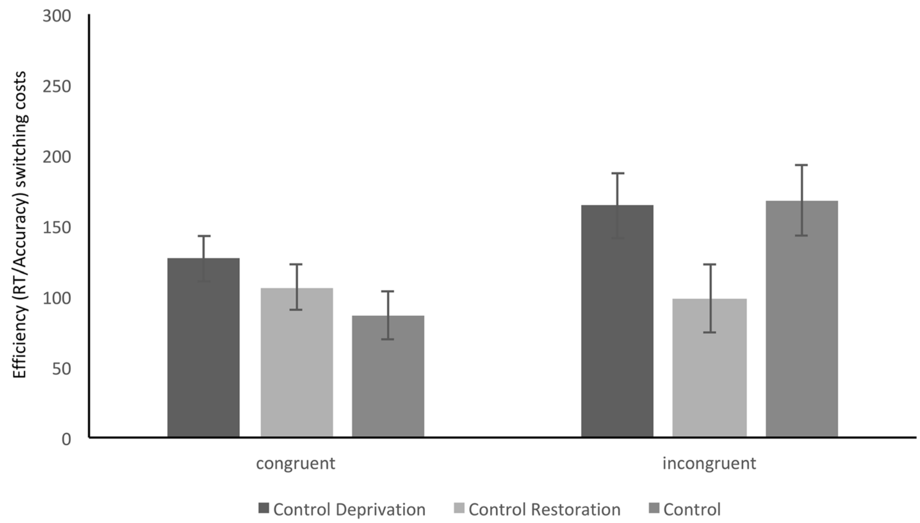

Fig. 3 Switching costs in experiment 3 (reversed efficiency index in ms) as a function of uncontrollability and stereotype congruency. Error bars represent 1 standard error

and higher than 2000 ms were excluded from the analysis of response times (see Ratcliff 1993).[8] The first trial of each block for RT and accuracy measures was excluded, since it cannot be coded as switch or no switch trial for further analyses (see Marzecová et al. 2013). Mean RT and accuracy scores were calculated from all the remaining trials.

Effects of control manipulation The effect of uncontrollability on switching costs in reaction times was not significant ($F<1$), similarly as the two-way uncontrollability × congruency interaction ($F(2,116)=1.29$, $p=.280$, η^2_p = 0.02) with switching costs as dependent variable. The main effect of uncontrollability on accuracy was not significant ($F<1$). We also conducted a rANOVA with congruency as within-subject factor and uncontrollability as a between-participants factor on accuracy measures and found again a significant uncontrollability x congruency interaction for switching costs in accuracies ($F(2,116)=3.66$, $p=.029$, η^2_p = 0.06). Planned comparisons revealed that on incongruent trials switching costs were not significantly lower after control restoration ($M=0.013$, $SD=0.053$) in comparison to control deprivation, ($M=0.033$, $SD=0.053$), $p=.11$, $d=-0.37$, and significantly lower in comparison to the control condition ($M=0.038$, $SD=0.057$), $p=.049$, $d=-0.45$.

Reversed efficiency analysis Analogous to Experiment 2 we tested the possibility of a trade-off between response time and accuracy in the GRST and therefore calculated an index of reversed efficiency by dividing average reaction times for each task condition, by the corresponding accuracy rates. The overall effect of uncontrollability on switching costs was not significant ($F(2,116)=1.48$, $p=.23$, η^2_p = 0.03). However, again, a significant uncontrollability × congruency interaction was observed, $F(2,116)=3.28$, $p=.041$, η^2_p = 0.05; see Fig. 3. This result replicated the one obtained in Experiment 2, in which performance in specific experimental conditions depended on congruency of presented gender roles. As in Experiment 2, we compared the performance in different uncontrollability conditions separately for stereotype-congruent and incongruent trials. A planned comparison analysis performed only for the stereotype incongruent trials revealed lower switching costs in the control restoration than in the deprivation condition ($M=99$, $SD=111$; $M=164$, $SD=190$ respectively), $p=.052$, $d=-0.42$, as well as in the control condition ($M=168$, $SD=135$), $p=.045$, $d=-0.56$. Control deprivation and control conditions did not differ significantly from each other ($p=.90$).

