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Role of Self-Control Strength in the Relation Between Anxiety and Cognitive Performance

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In the present work, we examine the role of self-control resources within the relationship between anxiety and cognitive test performance. We argue that self-control is required for keeping attention away from anxiety-related worries, which would otherwise distract a person from performing on the test. In Study 1 ($N = 67$) and Study 2 ($N = 96$), we found that state anxiety was negatively related to performance of verbal learning and mental arithmetic if participants' self-control resources were depleted, but it was unrelated if participants' self-control was intact. In Study 3 ($N = 99$), the worry component of trait test anxiety was more strongly related to perceived distraction by worries while performing an arithmetic task for participants with depleted self-control resources than for nondepleted participants. Furthermore, distraction by worries showed to be responsible for suboptimal performance. The findings may help to clarify the anxiety–performance relationship and offer a novel approach for counteracting performance decrements associated with test anxiety.

Keywords: anxiety, performance, ego depletion, self-control, self-regulation

In many modern societies, taking cognitive tests is a powerful basis for success and failure in school and employment. Although these tests are designed and often interpreted as pure measures of knowledge and intelligence, performance can be affected by other factors, thereby perhaps unfairly depriving some individuals of rewards and opportunities. Mere awareness of the very real importance of testing can activate motivations and emotions that ironically can dilute the test's accuracy at assessing cognitive ability. In particular, testing can cause worrying about doing well, and these worries can be sufficiently distracting that they impair performance (e.g., Deffenbacher, 1978; Eysenck, 1992; Sarason, 1988; Tobias, 1980; Wine, 1971). Anxiety in test situations has therefore come to be recognized as a pervasive contemporary problem (Spielberger & Vagg, 1995a; Zeidner, 1998). It is not surprising that the question of how to cope with test anxiety has been addressed by many researchers (e.g., Carver & Scheier, 1994; Folkman & Lazarus, 1985; Zeidner, 1996).

It might seem obvious that worrying about performance would hamper problem solving and lower test scores. Yet, the evidence that anxiety impairs test taking is surprisingly weak and inconsistent. The present investigation tested the hypothesis that the impact of anxiety on performance would be moderated by self-control. That is, often people can use self-control to stay focused, keep worries at bay, and perform effectively. Only when people's powers of self-control are weakened or compromised will anxiety produce substantial decrements in performance.

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Anxiety and Cognitive Performance

Anxiety can be defined as an aversive emotional experience that is caused by some kind of threat, including the possibility of being evaluated negatively (Eysenck, Derakshan, Santos, & Calvo, 2007; Spielberger & Vagg, 1995a). Anxiety is marked by heightened arousal, tension, nervousness, and worrisome thoughts (Spielberger & Vagg, 1995a). Researchers have long distinguished state and trait anxiety (Spielberger, 1983; Spielberger, Gorsuch, & Lushene, 1970). *State anxiety* refers to feeling anxious in the present moment. *Trait anxiety* reflects a dispositional tendency to feel anxious and worry in response to various threatening situations.

Test anxiety has been a particular focus of much research, given the importance of testing in modern life and the disruptive effects of anxiety on performance. In addition to the test anxiety literature (e.g., Spielberger & Vagg, 1995b), several related lines of research such as on achievement goals (Dickhäuser, Buch, & Dickhäuser, 2011; Elliot & McGregor, 1999), choking under pressure (Baumeister, 1984; Beilock, Kulp, Holt, & Carr, 2004), stereotype threat (Beilock, Rydell, & McConnell, 2007; Schmader & Johns, 2003; Steele, 1997), stress and coping (Lazarus, Deese, & Osler, 1952; Skinner & Brewer, 2002), or math anxiety (Ashcraft & Kirk, 2001; Groen & Parkman, 1972; Richardson & Suinn, 1972) have addressed the potential of threatening test conditions to impair performance. A vigorous research tradition has examined how anxiety interferes with various aspects of cognitive information processing required for effective test performance. Another line of work has focused more broadly on how overall performance (as indicated by test results) is affected by anxiety (for review, see

Zeidner, 1998). The present investigation is in this latter tradition, focusing on how and whether anxiety lowers test scores.

Test takers must use their working memory to comprehend problems and solve them. Insofar as some working memory is allocated to anxious worrying, the test taker has less available for effectively taking the test. Hence, anxiety could well lead to low test scores by effectively distracting the person with worries (e.g., Deffenbacher, 1977, 1978). Many writers therefore implicitly assume that anxiety, particularly its worry component, will generally impair performance (e.g., Elliot & McGregor, 1999). Meta-analyses have confirmed that as anxiety increases, test performance decreases (Hembree, 1988; Seipp, 1991). However, the effect is surprisingly weak.

The weakness of the effect of anxiety on performance is borne out by inconsistency across studies. Some studies have found significant effects, but others have failed to find it (see Eysenck et al., 2007; Zeidner, 1998). Some of the problem may be that researchers have often relied on using trait anxiety measures to predict performance (Zeidner, 1998). Trait anxiety is a rather distal predictor of performance, and may therefore not always be found to directly affect test performance (Elliot & McGregor, 1999).

Yet, some studies have even failed to find that current state anxiety impairs performance on cognitive tests (e.g., Brook, 1976; Díaz, Glass, Arnkoff, & Tanofsky-Kraff, 2001; Endler, Kantor, & Parker, 1994; Kantor, Endler, Heslegrave, & Kocovski, 2001). Thus, the research literature cannot support a blanket statement that state or trait anxiety will generally or reliably reduce test scores.[1] Hence, it seems imperative to identify factors that moderate whether anxiety impairs performance. In the present work, we argue that individuals' momentary capacity to exert self-control over their attentional processes may be such a moderating factor.

Self-Control and Depletion

Self-control has been defined as the process of deliberately altering or overriding one's responses (e.g., Baumeister, Vohs, & Tice, 2007; Muraven & Baumeister, 2000; Schmeichel & Vohs, 2009). The related term *self-regulation* emphasizes exerting control over one's actions and inner states so as to bring them into line with meaningful standards such as goals, values, and expectations (Carver & Scheier, 1981, 1982). Alongside other applications, people regulate their thought processes and attention, which could moderate the impact of anxiety on cognitive test performance.

The capacity for self-control is not fixed but rather seems vulnerable to state fluctuations. In particular, it appears to depend on a limited resource that gets depleted when it is used. The strength model of self-control (Baumeister et al., 2007) holds that one single energy supply, akin to the folk notion of willpower, is used for a broad variety of acts of self-control. Hence, after performing one self-control task, a person may exhibit poor self-control in other, seemingly unrelated spheres. For example, the ability to persevere or perform optimally may be reduced after people expend energy by controlling their thoughts or attention (e.g., Muraven, Tice, & Baumeister, 1998; Schmeichel, Vohs, & Baumeister, 2003). A meta-analysis has recently confirmed that these so-called *ego-depletion effects* have been replicated in many different laboratories and with different procedures (Hagger, Wood, Stiff, & Chatzisarantis, 2010). Thus, a given test taker's ability to exert control over thoughts, attention, and performance processes may fluctuate as a function of prior demands on self-regulatory resources.

