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Is ego depletion associated with increased distractibility? Results from a basketball free throw task

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ABSTRACT

Objectives: It has been repeatedly demonstrated that athletes in a state of ego depletion do not perform up to their capabilities in high pressure situations. We assume that momentarily available self-control strength determines whether individuals in high pressure situations can resist distracting stimuli.
Design/method: In the present study, we applied a between-subjects design, as 31 experienced basketball players were randomly assigned to a depletion group or a non-depletion group. Participants performed 30 free throws while listening to statements representing worrisome thoughts (as frequently experienced in high pressure situations) over stereo headphones. Participants were instructed to block out these distracting audio messages and focus on the free throws. We postulated that depleted participants would be more likely to be distracted. They were also assumed to perform worse in the free throw task.
Results: The results supported our assumption as depleted participants paid more attention to the distracting stimuli. In addition, they displayed worse performance in the free throw task.
Conclusions: These results indicate that sufficient levels of self-control strength can serve as a buffer against distracting stimuli under pressure.

In perceptual-motor tasks it can be essential to ignore irrelevant, potentially distracting stimuli, for instance task-irrelevant thoughts or the audience in the stands, in order to focus attention on the relevant stimuli (e.g., the rim of the basket; Abernethy, Maxwell, Masters, Van der Kamp, & Jackson, 2007). In high pressure situations individuals often have difficulties regulating their attention which can negatively affect their perceptual-motor performance (e.g., Baumeister, 1984). An often used indicator for perceived pressure in a given situation is the level of state anxiety (e.g., Gucciardi, Longbottom, Jackson, & Dimmock, 2010). Several studies have demonstrated that higher levels of anxiety are associated with impaired performance in different perceptual-motor tasks, for instance in basketball free throws (Wilson, Vine, & Wood, 2009), dart throwing (e.g., Nibbeling, Oudejans, & Daanen, 2012) or golf putting (Gucciardi et al., 2010).

According to Attentional Control Theory (ACT; Eysenck, Derakshan, Santos, & Calvo, 2007) higher levels of state anxiety make individuals prone to be distracted by irrelevant stimuli (e.g., worrisome thoughts). This increased distractibility is assumed to be caused by a dominance of the bottom-up stimulus-driven attentional system over the top-down goal-oriented attentional system in a state of anxiety (Corbetta & Shulman, 2002). Several studies have delivered empirical support for this assumption of ACT (e.g., Wilson et al., 2009).

Of particular importance to the present study, Eysenck and colleagues argued that individuals are generally able to counteract the negative effects of anxiety on attention. This argument is tentatively supported by studies in which anxiety was not negatively related to perceptual-motor performance (e.g., Woodman & Hardy, 2003). However, thus far it has not been sufficiently investigated which processes determine whether anxious individuals can (or cannot) counteract the negative effects of anxiety on attention. In this respect, we argue that an individual's ability to exert self-control might be an important variable that needs to be taken into account when investigating the relationship between anxiety, attention, and skilled performance in perceptual-motor tasks.

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Speaking in terms of the strength model of self-control, volitionally regulating one's attention is a self-control act that is dependent on momentarily available self-control strength (e.g., Baumeister, Bratslavsky, Muraven, & Tice, 1998). According to Baumeister and colleagues, all acts of self-control, meaning the process of volitionally controlling and overriding predominant response tendencies, are energized by the same metaphorical resource or strength of which the capacity is limited (e.g., Baumeister et al., 1998). After a primary self-control act, this resource can temporarily be depleted (a state termed *ego depletion*). As the resource is not immediately replenished, during this time subsequent self-control tasks are typically not executed sufficiently. It is important to note that the effects of ego depletion are not domain-specific, meaning that exerting self-control in one domain (e.g., impulse regulation) can have an effect on self-control from seemingly unrelated domains (e.g., emotion regulation; Baumeister et al., 1998). In general, one's self-control strength can be vital for tasks requiring emotion regulation (e.g., Bertrams, Englert, Dickhäuser, & Baumeister, 2013), persistence (e.g., Baumeister et al., 1998), decision making (e.g., Furley, Bertrams, Englert, & Delphia, 2013), and of particular importance for the current study attention regulation (Schmeichel & Baumeister, 2010). Findings from the field of sport psychology also support the assumptions of the strength model of self-control: In a state of ego depletion individuals are less persistent in physical endurance tasks (e.g., Bray, Martin Ginis, Hicks, & Woodgate, 2008), invest less effort in physical exercises (Dorris, Power, & Kenefick, 2012), display impaired performance in skilled perceptual-motor tasks (McEwan, Martin Ginis, & Bray, 2013), and are more likely to underperform in stressful situations (Englert & Bertrams, 2012). A recent meta-analysis revealed a reliable effect of ego depletion on subsequent self-control across 83 studies (Hagger, Wood, Stiff, & Chatzisarantis, 2010).