Meta-analysis

An additional mini meta-analysis was conducted to check whether the pattern of results showing an advantage in cognitive flexibility after control restoration vs. control deprivation experiences was replicated and also to estimate the size of the effect across the three studies (Goh et al. 2016). The meta-analysis was conducted using R-software 3.4.1 (2017) and the package 'metafor' 2.0-0 (Viechtbauer 2010). In this meta-analysis we included Cohen's d effect size measures for the comparison between the control restoration and the control deprivation condition for all three experiments with switching costs as DV since our main predictions concerned this comparison. To obtain a full picture of the reliability of the observed effects we performed separate meta-analyses for switching costs calculated for RTs, accuracy and efficiency scores (Fig. 4).

[8] RT data in the gender role switching task was normally distributed, as indicated by the Kolmogorov–Smirnov test performed for each experimental and task condition (all p's = .13).

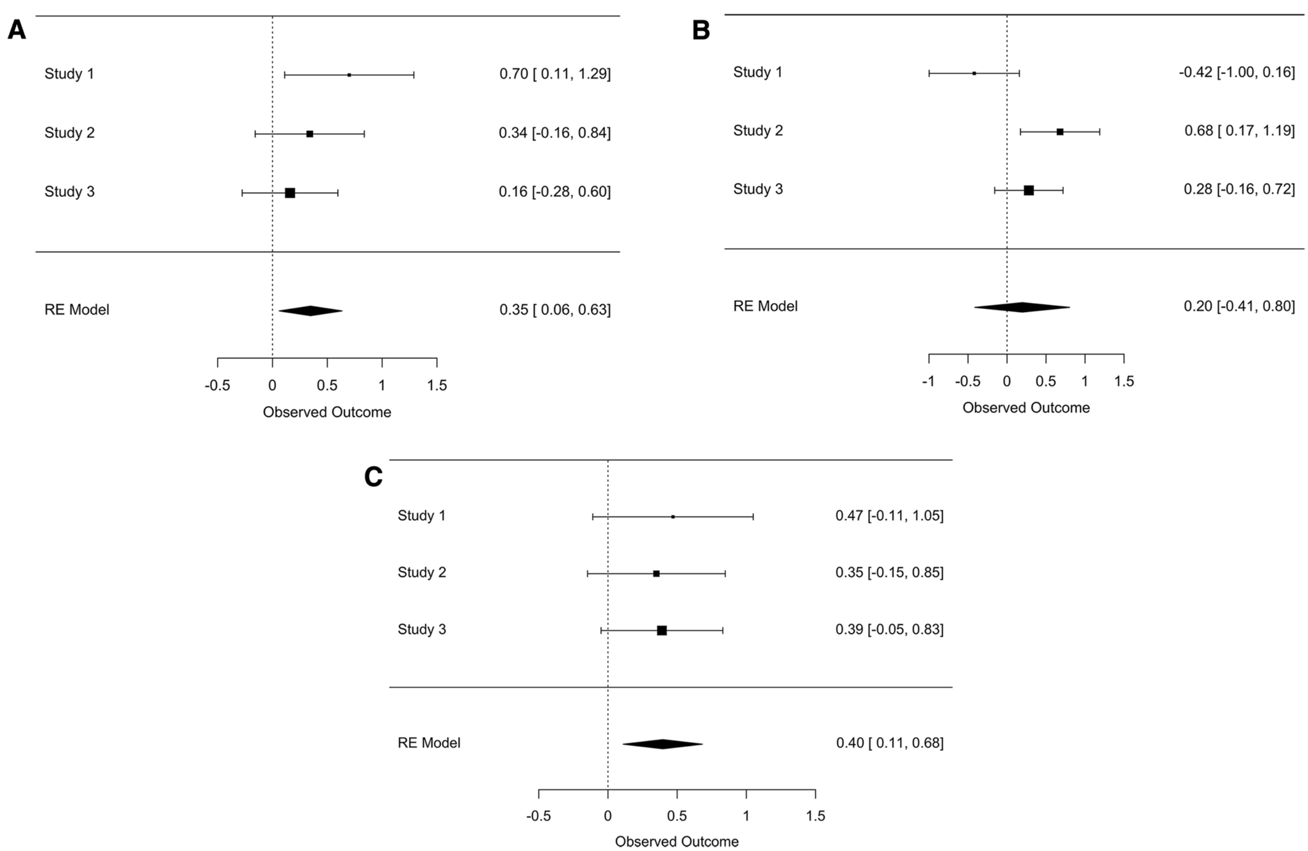

Fig. 4 Meta-analysis of the three experiments for switching costs in: **A** reaction time, **B** accuracy and **C** reversed efficiency results

Meta-analysis for RT switching costs The heterogeneity of the effect sizes was not significant ($Q(2) = 2.08$, $p = .353$, $I^2 = 0.00\%$). The analysis indicated that across the three studies, control restoration (vs. deprivation) was significantly related to lower switching costs ($d = 0.35$, $p = .018$, 95% CI [0.06, 0.63]).

Meta-analysis for accuracy switching costs The heterogeneity of the effect sizes was significant ($Q(2) = 7.92$, $p = .019$, $I^2 = 76.87\%$). The analysis indicated that across the three studies, control restoration (vs. deprivation) was not significantly related to change in switching costs ($d = 0.19$, $p = .529$, 95% CI [−0.41, 0.80]).

Meta-analysis for reversed efficiency switching costs The heterogeneity of the effect sizes was not significant ($Q(2) = 0.10$, $p = .953$, $I^2 = 0.00\%$). The analysis indicated that across the three studies, control restoration (vs. deprivation) was significantly related to lower switching costs ($d = 0.40$, $p = .007$, 95% CI [0.11, 0.68]).