Worries, Attention, and Test Performance

The present investigation was based on the following reasoning. In threatening test situations, people differ in the levels of anxiety they experience. Anxiety implies the experience of worries, such as about performing badly and receiving a poor evaluation. These worries impinge on working memory and distract attention from the test. Test takers may use their self-control resources to shunt the worries aside and concentrate on taking the test. When self-control resources are already depleted, however, people will not be able to maintain their attention on the test instead of their worries, and so anxiety will lead to poor performance. In contrast, when self-control resources are reasonably ample, people may be able to stay focused on the test instead of their worries, and so anxiety will have little or no impact on performance.

Theoretical and empirical work (e.g., Elliot & McGregor, 1999; Eysenck et al., 2007; Spielberger & Vagg, 1995a) suggests that trait test anxiety as well as state anxiety are closely related to experiencing worrisome thoughts about one's performance during a test. Such anxiety-related worries have been found to be fairly constant across a test situation (Spiegler, Morris, & Liebert, 1968; Zeidner, 1998). At the trait level, worry (i.e., occurrence of negative cognitions about one's performance during tests) and emotionality (i.e., occurrence of negative physiological and affective reactions during tests) have even been distinguished as major components of test anxiety (e.g., Liebert & Morris, 1967; Spielberger, 1980; Zeidner, 2007). Both theory and evidence have suggested that the worry component is more detrimental to performance than the emotionality component (Hembree, 1988; Morris, Davis, & Hutchings, 1981; Seipp, 1991). Meta-analytic results have shown that the worry–performance relationship is comparable to the overall relationship between test anxiety and performance, which has led to the conclusion that test anxiety and worry may be regarded as equivalent in terms of their power in predicting cognitive performance (Seipp, 1991; Zeidner, 1998).

Many writers—from test anxiety research as well as related areas (choking under pressure, stereotype threat, math anxiety)—have assumed that the impact of anxiety on test performance comes about because anxiety-related worries distract the person and thereby impair cognitive processing of the test questions (Ashcraft & Kirk, 2001; Beilock, 2008; Beilock et al., 2007; Cadinu, Maass, Rosabianca, & Kiesner, 2005; Eysenck, 1992; Hamilton, 1975; Sarason, 1984; Wine, 1971). In a similar vein, others (e.g., Schmader & Johns, 2003) have pointed out that stressful or threatening test conditions impair performance by

[1] Note that there appears to be a higher consistency across studies on the detrimental effects of high- compared with low-pressure or low-threat conditions on cognitive performance. Such comparison of different test situations has frequently been applied in the *choking under pressure* or *stereotype threat* research (e.g., Beilock et al., 2004; Schmader & Johns, 2003). In contrast, we look at individual differences in anxiety within high-pressure test situations. It is principally possible that, on average, performance differs between high- and low-pressure conditions, while at the same moment different degrees of anxiety in high-pressure conditions predict performance.

reducing cognitive resources of working memory. (To avoid confusion between the two concepts, we do not use the term *resources* in the following when we refer to free working memory space, but only for momentary available self-control energy.) If these views are correct, then people with test anxiety might perform well if they could manage to keep their minds focused on the test rather than on their worries.

Control of attention may therefore be crucial to minimizing the impact of anxiety on performance. Controlling attention is one important form of self-control (Schmeichel & Baumeister, 2010). Selective attention is a matter of focusing on some tasks or stimuli while ignoring or diverting attention away from other stimuli. For best results, test takers should focus all their attention on the test, which may require diverting it away from their worries. Unfortunately, anxiety seems to have precisely the opposite function, namely of automatically directing attention to threatening stimuli, a phenomenon referred to as *attentional bias in anxiety* (MacLeod, Mathews, & Tata, 1986; for a meta-analysis, see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007). As Eysenck et al. (2007) pointed out, worries operate as threatening stimuli. Instead of concentrating on how to answer the next question, the anxious person's mind may automatically focus on worries about how his or her life will be ruined if the test performance is poor.

In sum, anxiety in test situations creates a tendency to be distracted by task-irrelevant, threatening stimuli and also helps generate precisely such stimuli in the form of worries. To perform well in that condition, test takers must control attention by focusing it on the test and away from these worries. Their ability to do that will depend on their self-control resources, which may fluctuate depending on prior use, including for things unrelated to the test.

Present Investigation

Our core hypothesis was that the availability of self-control resources would moderate the impact of anxiety on test performance. Specifically, we predicted that state anxiety would impair performance when self-control resources were depleted, but that state anxiety would have little or no effect when people's resources were not depleted. In broader perspective, we reasoned that trait test anxiety in connection with testing would give rise to worries. However, how much these worries would distract people from the test, thereby lowering test scores, may be moderated by self-control resources. Distraction by worries should be higher when self-control resources for attention regulation are depleted compared with nondepleted.

In three studies, people whose self-control resources were depleted by an initial task were compared with people in a nondepleted control condition, in which self-control resources were left intact. Instead of comparing high- with low-pressure or low-threat situations, we focused on the role of differences in anxiety levels within high-threat test situations (which may represent the most typical test situations in mundane settings). In Studies 1 and 2, we measured state anxiety and examined its impact on verbal learning and arithmetic performance, respectively. In Study 3, we measured trait test anxiety (specifically its worry component) as well as self-reported distraction by worries while performing the arithmetic task. We predicted that higher state anxiety would predict lower test performance, but mainly in depleted participants and not in the nondepleted control participants (Studies 1 and 2). Furthermore, we predicted that the worry component of trait test anxiety would positively predict distraction by worries during test performing, again more strongly in the depletion than in the nondepletion condition (Study 3). Last, we predicted that higher distraction by worries would lead to lower test performance (Study 3).

Study 1

Study 1 provided the first test of the main hypothesis, which held that state anxiety would impair cognitive performance, but mainly when self-control resources were depleted. Cognitive performance was measured with a memorization task, in which participants were assigned to memorize a list of nonsense syllables, and free recall was tested after a distraction. Nonsense syllables were used to minimize any effects of prior knowledge, interest value, and personal meaning. Such procedures have long been used in test anxiety research (e.g., Deese, Lazarus, & Keenan, 1953; Rosenstein, 1960).

Several steps were taken to increase pressure and threat. The test was described as measuring an important aspect of intelligence. Participants were also told that the experimenter would provide personal feedback that would compare their performance with that of other participants. Importance and feedback both contribute to elevating threat in test situations (Zeidner, 1998).

The procedure for depleting self-control resources was adapted from Schmeichel (2007). All participants had to write a short passage. Control (nondepletion) condition participants received no further instructions, but participants in the depletion condition were instructed never to write the letters *e* or *n*. Because many words contain those letters, complying with that instruction required considerable self-regulation in the form of having to monitor the words and skip those letters. Writing the words without the forbidden letters required people to override well-ingrained habits of writing. Altering one's behavior to comply with rules and standards is the essence of self-regulation (e.g., Baumeister, Heatherton, & Tice, 1994; Carver & Scheier, 1981, 1982).