As previously mentioned, perceptual-motor tasks require selective attention so that irrelevant stimuli can be ignored (e.g., Wilson et al., 2009), meaning that the exertion of self-control may be necessary for efficient attention regulation during perceptual-motor tasks. In a series of studies, Englert and Bertrams (2012, 2013) demonstrated that the effects of pressure and related anxiety on performance in perceptual-motor tasks were moderated by momentarily available self-control strength. Anxiety only negatively affected performance if participants did not have sufficient self-control strength to counteract the debilitating effects of anxiety on attention regulation. When self-control strength was intact pressure and anxiety did not affect performance in any of the experiments. Moreover, self-control strength itself had no direct effect on performance but only in interaction with pressure and anxiety. In interpreting these results, the authors concluded that, in line with ACT (Eysenck et al., 2007), higher levels of anxiety were associated with increased distractibility (e.g., by worrisome ruminations). Furthermore, they argued that participants with high self-control strength were able to counteract the negative effects of anxiety on selective attention by volitionally regulating their attention.

The question arises, however, whether the anxious participants with depleted self-control strength in Englert and Bertrams's (2012, 2013) studies were actually distracted by task-irrelevant stimuli. As anxious depleted participants displayed worse performance than anxious participants with intact self-control strength, the authors proposed that increased distraction was responsible for these performance differences. They argued that the distraction may stem from worrisome thoughts that typically occur and may be one major source of distraction during high pressure situations (Oudejans, Kuijpers, Kooijman, & Bakker, 2011). However, the authors did not deliver evidence for the process of distraction itself. In the present paper we attempt to expand the findings of Englert and Bertrams by delivering first direct evidence for the assumed mechanism of increased distractibility under depleted self-control strength in high-pressure situations.

In the present study we experimentally manipulated momentarily available self-control strength in a between-subjects design. Participants then performed a series of basketball free throws under pressure, which can be considered a perceptual-motor task that requires attention regulation (e.g., Wilson et al., 2009). We did not manipulate pressure as an experimental factor as this was not the focus of the study, but built on previous self-control research consistently showing performance decrements only in high-pressure situations (e.g., Bertrams et al., 2013; Englert & Bertrams, 2012, 2013). While performing the free throws, the participants were listening to external auditory distraction presented via stereo headphones (for this procedure see also Furley et al., 2013). The audio stream contained typical worrisome thoughts athletes often experience in high pressure contexts (Oudejans et al., 2011). By these means we attempted to model what frequently may distract athletes' attention during such situations. Furthermore, the audio allowed us to measure distraction by irrelevant stimuli. Expanding previous findings we postulated that participants in the depletion group would be more distracted by the audio stream compared to the non-depletion group. Therefore, depleted participants should be more aware of changes in the audio stream than non-depleted participants while performing the basketball free throws under pressure. In replicating the results of Englert and Bertrams (2012, 2013), we also assumed that depleted compared to non-depleted participants would perform worse in the free throw task under pressure.

Method

Participants

The sample of the current study consisted of 31 experienced male basketball players ($M_{age} = 29.26$, $SD_{age} = 4.90$; 1 left-handed) from two clubs of the fourth highest German league (German Oberliga). Participants were randomly assigned to either the depletion group ($n = 16$) or the non-depletion group ($n = 15$). We obtained written informed consent from each participant before starting the experiment.

Materials and procedure

We conducted the study in a separate part of the gym of the respective basketball club. All questionnaires were administered as paper pencil versions, and we calculated overall scores by averaging each participant's value on the respective measure. As such, higher scores on our measures represent higher values of the respective variable. Participants first reported demographic information (age, experience, mother tongue, handedness, official free throw rate from current season).

To rule out differences in trait sport anxiety between our experimental groups, we assessed participants' dispositional sports anxiety by administering the German version of the Sport Anxiety Scale-2 (WAI-T; Brand, Ehrlenspiel, & Graf, 2009). Twelve items were answered on 4-point Likert-type scales (1 − *not at all* to 4 − *very much*) in regard to how participants generally feel before or during sports competitions. Four items each can be assigned to the subscales worry (e.g., “I worry that I will play badly”; $\alpha = .90$), somatic (e.g., “My stomach feels upset”; $\alpha = .81$), or concentration (e.g., “I lose focus on the game”; $\alpha = .85$).