Overall, two out of three meta-analyses supported our main prediction that control restoration leads to decreased switching costs (i.e. higher cognitive flexibility) in comparison to stable control deprivation.[9]

Discussion

In this experiment, we examined the possibility that a shorter duration of the uncontrollability period in the control restoration vs. deprivation condition might itself be a factor that increases flexibility, independently from the sequential control restoration experience. In order to clarify this issue, we compared a control restoration condition that consisted of the same number of unsolvable tasks as the control deprivation one (before the solvable tasks sequence). This simulated the situation of sequential control restoration providing a stronger test for our main hypothesis that the mere sequence of control restoration and not the duration of uncontrollability experiences, boosts cognitive flexibility.

The results revealed differences between control restoration and deprivation on the switching measure for accuracy and efficiency scores in task conditions that evoke additional

[9] Meta-analyses for the effects of comparisons between control deprivation and control conditions are placed in Supplementary Materials.

cognitive conflict, replicating the finding from Experiment 2. As previously seen, higher levels of cognitive flexibility (assessing switching costs for accuracy and efficiency measures) were more pronounced when participants had to switch between categorization rules while being exposed to stereotype incongruent gender roles. Therefore, it is not the length of control depriving experiences but the possibility to regain control that accounts for the enhanced level of flexibility in the control restoration condition. In fact, the entire experience of control loss and recuperation was longer than the one of control loss only and despite of that it still led to better performance, which suggests that participants benefit from the change of experiences (the lack of control to control sequence) and not just from a shorter period of uncontrollability. This conclusion obtained additional support from a meta-analysis performed on the data from all three experiments that revealed improved social category switching abilities after control restoration (vs. deprivation) experiences for reaction times and efficiency scores.