State anxiety was measured with the State-Trait Anxiety Inventory (STAI; Spielberger et al., 1970), which is one of the most frequently used measures in research on anxiety in test situations. It has been shown to be reliable and valid (e.g., Elliot & McGregor, 1999). We also measured trait self-esteem because differences on that trait have long been associated with anxiety and defensiveness, as well as self-control (e.g., Bertrams & Dickhäuser, 2012; Gailliot, Schmeichel, & Baumeister, 2006; Greenberg et al., 1992; Tangney, Baumeister, & Boone, 2004). In addition, we measured emotional reactions in case the manipulations might produce emotional reactions that could perturb test performance.

Method

Participants. Sixty-seven undergraduates (34 women, 33 men; M_{age} = 22.96 years, SD = 3.05) at a German university participated in exchange for 5 Euros. They were recruited via public notices posted throughout the university. Informed consent was obtained from all participants before the beginning of the experimental procedure.

Materials and procedure. At the beginning of the experiment, participants completed the German version of the Rosenberg (1965) Self-Esteem Scale (von Collani & Herzberg, 2003). The 10 items (e.g., "On the whole I am satisfied with myself") were answered on 4-point Likert-type scales from 1 (*strongly disagree*) to 4 (*strongly agree*). High scores indicate high self-esteem. (With all measures reported in this article, higher scores signify higher levels of the variable.) Cronbach's alpha for this measure was .91 in the present sample.

Ego depletion was manipulated with a writing task adapted from Schmeichel (2007). Participants were given pencil and paper and instructed to write an account of an event from their school days. By random assignment, half the participants ($n = 33$) were instructed to omit the letters e and *n* wherever they would normally appear in their writing (depletion condition). These letters are used in many German words, including all infinitive verb forms. The remaining participants ($n = 34$), in the nondepleted control condition, were given no such restrictions. All participants were stopped after 6 min.

After the writing task, participants completed a four-item manipulation check ("How difficult did you find the task?" "How effortful did you find the task?" "How exhausted do you feel right now?" "How hard did you find working on the task?") and a single item asking how difficult it was to recall memories about their school days. These ratings all ranged from 1 (*not at all*) to 7 (*very*). Participants also completed the 20-item Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988; German version by Krohne, Egloff, Kohlmann, & Tausch, 1996). The PANAS includes three items that refer to self-assurance (i.e., *strong*, *proud*, *determined*; Egloff & Krohne, 1996) that we used as an ancillary measure of self-assurance. Cronbach's alphas were .85 for the manipulation check, .91 for the PANAS subscale for positive affect, .78 for the PANAS subscale for negative affect, and .79 for the three PANAS items on self-assurance.

To elevate threat, all participants were informed via computer onscreen communications that the next procedure would involve a test measuring important aspects of intelligence, namely learning ability and working memory. They were also told that they would receive personal feedback from the experimenter after the test, including information about their performance compared with other participants' performance. After this announcement, there was a 30-s break, ostensibly to allow the test to be prepared. The actual reason for this break was to give participants time to think about the upcoming test, thereby allowing subjective feelings of concern and anxiety to build.

Immediately after the break, we measured state anxiety. Participants completed the 20 items (e.g., "I feel tense") of the State subscale of the STAI (Spielberger et al., 1970; German: Laux, Glanzmann, Schaffner, & Spielberger, 1981; $\alpha = .93$ in the present study). They indicated on 4-point Likert scales from 1 (*not at all*) to 4 (*very*) how much the statements applied to them at the moment.

Participants were then presented with 15 nonsense syllables in the form of consonant–vowel–consonant trigrams (e.g., *VAW*, which has no meaning in German). They were told to learn them as well as possible over the course of 1 min. After this, participants performed a distractor task consisting of simple arithmetic problems (e.g., 4 + 7) for another minute. Then they were given a blank sheet of paper and told to write down all the nonsense syllables they could remember from the earlier list. The number of correctly recalled trigrams was the main measure of cognitive learning performance.

Last, participants received a funnel debriefing and were thanked and paid. The experimenter made sure that no participant left the laboratory feeling distressed.

Results

Manipulation check. The writing task was perceived as requiring more exertion of self-control in the depletion condition compared with the nondepleted control condition ($M = 4.08$, $SD = 1.09$ vs. $M = 2.29$, $SD = 1.22$), $t(65) = 6.29$, $p < .001$, $d = 1.55$. Thus, our experimental manipulation was apparently successful.

Analysis strategy. Because state anxiety was a continuous measure, we used multiple regression analysis. Performance (i.e., number of nonsense syllables correctly recalled) was regressed on experimental condition, state anxiety, and the interaction of both predictors. Self-esteem was included in the regression model based on the a priori decision to control for it. State anxiety scores were centered.[2]

Our main prediction involved an interaction. To interpret it, we applied the recoding procedure recommended by Cohen, Cohen, West, and Aiken (2003): We ran the regression analysis two times with the same data, and during the second time, we altered the coding of the experimental condition. The first time, we coded the depletion condition as 0 and the nondepletion condition as 1, whereas it was the other way around the second time. By taking into account the coding of the experimental condition, we could determine how state anxiety was related to learning performance in each of the experimental conditions (the *B*, *SE B*, *t*, and *p* values of anxiety predicting learning performance apply to the condition, which was coded as 0).

Learning performance. The most important finding from Study 1 was a significant interaction between experimental condition and state anxiety, $B = 1.87$, $SE\ B = 0.93$, $t(62) = 2.01$, $p = .049$. The pattern of results confirmed the predictions. State anxiety significantly predicted learning performance in the depletion condition, such that higher state anxiety was related to recalling fewer trigrams, $B = -2.33$, $SE\ B = 0.83$, $t(62) = -2.80$, $p = .007$. Meanwhile, state anxiety did not predict learning performance in the nondepleted control condition, $B = -0.46$, $SE\ B = 0.66$, $t(62) = -0.69$, $p = .49$. Figure 1a depicts the main results.

The conditional main effect of experimental condition (depletion from prior writing task) on learning performance was not close to significance, $p = .91$. Thus, participants in the depletion

[2] Because the distribution of the self-esteem scores was severely skewed, we inverted the scores according to Tabachnick and Fidell's (2007) recommendations to normalize the distribution. For the same reason, we applied transformations to the number of mentally solved multiplication problems in Study 2 (square root transformation) and Study 3 (log transformation), as well as to the test anxiety emotionality scores (log transformation) and the distraction by worries scores in Study 3 (log transformation). The kind of transformation applied depended on the degree of the skew (see Tabachnick & Fidell, pp. 87–88). Decisions for correction and kind of transformation were based on Q-Q plots and histograms. For ease of presentation, the means, standard deviations, and depictions in the figures are based on untransformed values.