In a next step, we experimentally manipulated momentarily available self-control strength with a transcription task that is a well-established self-control task and has been successfully applied in previous research (Bertrams, Englert, & Dickhäuser, 2010). For that purpose participants transcribed a neutral text on a separate sheet of paper for 6 min. In the depletion group participants were instructed to always omit the letters "e" and "n", which are the most frequent letters in German, while transcribing the text. To follow these instructions individuals need to volitionally override their well-learned writing habits, which can be considered a self-control act (Bertrams et al., 2010). In the non-depletion group participants transcribed the same text without any further instructions.

Following this procedure, we applied a 4-item manipulation check (e.g., "How depleted do you feel at the moment?"; $\alpha = .88$) to test whether our experimental manipulation of momentarily available self-control strength worked (Bertrams et al., 2010). Participants answered the four items on 4-point Likert-type scales ranging from 1 (*not at all*) to 4 (*very much*).

As one could argue that the transcription task could have had unintended effects on mood, we applied the German version of the Positive and Negative Affect Schedule (PANAS; Krohne, Egloff, Kohlmann, & Tausch, 1996) following the manipulation check. Within the PANAS, negative mood (e.g., "bored"; $\alpha = .69$) as well as positive mood (e.g., "strong"; $\alpha = .92$) were assessed via 10 items each. With respect to how one feels at the moment, each item was answered on a 4-point Likert-type scale (1 – *not at all* to 4 – *very much*).

Then, participants were instructed to perform 30 free throws from the free throw line (a distance of 4.60 m) on a regular basket (height 3.04 m from the ground) with an official game ball. We created a pressure situation by telling participants that their performance would be compared with performance from other participants, that their team performance would be compared to the performance of other teams from their league, and that they would receive personal face-to-face feedback (see also Behan & Wilson, 2008; Englert & Bertrams, 2012; Wilson et al., 2009). According to ACT (Eysenck et al., 2007), this instruction should have led to a dominance of the bottom-up stimulus-driven attentional system and therefore increased distractibility (Corbetta & Shulman, 2002).

While performing the free throws all participants were listening to distracting audio messages at a constant volume. The messages were delivered via stereo headphones connected to an MP3 player device that was attached to the participant's shirt. (We made sure that the wire would not interfere with the free throw task beforehand). The audio stream consisted of typical worrisome thoughts athletes are experiencing in high pressure situations. These typical thoughts were adopted from the findings of Oudejans et al. (2011) who asked athletes about their typical thoughts and feelings in high pressure contexts. A bilingual expert translated the English sentences into German and a second bilingual expert translated the sentences back into English to make sure that our German translation matched the original statements reported by Oudejans and colleagues. This resulted in 17 sentences with a total of 129 words (e.g., "I was worrying about my performance"). These statements were presented by two different monotonous digital voices (a female and a male voice) which we programmed with specific software retrieved from the AT&T Research website (http://www2.research.att.com/~ttsweb/tts/demo.php). The digital voice changed from male to female or from female to male after 17 sentences (i.e., after 50 s) in a counterbalanced order. The audio stream lasted during the entire free throw task, meaning that it was repeated till the participant finished his free throws (i.e., longest time needed to complete the free throw task was 4.31 min). Participants were instructed to ignore the audio stream and to solely focus on the free throws. After performing 10 practice free throw trials with the headphones on, participants performed the 30 experimental free throws. For analyses, we calculated each participant's free throw percentage (number of successful free throws $\times$ 100/30).

After finishing the free throws, we asked participants whether they had noticed that the digital voices of the audio stream changed while they were performing the free throw task. We assumed that participants from the depletion group would be more distractible, meaning that they would be more likely to notice the change of the digital voices than participants from the non-depletion group.

Finally, we thanked the participants for participation, probed them for suspicion, and debriefed them.

Results

Preliminary analyses

Statistically significant mean differences in the manipulation check indicate that our experimental manipulation of momentarily available self-control strength was successful in the present study, $F(1, 29) = 32.80$, $p < .001$, $\eta^2_p = .53$. Moreover, the two groups (depletion, non-depletion) neither differed in their official free throw success rate from the current season, nor in any of the trait anxiety subscales, nor in positive or negative mood, $ps > .17$. Thus, none of these variables could explain the effects of self-control strength, analyzed in the following.