Additionally, we found that the duration of experienced controllability, also played an important role and influenced overall cognitive performance. Specifically, we found similar levels of performance in control and control deprivation conditions even though those two conditions differed in terms of subjectively experienced control, certainty, as well as positive and negative emotions. It is important to notice that in this experiment, the control enhancing experience and the control depriving experience was limited to four tasks. Thus, shorter periods of control deprivation seemed to lead to a weaker impairment of cognitive flexibility. This finding is consistent with the cognitive exhaustion model of uncontrollability (Sedek and Kofta 1990, see also; Bukowski and Kofta 2017), which assumes, that only prolonged and repeated experiences of control loss lead to deficits in cognitive performance, especially involving executive attentional functions. In fact, shorter periods of uncontrollability might enhance motivation, alternate the cognitive style, but there is no empirical evidence that they would indeed boost performance that involves cognitive control. Instead, a linear decrease of cognitive performance as a function of the length of control deprivation was previously observed (Ric and Scharnitzky 2003). The findings of this study are in line with this claim that reduced length of uncontrollability experiences influences cognitive performance to a lesser degree. At the same time, it could be argued that shorter control enhancing experiences are not sufficient to learn, accumulate an experience of having control and increase the participant's level of performance on a subsequent cognitive task. However, what can be observed here more clearly than in the previous studies is that the same length of control deprivation when combined with subsequent control enhancing experiences boosts performance by reducing the costs of switching between social categories in comparison to both groups that contained experiences of stability, either of uncontrollability or control.

This study revealed some interesting patterns of results with regard to the motivational processes involved in control restoration. Participants in control restoration and control deprivation conditions, despite the clear differences in cognitive flexibility, reported similar levels of approach-based affect, which for both groups was lower than the one observed when personal control was enhanced. Thus, the results obtained in the previous studies which revealed more positive affect (including positive low-approach affect in Study 2) in control restoration than deprivation condition might be due to the fact that in the present study a longer period of uncontrollability was induced in the control restoration condition and a shorter period of uncontrollability was induced in the control deprivation condition. This change perhaps made the two conditions more similar in terms of experienced affective states but not in terms of performance.[10] More importantly, the groups also differed in perceived uncertainty. As in Study 1 and 2, participants in this study experienced lower levels of uncertainty in the control restoration condition than those in the stable control deprivation condition, which suggests that decreased level of uncertainty is an important aspect of a control restoration experience.

General discussion

Previous research investigating the effects of control deprivation on cognition focused largely on performance deficits caused by prolonged and stable experiences of uncontrollability (see Bukowski and Kofta 2017; Kofta and Sedek 1998; Sedek and Kofta 1990; von Hecker and Sedek 1999). In the present research, we started out with Brehm's (1993) observation that organisms exhibit great variability and flexibility in their abilities to restore control. We found that humans were indeed able to act flexibly when control deprivation experiences were unstable, that is, when lack of control experiences were followed by controllable events. These findings are in line with a view of human agency, which proposes that situational factors can enable various coping mechanisms with uncontrollability, or even encourage expressions of personal control (Bukowski et al. 2017; Swann and Jetten 2017). Importantly, while previous studies focused mainly on investigating the effects of control deprivation in non-social contexts, our study demonstrated that uncontrollability can also influence processing of social

[10] An analogical mediation analysis as in Experiment 2 testing indirect effects of control restoration (vs. deprivation) via low approach positive affect on switching costs did not yield significance.

categories. This aspect is very important since humans being social animals, often experience control deprivation in relation to others and also change their perceptions of others as a result of experienced uncontrollability. Our research brings to forefront three main insights: (1) a realization that the impact of control deprivation on cognitive flexibility is modulated by stability of such experiences, (2) that uncertainty reduction, approach-based motivation and positive affective states can together drive these effects of flexibility enhancement and (3) an awareness that control restoration experiences can subsequently increase switching abilities between social categories. In the discussion below, we would like to focus on these main and novel aspects of this research.

(In)stability of control deprivation and cognitive flexibility

What is substantial for detrimental effects of control deprivation on cognition is the consistent accumulation of experiences that reveal lack of contingency between intentions and actions (for a review see Bukowski and Kofta 2017). Consistently with this assumption, a sequence of uncontrollable events that is disrupted and substituted by controllable ones can not only prevent those cognitive deficits from taking place, but also immunize against future, possible periods of control loss. This "immunization" could be observed in our research in the form of improved cognitive adaptation to conflictive environmental demands. Specifically, participants after experiencing control restoration were not as susceptible to incongruent information (involving social stereotypes) as their counterparts who experienced only control deprivation. In the light of previous research that revealed more rigid and biased processing after threats to control, our findings showed conditions in which control depriving experiences promote more flexible processing strategies. Similarly, Whitson and Galinsky (2008) showed that the impact of lack of control on illusory pattern perception can be diminished after self-affirmation. Yet, another important factor that modulates the impact of uncontrollability experiences on flexibility, apart from their stability, is the length of this experience. This factor that was studied in previous research on control deprivation seems to have a cumulative, linear detrimental impact on cognitive performance, and cognitive flexibility, based on our findings, does not seem to be an exception from that pattern (Mikulincer 1994; Ric and Scharnitzky 2003).