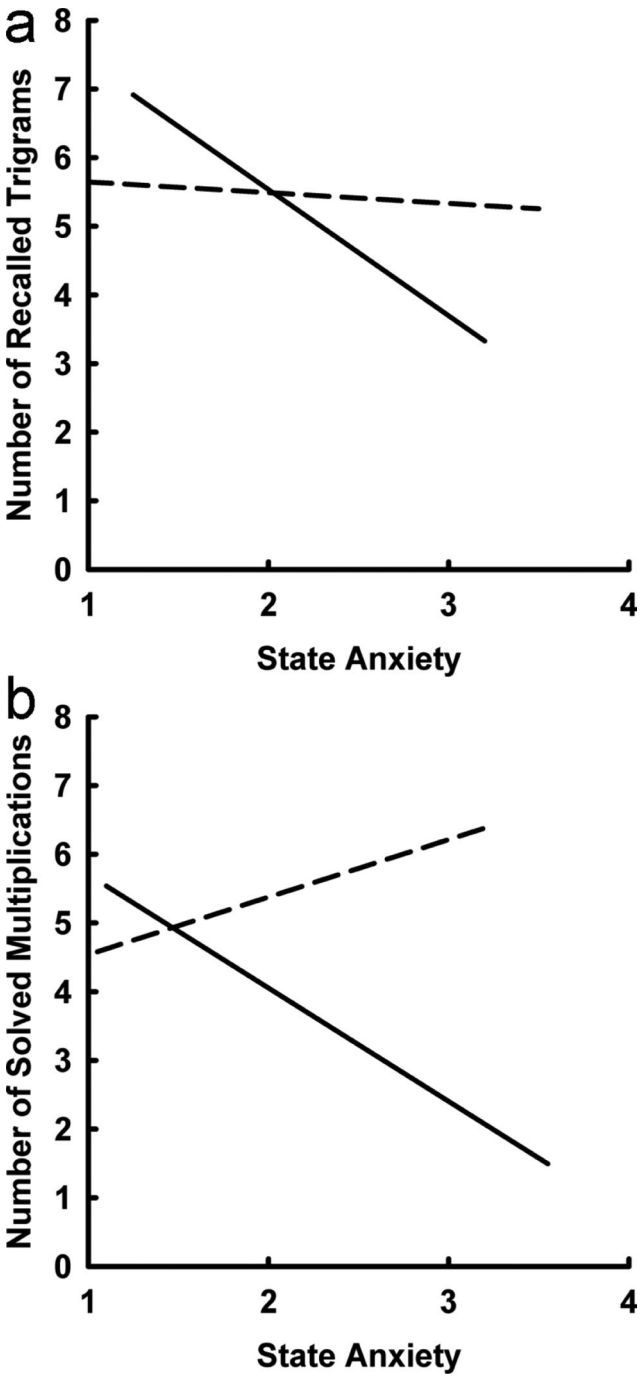

Figure 1. (a) Verbal learning performance in Study 1 and (b) arithmetic performance in Study 2 depending on state anxiety and experimental condition (depletion vs. no depletion of self-control resources). Continuous line = depletion condition; dashed line = nondepletion condition.

condition ($M = 5.21$, $SD = 1.88$) recalled the same amount of trigrams as participants in the nondepletion condition ($M = 5.47$, $SD = 2.09$). Self-esteem was not a statistically significant predictor of learning performance, $p = .29$.

Supplementary analyses. Additional analyses confirmed that the two conditions were not confounded by other factors. The announcement of the upcoming test did not produce different levels of state anxiety between the depletion condition ($M = 2.18$, $SD = 0.49$) and the nondepletion condition ($M = 2.11$, $SD = 0.56$), $p = .63$. The two conditions did not have significant baseline differences in self-esteem, $p = .92$. They did not differ with respect to how difficult it was to recall events from their school days, $p = .24$. (Thus, although the two conditions differed as to the difficulty of writing the account, they did not differ with regard to the accessibility of the memory itself.) Consistent with previous uses of this manipulation (e.g., Schmeichel & Vohs, 2009), the type of writing task had no effect on positive or negative affect, $ps > .23$. On the three PANAS items we used to create an index of self-assurance, there was again no difference, $p = .20$. Taken together, these results suggest that the two groups in our design differed on the manipulated variable (difficulty of writing) and not on other assorted, potentially relevant variables.

Discussion

Study 1 provided preliminary evidence that state anxiety mainly impairs performance when self-regulatory resources are low. Among participants who had expended self-control resources on a prior, irrelevant exercise, performance went down as state anxiety went up. In contrast, among participants who had not depleted their self-control resources in a previous task, state anxiety had no relation to cognitive performance.

The impact of self-control depletion on performance was not influenced by any of the potentially confounding variables we measured. There were no differences in positive or negative emotion, nor were there differences in feelings of self-assurance. Trait self-esteem did not contribute to our findings. Therefore, it seems most plausible to interpret the findings as reflecting the impact of self-control in minimizing the degree to which state anxiety interferes with learning and memory.

Study 2

Study 2 was designed as a conceptual replication of Study 1, with substantial changes in procedure. The most important difference was in the nature of the test. Whereas in Study 1 we measured memorization of nonsense syllables, in Study 2, we measured performance at mental arithmetic. The memorization task in Study 1 is an abstract, content-free task that has abstract similarity to verbal learning in general. In contrast, arithmetic performance is a substantive task that closely resembles what many school pupils are tested on in schools worldwide. By measuring effects on both verbal learning (Study 1) and mathematical skills (Study 2), we sought maximal generalizability.

Several other changes are noteworthy. We standardized the writing task for the experimental manipulation of self-control resources by giving all participants the same text to transcribe instead of letting participants write their own stories. We added an item to the manipulation checks to assess self-perceived quality of writing. This was intended to assess whether participants felt less self-efficacious and competent when performing the difficult compared with the relatively easy version of the writing task. Last, we dropped the self-esteem measure because it had no impact on anything in Study 1.

The predictions were the same as for Study 1. Prior work has shown that performance of multiplication problems can be im-

paired by working memory load (Seitz & Schumann-Hengsteler, 2000). State anxiety should therefore impair performance in the same way, insofar as attending to anxious, worrisome thoughts should detract from the ability to do mental computations. Our hypothesis was that these impairments would be strongest when people's self-control resources were depleted. Hence, we predicted that state anxiety would negatively predict performance among participants who had performed the depleting (difficult) version of the writing task but would have little or no effect on participants who performed the writing task that did not require self-regulatory exertion.

Method

Participants. Ninety-six undergraduates (61 women, 35 men; M_{age} = 23.10 years, SD = 4.27) at a German university participated in exchange for 4 Euros. Participants were recruited via public notices posted throughout the university. Before starting the experimental procedure, the experimenter obtained informed consent from each participant.