Main analyses

A Pearson's chi square test for independence indicated that significantly more participants from the depletion group noticed that there was a voice change in the audio stream (68.8%) than participants from the non-depletion group (31.2%), $\chi^2(1, N = 31) = 3.89$, $p = .05$, $\Phi = -.35$. This supports the assumption that depleted participants were more distracted by the audio stream than participants from the non-depletion group. Distraction was strongly negatively related to performance such that hearing the change in voice was associated with worse performance, $r = -.55$, $p = .002$.

Moreover, as expected, an independent samples t-test revealed that participants from the depletion group (M = 50.42%, $SD = 12.99$) displayed poorer performance in the free throw task compared to participants from the non-depletion group (M = 61.33%, $SD = 12.65$), $t(29) = -2.37$, $p = .03$, $d = 0.85$. This effect remained statistically significant when participants' official free throw success rate of the current season was controlled for in an analysis of covariance (ANCOVA), $F(1, 28) = 4.01$, $p = .05$, $\eta^2_p = .13$. In the depletion group ($M_{adjusted}$ = 51.75%, $SE = 2.81$) participants recorded a lower free throw percentage compared to participants in the non-depletion group ($M_{adjusted}$ = 59.92%, $SE = 2.90$). This finding delivers further support for our assumption that the group differences in free throw performance were caused by differences in momentarily available self-control strength and not by pre-experimental differences in free throw competence.

Ancillary analyses

After demonstrating that availability of self-control strength (i.e., the depletion manipulation) was related to distraction (i.e., recognizing the change in voice) as well as to free throw performance, and that distraction was linked to worse free throw performance, we sought initial evidence that distraction would mediate the relationship between availability of self-control strength and performance. Therefore, we additionally regressed free throw performance simultaneously on available self-control strength and distraction, applying multiple regression analysis.

The analysis revealed that the relationship between self-control strength and free throw performance disappeared when distraction was an additional predictor in the same regression model, β = .24, t = 1.47, p = .15. Distraction, however, still significantly predicted free throw performance in this model, β = −.46, t = −2.82, p = .01. This relational pattern is indicative of the notion that distraction mediated the effect of self-control strength on performance (see Baron & Kenny, 1986). However, due to the small sample size the results of this analysis have to be interpreted with caution.

Discussion

Individuals are not always capable of displaying their best performance in perceptual-motor tasks in high pressure situations (e.g., Gucciardi et al., 2010; Wilson et al., 2009). For successful task completion selective attention is required to block out irrelevant information (e.g., Wilson et al., 2009). However, high pressure situations have been suggested to lead to a dominance of the bottom-up stimulus-driven attentional system (Eysenck et al., 2007), making individuals more distractible and thus leading to impaired performance in tasks requiring selective attention (Corbetta & Shulman, 2002). By investing additional effort individuals are generally able to counteract the negative anxiety effects on attention and subsequent performance (Eysenck et al., 2007). Intact self-control strength seems to be a protective factor in this regard (Englert & Bertrams, 2012, 2013), as in our study participants with intact self-control strength were more adept in ignoring distracting stimuli and additionally displayed superior performance in comparison to participants with depleted self-control strength. Table 1.

Expanding previous findings by Englert and Bertrams (2012, 2013), we tested for the first time whether individuals with depleted and intact self-control strength differed in their distractibility by external stimuli. As it is difficult to measure the degree of distractibility in high pressure situations directly we confronted our participants with external auditory distraction presented via stereo headphones (see Furley et al., 2013). We chose typical thoughts of athletes in high pressure situations as our auditory distraction, simulating and accentuating internal worries that frequently occur under pressure (Oudejans et al., 2011). In line with our prediction, the results indicated that depleted individuals were more distractible as they paid more attention to these stimuli compared to participants with intact self-control strength. Apparently, participants with sufficient self-control strength were able to volitionally shift their attention away from the irrelevant thoughts. In addition, participants who were more aware of the audio stream (i.e., were more distracted by it) performed significantly worse in the free throw task. This finding supports previous findings on the "quiet eye" (e.g., Behan & Wilson, 2008), suggesting that performance in far-aiming tasks depends on attention being focused on the target.

Table 1
Descriptive statistics: means and standard deviations.