The role of uncertainty and approach-based positive affect in boosting flexibility

What was not entirely clear is the process underlying the effects of control restoration on cognitive flexibility. In the introduction, we pointed out two possible processes—one more cognitive related to the role of environmental uncertainty and the second, motivational, related to reward processing and approach-based positive affective states. On one hand, changing task solvability that leads to evoked and reduced uncertainty seemed to play an important role in boosting flexibility (in all three studies the level of uncertainty was reduced in the control restoration group in comparison to the control deprivation one), on the other hand, we obtained mixed evidence for the importance of affective processes. Thus, it could be argued with certain caution that a sudden withdrawal of uncertainty related to the missing contingency between intentions and actions could have influenced the performance on a consecutive switching task. The mechanism might resemble the one of conflict adaptation, which shows that after exposure to incongruent trials the congruency effect (i.e. more efficient processing of congruent vs. incongruent trials in a task) is reduced (Kleiman et al. 2014). We observed that costs related to switching are reduced when participants previously experienced a change in the predicted solvability of the tasks they performed. Abilities to shift between mental sets seem to be more adaptive especially in uncertain environments (Nederhof et al. 2014). Knowing that prolonged experience of uncontrollability impairs one's ability to select goal relevant from irrelevant information and evokes a sense of high behavioral uncertainty (related to response selection; Bukowski and Kofta 2017), shifting to a different response strategy might be a crucial ability in overcoming the detrimental effects of control deprivation. Paradoxically, uncertain and unstable environments can provide the opportunity for learning and enhance task motivation by undermining the perceived stability of lacking control and the tendency to prescribe deficits in control to one's own self-efficacy. Interestingly, recent research on unpredictable environments, showed that individuals who as children experienced unpredictability in the family home, were better in cognitive switching but the same effect was not found in those who experienced long-term hardship and poverty (Mittal et al. 2015). This finding is consistent with a more general observation that highly unusual life experiences (so called "diversifying experiences") can be linked to increased flexible thinking and creativity (Gocłowska et al. 2017). Our results resemble those of Mittal et al. (2015) by showing that when uncontrollable conditions are mixed with subsequent controllable ones, the ability to switch between categories is improved, and especially so, in more uncertain (expectancy-incongruent) conditions.

Still, approach-based positive affect seemed to play also an important role in driving the effects of more efficient task-switching after control restoration. The data we collected on subjective and phenomenal experiences measures suggested that low approach affect arose only when the periods of preliminary control deprivation were shorter and the entire manipulation was less cognitively demanding. Previous research showed that threats to personal control induced approach based motivational states (Greenaway et al. 2015). We did not find higher approach after longer lasting experiences of control deprivation (i.e. already after four unsolvable tasks) but short term or unstable experiences of control loss seemed to be related to approach-based motivational states. In fact, prolonged periods of control deprivation lead to a general affective deficit (a mixture of negative emotions, one of the critical symptoms of the learned helplessness syndrome) that could trigger inaction and reactive depression (Hiroto and Seligman 1975; Kofta and Sędek 1989; Roth and Kubal 1975; Sedek and Kofta 1990).

Integrating these two, complementary explanations, why control restoration modulates cognitive flexibility, we think that reduced uncertainty could play an important motivational role. This might occur because uncertainty reduction is by itself rewarding and leading to the activation of low approach positive affective states (like relaxation or interest related to anticipated goal completion; Gable and Harmon-Jones 2011). Also, the probability of success in the control restoration condition can be judged as higher, since participants experience a shift in their solvability, which in turn could serve as a rewarding experience inducing a positive affective state and mobilizing effort (Richter and Gendolla 2009). Thus, moderate levels of uncertainty related to changing, unclear task solvability might be also an important motivational mechanism that leads to increased expenditure of cognitive effort and performance.