Materials and procedure. Study 2 was similar to Study 1, with the following changes. The self-esteem scale was not administered. For the writing task, rather than write a story from their own lives, participants received a passage about the history of the city of Mannheim, Germany, and were then instructed to transcribe the text on a blank sheet. (The historical material was selected so as to avoid arousing and controversial material, such as battles.) As in Study 1, the depletion condition (n = 48) was created with instructions to omit the letters *e* or *n*, whereas the nondepletion control condition (n = 48) had no such restrictions (e.g., in the depletion condition, the word *Mannheim* had to be written *Mahim*). All participants were stopped after 6 min. After this, along with the manipulation check and PANAS, participants rated how favorably they evaluated their performance on the writing task on a scale from 1 (*not at all*) to 7 (*very*).

To increase threat, we presented the task for Study 2 as a test of mental flexibility and cognitive processing speed. The performance measure involved a series of three-digit × one-digit multiplication problems (e.g., 773 × 2), which had to be done purely in one's mind, without benefit of writing. Participants had 3 min to solve as many as possible.

Cronbach's alphas in the present study were .78 for the manipulation check, .91 and .85 for the PANAS subscales of positive affect and negative affect, .76 for the three PANAS items regarding self-assurance, and .91 for the State subscale of the STAI.

Results

Manipulation check. The manipulation check indicated that participants in the depletion condition (M = 4.04, SD = 1.37) exerted more self-control than participants in the nondepletion condition (M = 2.45, SD = 1.06), $t(94) = 6.37$, $p < .001$, d = 1.30, during the writing task. Thus, the experimental manipulation of self-regulatory exertion was successful.

Analysis strategy. We analyzed the relation between state anxiety and arithmetic performance (i.e., the number of correctly solved multiplication problems) depending on the experimental condition (i.e., depletion vs. no depletion of self-control resources) by applying multiple regression analysis and the recoding procedure. This was analogous to what we did in Study 1.

Arithmetic performance. The interaction between experimental condition and state anxiety (centered scores) approached significance, B = 0.49, $SE\ B$ = 0.29, $t(92) = 1.70$, $p = .09$. In the depletion condition, higher state anxiety was marginally significantly associated with lower arithmetic performance, $B = -0.36$, $SE\ B$ = 0.19, $t(92) = -1.88$, $p = .06$. In the nondepleted control condition, in contrast, state anxiety and arithmetic performance produced a nonsignificant trend in the opposite direction, B = 0.13, $SE\ B$ = 0.22, $t(92) = 0.60$, $p = .55$. Figure 1b depicts these results.

The effect of experimental condition on multiplication performance was significant, B = 0.36, $SE\ B$ = 0.14, $t(92) = 2.61$, p = .01. Participants in the depletion condition solved fewer problems than those in the nondepleted control condition (M = 3.79, SD = 3.02 vs. M = 5.50, SD = 3.51).

Supplementary analyses. As in Study 1, levels of state anxiety (measured after the threatening test was explained) were essentially the same in the two conditions (M = 2.16, SD = 0.52 in the depletion condition vs. M = 2.15, SD = 0.46 in the nondepletion condition), $p = .92$. Moreover, the two experimental conditions did not differ as to positive or negative affect, ps > .23. On the three PANAS items measuring self-assurance, there was once again no difference between conditions, $p = .41$. Likewise, participants' evaluations of their own performance on the writing task did not differ between the two conditions, $p = .63$. Thus, it seems unlikely that the experimental manipulation of self-regulatory depletion produced differences in emotion, self-efficacy, or perceptions of one's own performance.

Discussion

Once again, ego depletion moderated the impact of state anxiety on task performance. Among participants who had performed a prior, irrelevant task that required exertion of self-control, higher state anxiety led to poorer performance. Among participants who had not performed a prior exercise of self-control, state anxiety had no effect on performance. Thus, Study 2 replicated the findings of Study 1, despite substantial changes in procedure that included a different kind of cognitive performance and some differences in the initial, depleting self-control task. It should be noted, however, that the effect was smaller than in Study 1, indicated by probability levels falling just short of conventional levels of statistical significance. (If we had used one-tailed probabilities, as is often considered appropriate with replication studies insofar as only one direction of difference can replicate a previous finding, the results would have been significant.) In any case, the observed pattern was in line with our rationale and matched that of Study 1.

Study 2 provided further evidence that the effects of prior self-regulation were due to depletion of resources rather than some other factor. As in Study 1, we found no effects of mood or emotion. State anxiety did not differ between the two conditions, thus ruling out the possibility that the depletion manipulation increased anxiety levels. Thus, depletion appears to have increased the impact of state anxiety rather than increasing state anxiety itself. We also found no difference between conditions in self-assurance. All of this was consistent with what Study 1 showed. Turning to the new measure added in Study 2, we found no differences between experimental conditions on evaluative ratings of one's own performance.

Hence, it seems that depletion of limited regulatory resources provides the most plausible and parsimonious explanation for the effects of prior self-regulation on whether state anxiety impairs performance. These results lend confidence to the interpretation that changes in self-control resources, rather than changes in self-efficacy, in self-perceived performance, in mood, or in other factors, produced the harmful effects of state anxiety on test performance. State anxiety impaired performance when self-regulatory resources were depleted, but it had little or no impact when self-control was intact.

Study 3

Study 3 extended the investigation to examine the influence of test anxiety and self-control resources on distraction by worries during test performing. This was intended to illuminate the inner processes that contribute to the performance impairments found in Studies 1 and 2. Specifically, in Study 3, we asked participants to rate how much they had been distracted by worries during the arithmetic task. The prediction was that anxiety-related worries would distract persons whose self-control resources were depleted because they would not be able to use self-control to push them aside so as to concentrate on performing well. In contrast, when self-control resources were intact, people would be able to prevent worries from distracting them during their task performance.

The focus of Studies 1 and 2 was on state anxiety. To complement them, the focus of Study 3 was on trait test anxiety—particularly, the worry component of trait test anxiety, which was the most relevant to our theory and hypotheses. A simple and straightforward prediction was that being prone to experience anxiety-related worries during tests (i.e., scoring high in the worry component of trait test anxiety) would lead to more distraction by such worries during a test. This has been a standard assumption in much of the test anxiety research literature (see Zeidner, 1998). Our more novel and important prediction was that this effect would obtain primarily after ego depletion. That is, when participants expended self-control resources during an initial task, the high availability of worries in participants scoring high in the worry component would manifest as distraction by worries during the test, as well as in poorer performance, but when self-control resources were intact and not depleted, worries could be kept under control and thus prevented from interfering with task performance.

The manipulation of depletion for Study 3 has been used extensively (e.g., Masicampo & Baumeister, 2008; Schmeichel, 2007; Schmeichel et al., 2003). Participants watched a video of a woman being interviewed. During the video, a series of words appeared in the lower part of the screen. In the depletion condition, participants were instructed not to look at the words and, if they did find themselves looking at the words, they should immediately redirect their attention to the woman. Attention automatically orients toward a novel stimulus (Schneider & Shiffrin, 1977), so it would be natural to look at the words. This manipulation thus depletes people's resources by requiring them to override the natural tendency and redirect their attention repeatedly.