Variable	Experimental group			
	Depletion		Non-depletion	
	M	*SD*	*M*	*SD*
WAI-T worry	1.83	0.60	1.72	0.85
WAI-T somatic	1.67	0.54	1.63	0.72
WAI-T concentration	1.92	0.70	1.63	0.61
PANAS positive	1.96	0.66	1.90	0.68
PANAS negative	1.23	0.26	1.13	0.15
Free throw % current season	59.00	7.73	62.80	10.78
Manipulation Check	2.84	0.61	1.50	0.69
Free throw % in experiment	50.42	12.99	61.33	12.65

Note. n = 16 in depletion group, n = 15 in non-depletion group. WAI-T = Wettkampfängstlichkeitsinventar (German version of the Sports Anxiety Scale, SAS-2). PANAS positive = German version of the Positive and Negative Affect Schedule − positive affect. PANAS negative = German version of the Positive and Negative Affect Schedule − negative affect.

Replicating previous research (Englert & Bertrams, 2012, 2013), the present study revealed that ego depletion impairs perceptual-motor performance under pressure. In ancillary analyses, we also found initial evidence that distraction mediated the effect of self-control strength on performance under pressure. While the overall relational pattern was principally in line with a mediation process (Baron & Kenny, 1986), the finding must be considered as preliminary due to the small sample size. Future research may use the present result as a starting point for examining mediation with more advanced statistical techniques that require large sample sizes or a series of experiments (e.g., Spencer, Zanna, & Fong, 2005).

The findings allow an integration of ACT (Eysenck et al., 2007) and the strength model of self-control (Baumeister et al., 1998). Eysenck et al. (2007) stated that the automatic tendency of anxious individuals to process information in a bottom-up manner can be volitionally overridden, thereby avoiding performance decrements in tasks with relatively high requirements to concentrate. However, the authors did not explicitly clarify which processes are responsible for overriding this automatic tendency. Moreover, they did not predict under which conditions overriding of this tendency succeeds or fails. The strength model of self-control may provide a viable explanation as attention regulation can be considered a self-control act (Schmeichel & Baumeister, 2010). Thus, situational or even dispositional variables that affect the availability of self-control strength may impact whether people gain back attentional control and overcome distractibility in stressful situations. This may explain why in some studies individuals were able to perform at a high level in high pressure situations (e.g., Woodman & Hardy, 2003) while in other studies they were likely to underperform (e.g., Beilock & Gray, 2007). It may be possible that in the first mentioned as compared to the latter mentioned studies participants commanded high levels of self-control strength enabling them to counteract the effects of pressure and anxiety on attention. The results of our study further support this assumption.

Nonetheless, there are several critical aspects to consider in the present study. First, we presented external distraction in the form of worrisome thoughts to our participants, assuming that these are typical thoughts running through the mind of an athlete in a high pressure situation. We adapted these statements from a study by Oudejans et al. (2011) in which athletes reported their typical thoughts and feelings in high pressure situations. However, it is not an easy undertaking to create representative statements fitting all participants, as worrisome thoughts are really subjective and may differ from athlete to athlete (Oudejans et al., 2011). An alternative would have been to ask our participants retrospectively whether they were distracted while executing the free throws. Applying this methodology could however confound with participants' free throw performance, as participants with lower free throw scores could blame an increased distractibility as the reason for their low free throw total (cf. Zeidner, 1998). A solution to this potential shortcoming could be to apply eye tracking technology. In several studies it has been demonstrated that individuals under pressure in comparison to no pressure display a less efficient gaze behavior (e.g., Behan & Wilson, 2008; Nibbeling et al., 2012). In this conceptualization, one's gaze behavior is indicative of the ability to selectively pay attention towards task-relevant information (e.g., Behan & Wilson, 2008; Nieuwenhuys & Oudejans, 2012). Therefore, in future studies our findings could be expanded by applying specific eye tracking technology in order to examine the role of self-control strength for selective attention in perceptual-motor tasks.

Second, we did not experimentally manipulate state anxiety but instead induced anxiety in all of our participants (see Englert & Bertrams, 2012; Study 2). However, we did this intentionally as we were interested in examining the proposed distractibility mechanism of how state anxiety impacts performance. As Eysenck et al. (2007) pointed out that the top-down goal-oriented and the bottom-up stimulus-driven attentional system should be in balance amongst individuals in low pressure situations, these individuals should be less affected by irrelevant stimuli. Therefore, in this case, it should not matter whether participants' self-control strength is running low as no self-control is necessary to volitionally regulate one's attention. The nearly equal performance between the depletion and the non-depletion group in participants with low levels of anxiety reported by Englert and Bertrams (2012, 2013) supports this claim. Hence we did not include experimental groups with low levels of anxiety in our study design.