Not only success probability seems to matter though for performance but also the length of control depriving experience. In shorter control deprivation experiences approach-based affect is an important factor that boosts flexible, or cognitively "open" cognitive processing (Harmon-Jones et al. 2013). Still, control restoration experiences that are more stretched in time and include longer periods of control depriving and restoring events can diminish the role of positive approach-related affect and maintain the beneficial motivational effects of uncertainty reduction. This is of course only a speculative explanation and in future research, systematic control for the length of uncontrollable experiences should be applied.

Also, the carry over effects on subsequent tasks that involve different cognitive functions would need to be explored in depth. A novel strand of research demonstrates the effects of motivation on enhanced cognitive control but examining it in a trial-by-trial and contextual (block-based) manner (Botvinick and Braver 2015). Our research provides preliminary findings that a motivating experience can have sequential carry-over effects also on a task-by-task basis. We believe that further research is needed to pinpoint the specific motivational mechanisms underlying the beneficial effects of restored personal control on cognitive flexibility.

Socially relevant consequences of control loss and restoration

The last but not least important highlight of our research is that it places the effects of control deprivation and restoration in the context of switching between social categories. Previous research on the effects of threatened personal control focused mainly on various negative consequences for social perception. Several findings showed that after control deprivation people exhibited an increased tendency to rely on illusory perceptions of structure as exemplified in beliefs in superstitions or conspiracies (Whitson and Galinsky 2008). In fact, searching for structure, contingencies and fixed rules in the environment might itself be considered as different forms of coping with control threat which are related to a more avoidance based motivational state. However, fluctuations of control loss and restoration can also lead to a more flexible processing style that boosts the motivation and ability to shift between different levels of social categorization. Our research highlights this brighter side of control loss dynamics, by showing that when threat to control is activated and then withdrawn, then this state of instability might paradoxically promote more flexible social perception of others. In such cases people can move from a more habitual and mindless state to a deliberate and mindful processing mode (Louis and Sutton 1991). Most importantly, our research provided some preliminary evidence for the claim that an unstable environment related to a restored sense of control can promote a more flexible way of categorizing others. We think that this enhanced flexible style of person categorization (i.e. open for certain malleability of conceptual boundaries) might be an adaptive response related to unstable uncontrollability.

Limitations

One possible weakness of the research presented here is that significant results supporting our main prediction regarding the flexibility enhancing control restoration experience were present on different dependent measures across the three experiments. More specifically, Experiment 1 revealed a significant pattern for RTs but not for accuracies or the efficiency scores, Experiment 2 revealed the strongest effects for accuracies and efficiency scores, whereas the results from Experiment 3 showed only a tendency in the predicted direction for accuracy and efficiency scores. The effects were more pronounced when additional cognitive conflict was present in the task. Nevertheless, a meta-analysis performed on the three experiments provided evidence for the predicted effect of control restoration (vs. control deprivation) on reduced switching costs for the reaction time and reversed efficiency measures, but not for the accuracy measures. Lack of effects for the accuracy score might be due to lack of significant results on this variable in Experiment 1, in which no trade-off between RT and accuracy could be observed, unlike in the following experiments that used a different task-switching procedure. Another limitation of this research might be based on the moderately under-powered results from Experiment 1.

Conclusion

In sum, our studies demonstrated that various uncontrollability experiences can impair or enhance flexibility of switching between social categories, depending on the stability of control deprivation experiences. Therefore, exposure to uncontrollability experiences that vary in stability and dynamics do not necessarily have to lead to negative social consequences (e.g. reliance on stereotypes), as it could also trigger higher cognitive flexibility. The experience of regaining control seems to provide a motivational and cognitive boost that prevails over the detrimental effects of control loss. Future research should focus more directly on the dynamics of control loss and restoration to obtain a deeper understanding of the causes that lead to diverse consequences of uncontrollability on thought and action.

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