To increase the interval between the measures of worry (i.e., the Worry subscale from trait test anxiety scale) and of distraction by worries, we administered another self-report measure right after the test anxiety scale. Specifically, we included a measure of socially desirable responding tendencies. This was also thought to be possibly useful as an additional control, given the possibility that test anxiety measures can be confounded with socially desirable responding (Zeidner, 1998). As a further control, we assessed the emotionality component of trait test anxiety. The worry and the emotionality components have been found to be distinguishable, yet correlated (Zeidner, 1998, 2007).

Our dependent measures included not only ratings of distraction by worries but also actual task performance, using the multiplication test from Study 2. By measuring both degree of distraction by worries and actual performance, we were able to ascertain whether any effects of the worry component of trait test anxiety on task performance—possibly moderated by ego depletion—were mediated via distraction by worries. The prediction was that test-anxious worries would mainly impair performance when self-control resources were depleted, and that this effect would be mediated by an increase in being distracted during performing the test.

Method

Participants. Ninety-nine undergraduates (58 women, 41 men; $M_{age} = 23.99$ years, $SD = 7.03$) at a German university took part, responding to notices posted around campus. Data from one additional participant (a foreign student) were discarded because language difficulties precluded following instructions.

Materials and procedure. After giving informed consent, participants completed the items measuring worry (five items; e.g., "I am thinking about the consequences of possible failure") and emotionality (four items; e.g., "My heart is pounding") of the brief version of the Test Anxiety Inventory—German (TAI–G; Wacker, Jaunzeme, & Jaksztat, 2008). This is a standardized, reliable, and valid measure of trait test anxiety. Participants were instructed to indicate on 4-point Likert scales (1 = *almost never* and 4 = *almost always*) how they generally feel and what they generally think about in test situations. In the present study, Cronbach's alphas were .86 for the worry component and .88 for the emotionality component of trait test anxiety.

Next, participants completed the Balanced Inventory of Desirable Responding (Paulhus, 1994; German: Musch, Brockhaus, & Bröder, 2002) consisting of 10 items that measure self-deceptive enhancement (e.g., "I always know why I like things") and another 10 items for the measurement of impression management (e.g., "There have been occasions when I have taken advantage of someone," reverse scored). Participants gave their responses on 7-point scales ranging from 1 (*completely disagree*) to 7 (*completely agree*). Cronbach's alphas were .61 for the Self-Deceptive Enhancement subscale and .63 for the Impression Management subscale.

The depletion of self-regulatory resources manipulation involved participants watching a silent video clip that depicted a young woman being interviewed by an off-camera interviewer (attention control video; e.g., Schmeichel et al., 2003). Participants were told that they would have to rate the nonverbal behavior of the woman afterward. While the interview was shown on the left side of the screen, a series of short common words (e.g., *horn*) appeared on the right side in the lower corner. The words were printed in black letters on a white background and each word appeared for 10 s. Participants randomly assigned to the depletion condition ($n = 48$) were instructed to focus solely on the woman,

to pay no attention to the words, and to redirect their attention immediately back to the woman if they noticed their attention had shifted to the words. Participants in the nondepletion condition ($n = 51$) received no further instructions on how to watch the video. After the video, participants completed a three-item manipulation check ("How much did you suppress looking at the words that appeared in the video?" "How effortful did you find watching the video?" "How exhausted do you feel right now?"; $\alpha = .56$) on Likert scales from 1 (*not at all*) to 7 (*very*). They also completed six ratings of the woman in the video (intended to validate the cover story) and the PANAS ($\alpha = .82$ for the Positive Affect subscale, $\alpha = .81$ for the Negative Affect subscale, and $\alpha = .52$ for the three items on self-assurance).

The performance measure was the one used in Study 2. It was preceded by the same description of importance and impending feedback, which was intended to increase performance pressure and heighten the threat for all participants.

Immediately after the cognitive task, participants rated their degree of distraction by worries during the multiplication task. They were asked to indicate on a scale from 1 (*not at all distracted*) to 7 (*extremely distracted*) to what degree different kinds of worrisome thoughts (e.g., "Worries about the consequences of a possible failure") distracted them from their mental calculations. The content of the five items was based on the five items of the TAI–G (Wacker et al., 2008) that focus on the experience of worries (see above). In contrast to the original TAI–G items that simply ask whether the person has such worries during tests, this measure referred to the degree to which participants felt that they were distracted by such worrisome thoughts while performing the cognitive task. Pretesting provided evidence for the reliability and validity of the scale. In the present study, Cronbach's alpha for the distraction by worries scale was .91.

Last, participants were debriefed, thanked, paid, and dismissed.

Results

Manipulation check. The experimental manipulation of self-control strength was successful, as indicated by a significant difference on the manipulation check between the depletion condition ($M = 4.16$, $SD = 1.25$) and the nondepletion condition ($M = 3.27$, $SD = 1.26$), $t(97) = 3.54$, $p < .001$, $d = 0.71$. Thus, participants did exert more effortful self-control of attention in the depletion condition than in the nondepletion control condition.

Analysis strategy. Our main hypothesis was that ego depletion would increase the degree to which highly worried participants would be distracted by their worries during test performance. In addition, we expected that the degree of distraction by worries would predict arithmetic performance. Furthermore, we predicted that distraction would mediate the effect of test-anxious worries on performance, but only among depleted participants. In combination, these predictions constituted a moderated mediation model. To test it, we used a recently developed analysis tool combining multiple regression and bootstrapping methods (MODMED; Preacher, Rucker, & Hayes, 2007). The analysis included the regression of perceived distraction by worries on the worry component of trait test anxiety, experimental condition of self-regulatory depletion, and the interaction of both predictors. Self-deceptive enhancement and impression management (the two aspects of socially desirable responding) as well as the emotionality component of trait test anxiety were also included as predictors to control for them. Moreover, arithmetic performance was regressed on the same predictors plus distraction by worries as additional predictor. Mediation of the relationship between worry and performance via distraction by worries was tested with bootstrapping applying 5,000 resamples.

Distraction by worries. The interaction between the worry component of trait test anxiety and experimental (depletion) condition had a significant impact on degree of perceived distraction by worries, $B = -0.14$, $SE\ B = 0.06$, $t(92) = -2.27$, $p = .03$. This indicates that the relationship between worry and distraction differed significantly between the two experimental conditions. In the depletion condition, higher worry predicted more distraction by worries, $B = 0.22$, $SE\ B = 0.06$, $t(92) = 3.69$, $p < .001$. This link between worry and distraction by worries was substantially weaker among participants in the nondepleted control condition, $B = 0.08$, $SE\ B = 0.05$, $t(92) = 1.72$, $p = .09$. Figure 2 depicts these results.