Third, Gray (2004; see also Beilock & Gray, 2007) provided evidence that attention directed to extraneous auditory information was beneficial for skilled perceptual-motor performance in comparison to attention directed towards skill execution. At first sight, this finding seems to contradict the present finding in which attention directed towards the extraneous auditory stream was detrimental for perceptual-motor performance. However, as the present auditory stream represented typical performance worries (Oudejans et al., 2011) in comparison to an irrelevant auditory discrimination task in Gray (2004), the nature of the respective tasks might have accounted for the contrasting pattern of results. On a theoretical level, it might be warranted to think of functional attention regulation not in terms of distraction versus skill-focus attention, but instead of task-beneficial and task-detrimental attention regulation (see Nieuwenhuys & Oudejans, 2012; for a similar line of argumentation regarding task-relevant versus task-irrelevant). Therefore, future studies should investigate whether the quality and valence of extraneous auditory information in dependency of self-control strength is essential for subsequent performance.

Finally, at the moment there is an ongoing debate on the processes underlying the ego depletion effect and the assumptions of the strength model of self-control. Several researchers have argued that the depletion effect on subsequent performance may be due to motivational shifts (e.g., Inzlicht & Schmeichel, 2012), to resource allocation (Beedie & Lane, 2012), or to subjective theories about the limitations of one's self-control strength (Job, Dweck, & Walton, 2010). Although these alternative accounts to the strength model of self-control have received some empirical support, recent studies controlling for these alternative explanations have been in favor of the strength model of self-control (e.g., Graham, Bray, & Martin Ginis, 2014), and also the meta-analysis by Hagger et al. (2010) supports the claim that primary self-control acts impair subsequent acts of self-control. In the present work, we were interested in the relationship among ego depletion, distraction, and skilled perceptual-motor performance and not in the underlying mechanisms leading to the well-established ego-depletion effect. Nonetheless, researchers should pay close attention to this ongoing debate in order to further understanding of the mechanisms leading to ego depletion effects. Recently, Carter and McCullough (2014) argued that the effect of ego depletion on subsequent performance may be overestimated and that a publication bias may have led to the large effect sizes ($d^+ = 0.62$) in the meta-analysis of Hagger et al. (2010). The authors discuss whether the depletion effect may simply be a result of the tendency of editors and authors to only publish significant findings. As we agree that publication bias may be a problem in all fields of psychological research (e.g., Bakker, van Dijk, & Wicherts, 2012), especially in arriving at a reliable approximation of the "true" effect of an experimental manipulation, we acknowledge that the fairly small sample size in the present study might be skewing the effect size. While we do not question the existence of the reported effect, future research with larger sample sizes should replicate our initial findings in order to achieve a more reliable understanding of the effect that ego depletion has on distraction and skilled perceptual-motor performance.

Concluding remarks

The current results have some practical implications. As we demonstrated that depleted individuals were more likely to be distracted by task-irrelevant stimuli it seems beneficial to find ways to boost one's self-control strength. By these means distraction and related performance decrements in perceptual-motor tasks may be mitigated or even avoided. Baumeister and colleagues compare self-control strength to a muscle that on the one hand can become exhausted and depleted but which, on the other hand, can also be strengthened (for an overview, see Baumeister, Gailliot, DeWall, & Oaten, 2006). For instance, in a study by Oaten and Cheng (2007) an intervention group that was instructed to regularly exert self-control with respect to their financial spending for four months improved their self-control in an unrelated selective attention task in the long run compared to participants from a control group who did not receive a specific self-control training. Following the muscle metaphor, there are also possibilities to replenish one's exhausted self-control strength. For example, as Tyler and Burns (2008) found out, brief active relaxation helps to revitalize recently depleted self-control strength. Integrating such active relaxation into the workout routines of athletes might enable them to perform at higher levels under pressure.

References

Abernethy, B., Maxwell, J. P., Masters, R. S. W., Van der Kamp, J., & Jackson, R. C. (2007). Attentional processes in skill learning and expert performance. In G. Tenenbaum, & R. C. Ecklund (Eds.), *Handbook of sport psychology* (Vol. 3, pp. 245–263). New York: Wiley.

Bakker, M., van Dijk, A., & Wicherts, J. M. (2012). The rules of the game called psychological science. *Perspectives in Psychological Science, 7*, 543–554. http://dx.doi.org/10.1177/1745691612459060.

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*, 1173–1182. http://dx.doi.org/10.1037/0022-3514.51.6.1173.

Baumeister, R. F. (1984). Choking under pressure: self-consciousness and paradoxical effects of incentives on skillful performance. *Journal of Personality and Social Psychology, 46*, 610–620. http://dx.doi.org/10.1037/0022-3514.46.3.610.

Baumeister, R. F., Bratslavsky, E., Muraven, M., & Tice, D. M. (1998). Ego depletion: Is the active self a limited resource? *Journal of Personality and Social Psychology, 74*, 1252–1265. http://dx.doi.org/10.1037/0022-3514.74.5.1252.

Baumeister, R. F., Gailliot, M., DeWall, C. N., & Oaten, M. (2006). Self-regulation and personality: how interventions increase regulatory success, and how depletion moderates the effects of traits on behavior. *Journal of Personality, 74*, 1773–1802. http://dx.doi.org/10.1111/j.1467-6494.2006.00428.x.

Beedie, C. J., & Lane, A. M. (2012). The role of glucose in self-control another look at the evidence and an alternative conceptualization. *Personality and Social Psychology Review, 16*, 143–153. http://dx.doi.org/10.1177/1088868311419817.

Behan, M., & Wilson, M. (2008). State anxiety and visual attention: the role of the quiet eye period in aiming to a far target. *Journal of Sports Sciences, 26*, 207–215. http://dx.doi.org/10.1080/02640410701446919.

Beilock, S. L., & Gray, R. (2007). Why do athletes choke under pressure? In G. Tenenbaum, & R. C. Eklund (Eds.), *Handbook of sport psychology* (3rd ed.). (pp. 425–444). Hoboken: John Wiley & Sons.

Bertrams, A., Englert, C., & Dickhäuser, O. (2010). Self-control strength in the relation between trait test anxiety and state anxiety. *Journal of Research in Personality, 44*, 738–741. http://dx.doi.org/10.1016/j.jrp.2010.09.005.

Bertrams, A., Englert, C., Dickhäuser, O., & Baumeister, R. F. (2013). Role of self-control strength in the relation between anxiety and cognitive performance. *Emotion, 13*, 668–680. http://dx.doi.org/10.1037/a0031921.

Brand, R., Ehrlenspiel, F., & Graf, K. (2009). *Wettkampf-Angst-Inventar (WAI). Manual zur komprehensiven Eingangsdiagnostik von Wettkampfangst, Wettkampfängstlichkeit und Angstbewältigungsmodus im Sport* [*Competition Anxiety Inventory.*

Manual for comprehensive diagnostics of competitive trait and state anxiety, and coping]. Köln: Sportverlag Strauß.

Bray, S. R., Martin Ginis, K. A., Hicks, A. L., & Woodgate, J. (2008). Effects of self-regulatory strength depletion on muscular performance and EMG activation. *Psychophysiology, 45*, 337–343. http://dx.doi.org/10.1111/j.1469-8986.2007.00625.x.

Carter, E. C., & McCullough, M. E. (2014). Publication bias and the limited strength model of self-control: has the evidence for ego depletion been overestimated? *Frontiers in Psychology, 5*, 1–11. http://dx.doi.org/10.3389/fpsyg.2014.00823.

Corbetta, M., & Shulman, G. L. (2002). Control of goal-directed and stimulus-driven attention in the brain. *Nature Reviews Neuroscience, 3*, 201–215. http://dx.doi.org/10.1038/nrn755.

Dorris, D. C., Power, D. A., & Kenefick, E. (2012). Investigating the effects of ego depletion on physical exercise routines of athletes. *Psychology of Sport and Exercise, 13*, 118–125. http://dx.doi.org/10.1016/j.psychsport.2011.10.004.

Englert, C., & Bertrams, A. (2012). Anxiety, ego depletion, and sports performance. *Journal of Sport and Exercise Psychology, 34*, 580–599.

Englert, C., & Bertrams, A. (2013). Too exhausted for Operation? Anxiety, depleted self-control strength, and perceptual-motor performance. *Self and Identity, 12*, 650–662. http://dx.doi.org/10.1080/15298868.2012.718865.

Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: attentional control theory. *Emotion, 7*, 336–353. http://dx.doi.org/10.1037/1528-3542.7.2.336.

Furley, P., Bertrams, A., Englert, C., & Delphia, A. (2013). Ego depletion, attentional control, and decision making in sport. *Psychology of Sport and Exercise, 14*, 900–904. http://dx.doi.org/10.1016/j.psychsport.2013.08.006.