Experimental condition did not predict distraction by worries, $p = .77$. Depleted participants ($M = 3.31$, $SD = 1.69$) were not more distracted by worries than nondepleted control participants ($M = 3.48$, $SD = 1.80$). Neither self-deceptive enhancement nor impression management nor emotionality predicted the degree of perceived distraction by worries, $ps > .17$.

Arithmetic performance. Being distracted by worries might easily impair performance at mental arithmetic. Consistent with that view, over and above the other predictors, higher distraction by worries predicted a lower number of solved arithmetic problems, $B = -0.45$, $SE\ B = 0.14$, $t(91) = -3.16$, $p = .002$. None of the other variables predicted arithmetic performance, $ps > .13$.

To determine whether the worry component of trait test anxiety had an effect on arithmetic performance mediated via distraction by worries, we viewed the bootstrap 95% confidence intervals for each of the two experimental conditions (see Preacher et al., 2007). In the depletion condition, the confidence interval [−0.19, −0.03] did not include zero, indicating that the so-called indirect effect

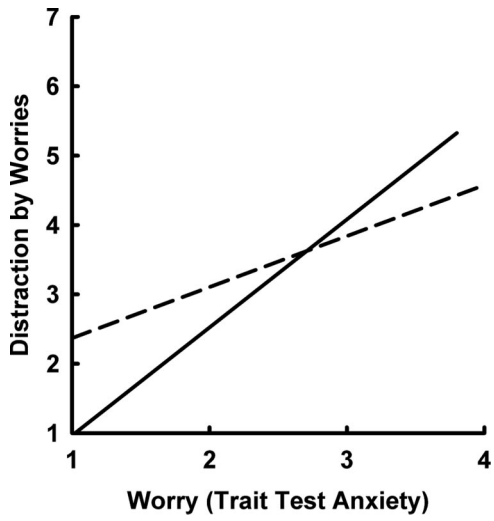

Figure 2. Perceived distraction by worries depending on the worry component of trait test anxiety and experimental condition (depletion vs. no depletion of self-control resources). Continuous line = depletion condition; dashed line = nondepletion condition.

was significantly different from zero at $\alpha = .05$. In other words, worry and performance were indirectly linked, mediated via distraction by worries. This was not the case in the nondepleted control condition in which the confidence interval [−0.10, 0.01] contained zero. Thus, distraction by worries mediated the relation between worry and cognitive performance only when self-control resources were depleted. This finding was confirmed by additional Sobel tests. The conditional indirect effect of worry on arithmetic performance via distraction by worries was significant for the depletion condition, Sobel $z = -2.35$, $p = .02$, whereas this effect was not significant for the nondepleted control condition, Sobel $z = -1.45$, $p = .15$.

Supplementary analyses. There were no baseline differences between the two experimental conditions in the trait test anxiety components worry and emotionality, nor were there differences in self-deceptive enhancement or in impression management, ps $> .37$. Thus, at the start of the procedure, the two groups were similar on relevant traits.

Following the manipulation, there were no differences between the two conditions in positive or negative affect; likewise, there were no differences on the self-assurance measure, ps $> .58$. Hence, the differences between the two conditions appear to have been mainly due to the intended effect on self-regulatory exertion and not to other variables.

Discussion

Study 3 extended the findings of the first two studies. We replicated their finding that anxiety—more specifically, its worry component—and self-regulatory depletion interacted to determine test performance. The novel finding was that they also interacted to predict the degree of distraction by worries. People with high chronic tendencies to experience worry during tests were more distracted by their worries than other participants, but this applied most strongly to people who had already performed a task that required self-regulation. That is, worries mainly interfered with test-taking performance under ego depletion. When people had not expended resources in a previous self-regulation task, even worry-prone individuals performed well on the test.

Study 3's findings thus illuminate the link between trait test anxiety and actual cognitive performance. People who were prone to test-anxious worries and whose self-control resources were depleted were relatively distracted by their worries, and this distraction linked worry to performance decrements. When self-control powers were left intact, however, the dismal progression from worry to distraction to poor performance did not happen. In line with previous research (e.g., Deffenbacher, 1977), these effects of test anxiety were specific to the worry component and independent of the emotionality component of trait test anxiety (e.g., being highly physiologically aroused during test taking).

It was conceivable that part of the observed link between intrusive worries and poor performance could reflect an attempt by some participants to rationalize or excuse poor performance. The measure of distraction by worries was retrospective in the sense that they rated their degree of distraction after they had taken the test. Participants who knew they had performed badly might wish to blame it on distraction by saying that they could have performed better if their worries had not disturbed them so much. If this were the main basis for the results, however, it would presumably have been most pronounced among people who habitually use such self-deceptive, excuse-making strategies. We analyzed carefully for effects of self-deceptive enhancement (trying to fool oneself) and impression management tendencies (trying to fool others) and found nothing. Our findings were obtained despite controlling for those variables. Hence, it seems unlikely that our results were due to making excuses.

The most parsimonious explanation is that people use self-control to prevent anxiety-related worries from interfering with performance. When people's powers of self-control are largely intact, they can succeed at keeping worries at bay and therefore can perform reasonably well. When self-control has been weakened by prior exertion and expenditure of limited willpower resources, however, worries can more readily intrude. Under such conditions, worries distract test-anxious persons and thereby interfere with effective performance.

General Discussion

In the present research, we sought to illuminate why anxiety sometimes impairs test performance and sometimes does not. We found that the impact of anxiety depended on self-control and in fact on the state of the person's self-control resources. We reasoned that anxiety often impairs performance because it evokes worrisome thoughts that distract the person, thereby reducing the attention, mental effort, and time available for doing well on the test. Self-control can be useful for helping the test taker regulate attention so that distracting thoughts can be shoved aside, thereby enabling the person to concentrate more usefully on the test itself. Our findings largely support this analysis.

We found that the currently felt levels of state anxiety impaired test performance among participants who had depleted their self-control resources during a previous task unrelated to the test. This occurred for both verbal learning (Study 1) and arithmetic calculations (Study 2), two major and common types of tests. In contrast, state anxiety had no effect on performance among participants who had not depleted their self-control resources. Taken together, these findings suggest that self-control can be used to enable the person to perform well despite anxiety. Only when the capacity for self-control was weakened did state anxiety lead to poor performance.

We also examined the effects of trait test anxiety (Study 3). Trait test anxiety conceptually involves the predisposition to worry during testing, which appears to be the primary reason for anxiety-related performance decrements (Hembree, 1988; Seipp, 1991). Sure enough, we found that the higher people scored on the worry component of trait test anxiety, the more likely they were to report being distracted by worries while taking the test. Crucially, however, this effect was moderated by self-control resources. The effect was significant among people whose self-control capacity had been compromised, insofar as they had expended some of their resources on a prior, irrelevant task. Among persons whose self-control had been left intact, there was only a weak trend linking higher trait test anxiety to being more distracted by worries during an actual test. Thus, again, people seemed to use their self-control to enable them to concentrate on work without being distracted by worries.