Graham, J. D., Bray, S. R., & Martin Ginis, K. A. (2014). "Pay the piper": It helps initially, but motivation takes a toll on self-control. *Psychology of Sport and Exercise, 15*, 89–96. http://dx.doi.org/10.1016/j.psychsport.2013.09.007.

Gray, R. (2004). Attending to the execution of a complex sensorimotor skill: expertise differences, choking, and slumps. *Journal of Experimental Psychology: Applied, 10*, 42–54. http://dx.doi.org/10.1037/1076-898X.10.1.42.

Gucciardi, D. F., Longbottom, J. L., Jackson, B., & Dimmock, J. A. (2010). Experienced golfers' perspectives on choking under pressure. *Journal of Sport and Exercise Psychology, 32*, 61–83.

Hagger, M. S., Wood, C., Stiff, C., & Chatzisarantis, N. L. D. (2010). Ego depletion and the strength model of self-control: a meta-analysis. *Psychological Bulletin, 136*, 495–525. http://dx.doi.org/10.1037/a0019486.

Inzlicht, M., & Schmeichel, B. J. (2012). What is ego depletion? Toward a mechanistic revision of the resource model of self-control. *Perspectives on Psychological Science, 7*, 450–463. http://dx.doi.org/10.1177/1745691612454134.

Job, V., Dweck, C. S., & Walton, G. M. (2010). Ego-depletion – is it all in your head? Implicit theories about willpower affect self-regulation. *Psychological Science, 21*, 1686–1693. http://dx.doi.org/10.1177/0956797610384745.

Krohne, H. W., Egloff, B., Kohlmann, C.-W., & Tausch, A. (1996). Untersuchungen mit einer deutschen Version der "Positive and Negative Affect Schedule" (PANAS) [Investigations with a German version of the Positive and Negative Affect Schedule (PANAS)]. *Diagnostica, 42*, 139–156.

McEwan, D., Martin Ginis, K. A., & Bray, S. R. (2013). The effects of depleted self-control strength on skill-based task performance. *Journal of Sport and Exercise Psychology, 35*, 239–249.

Nibbeling, N., Oudejans, R. R. D., & Daanen, H. A. M. (2012). Effects of anxiety, a cognitive secondary task, and expertise on gaze behavior and performance in a far aiming task. *Psychology of Sport and Exercise, 13*, 427–435. http://dx.doi.org/10.1016/j.psychsport.2012.02.002.

Nieuwenhuys, A., & Oudejans, R. R. D. (2012). Anxiety and perceptual-motor performance: toward an integrated model of concepts, mechanisms, and processes. *Psychological Research, 76*, 747–759. http://dx.doi.org/10.1007/s00426-011-0384-x.

Oaten, M., & Cheng, K. (2007). Improvements in self-control from financial monitoring. *Journal of Economic Psychology, 28*, 487–501. http://dx.doi.org/10.1016/j.joep.2006.11.003.

Oudejans, R. R. D., Kuijpers, W., Kooijman, C. C., & Bakker, F. C. (2011). Thoughts and attention of athletes under pressure: skill-focus or performance worries? *Anxiety, Stress, and Coping, 24*, 59–73. http://dx.doi.org/10.1080/10615806.2010.481331.

Schmeichel, B. J., & Baumeister, R. F. (2010). Effortful attention control. In B. Bruya (Ed.), *Effortless attention: A new perspective in the cognitive science of attention and action* (pp. 29–49). Cambridge, MA: MIT Press. http://dx.doi.org/10.7551/mitpress/9780262013840.003.0002.

Spencer, S. J., Zanna, M. P., & Fong, G. T. (2005). Establishing a causal chain: why experiments are often more effective than mediational analyses in examining psychological processes. *Journal of Personality and Social Psychology, 89*, 845–851. http://dx.doi.org/10.1037/0022-3514.89.6.845.

Tyler, J. M., & Burns, K. C. (2008). After depletion: the replenishment of the self's regulatory resources. *Self and Identity, 7*, 305–321. http://dx.doi.org/10.1080/15298860701799997.

Wilson, M. R., Vine, S. J., & Wood, G. (2009). The influence of anxiety on visual attentional control in basketball free throw shooting. *Journal of Sport and Exercise Psychology, 31*, 152–168.

Woodman, T., & Hardy, L. (2003). The relative impact of cognitive anxiety and self-confidence upon sport performance: a meta-analysis. *Journal of Sports Sciences, 21*, 443–457. http://dx.doi.org/10.1080/0264041031000101809.

Zeidner, M. (1998). *Test anxiety: The state of the art*. New York, NY: Plenum Press.