Study 3 confirmed that distraction by worries impaired performance on the arithmetic test. The more distraction people reported,

the worse they did. Among depleted participants, distraction provided a significant, mediating link: Higher levels of trait test-anxious worrying led to more distraction by worries during the test, which in turn led to poor performance. Among nondepleted persons, however, this pathway was not significant. People high in worrying but with their full powers of self-control managed not to let their worries distract them as much, and this prevented these worries from lowering their performance.

Implications and Future Research

We began by noting inconsistencies in prior research findings on test anxiety: Some studies but not others have found that anxiety impairs test performance (Eysenck et al., 2007). Availability of self-control resources may be a fluctuating state that accounts for some of these differences. We replicated both kinds of findings: Anxiety impaired test performance when self-control resources were depleted but had no effect when self-control was intact. Future researchers may profit by attending carefully to whether their participants' self-control resources have been depleted by prior demands or are closer to full strength. Conclusions about the impact of anxiety and worry on test taking may be quite different depending on whether the test was preceded by a refreshing rest or a challenging task (possibly including things that happened prior to the experimental session).

More broadly, our findings may help fill some gaps in evolving theories about test anxiety. Recently, Eysenck et al. (2007) proposed attentional control theory as an improvement on the well-established processing efficiency theory (Eysenck & Calvo, 1992). Both theories invoke attentional processes in working memory to explain how anxiety affects cognitive performance. They assume that anxiety is not generally related to cognitive performance. To explain this, they propose that highly anxious people compensate for any distracting effects by increasing effort. The mechanism behind such compensation has not been fully clear. Our results suggest that self-control is a vital part of that mechanism, which offers the additional advantage that we can explain when anxiety will versus will not impair performance (i.e., depending on the variable state of the person's capacity for self-control). Consistent with that analysis, state self-control and ego depletion have been reliably linked to the experience of effort (see Hagger et al., 2010, for meta-analysis).

Given the great many benefits associated with self-control, we have assumed that having one's self-regulatory resources available is generally a good thing (Baumeister & Alquist, 2009; Tangney et al., 2004). That assumption could be challenged, however, on the basis of findings of adverse effects of mental control. In particular, Wegner (1994) has shown that suppressing thoughts can produce a so-called *rebound effect*, in which the person is plagued by frequent intrusive occurrences of thoughts that were previously suppressed. We much admire that work and do not think it contradicts our findings or our theory. Indeed, one possible explanation for rebound effects is that the person depletes self-regulatory resources by trying to suppress the thought, and once the resources are depleted, the thought can no longer be kept out of mind. Wegner himself proposed that rebound effects occur not while one is trying to suppress but rather only after one ceases trying to suppress the thought. In any case, the present findings do not fit the view that attempts to control one's thoughts are inherently counterproductive. If suppressing thoughts inevitably caused them to occur all the more frequently, then nondepleted anxious participants would have been distracted because they sought to stifle their worries, and their performance would have suffered. That is not what happened. Anxious participants who were not depleted were apparently able to keep their anxieties from distracting them and interfering with their test-taking performance. Thus, our results suggest that conscious mental control and self-regulation are beneficial.

The present findings confirm that effective test performance requires more than being smart and knowing the material. For some people, at least, self-control is highly relevant, not least because it can prevent anxiety from interfering with one's performance. A person may have the requisite knowledge and intelligence to do well, but actually doing well also requires managing attention effectively, such as by maintaining focus on the test and not being distracted by task-irrelevant thoughts, especially including worries about the test. Thus, self-control can help anxious people avoid the cognitive distractions that cause poor performance.

Last, it may be possible to suggest practical applications based on our findings to help people who suffer from test anxiety. Ensuring high levels of self-control resources may help such individuals perform up to their ability level. To help depleted individuals perform better at self-control, it may be useful to prepare for the test with a brief period of relaxation (Tyler & Burns, 2008), an exercise in self-affirmation (Schmeichel & Vohs, 2009), or even a glucose-rich snack (Gailliot et al., 2007). More lasting benefits may be gained by cultivating a lasting improvement in self-control strength by regular exercises (see Baumeister, Gailliot, DeWall, & Oaten, 2006, for review). Such exercises may even be useful in therapy and other self-improvement attempts. Muraven (2010) showed that building self-control strength with simple exercises tripled the rate of success at quitting smoking. School settings might increase the validity of test results by scheduling exams after breaks so that students would have sufficient self-control resources to prevent some of their scores from being artificially lowered by anxiety. It may also be particularly helpful to combine exercises and strategies for the improvement of self-control with other effective methods that alleviate the effects of anxiety on performance (e.g., expressive writing; Ramirez & Beilock, 2011).

In addition to future studies that examine improvements in self-control as a way to cope with negative consequences of test anxiety, it may also be worthwhile to take into account existing individual differences in self-control. Self-control has been investigated extensively as a relatively stable personality trait (de Ridder, Lensvelt-Mulders, Finkenauer, Stok, & Baumeister, 2012; Mischel, Shoda, & Rodriguez, 1989). Individuals high in trait test anxiety but low in trait self-control should suffer the most from intrusive, distracting worries and hence perform worst on tests, if all else is equal. Such individuals could be identified by use of standard measures of trait test anxiety and trait self-control, and help and support could be directed their way. Future work should also incorporate variables that resemble good or poor self-control and have particular relevance in test situations. For instance, people high in *negative urgency*—the tendency to engage in rash action in response to extreme negative affect (Cyders & Smith, 2008)—might sacrifice accuracy for speed when feeling anxious

during test performance. Last, the present approach could be extended to performances by stereotyped individuals. Self-control might contribute to avoiding performance decrements in academic tests that have been found under stereotype activation (e.g., Beilock et al., 2007; Schmader & Johns, 2003).

Limitations and Alternative Explanations

Over the course of this investigation, we tested a variety of factors that might have provided alternative explanations for the present results. Fortunately, the findings have ruled out many of these alternative causes as able to explain our main results. Trait self-esteem was completely unrelated to the present pattern of findings (Study 1). Our global measures of positive and negative affect played no role (Studies 1–3). A measure of self-assurance based on three items from the affect measure likewise yielded nothing (Studies 1–3). Dispositional tendencies toward self-deceptive self-enhancement had no effect on distraction by worries, and likewise dispositional inclinations toward impression management had no effect (Study 3). Those two traits also proved irrelevant to performance on the arithmetic test (Study 3). The same was true for the emotionality component of trait test anxiety, which in theory could explain why test anxiety impairs performance, although past work has found its effects to be minimal in comparison with the worry component. Thus, although emotion, self-esteem, self-efficacy, and social desirability biases have been shown in other contexts to influence performance, they were not responsible for the effects we observed.

The effects of ego depletion cannot be attributed to heightened anxiety. We found that state anxiety levels did not differ as a function of depletion condition (Studies 1 and 2). Thus, the state of self-control resources did not affect levels of state anxiety; rather, they affected the degree to which that anxiety interfered with performance (including by distracting the person with worries). The depletion condition was repeatedly rated as more difficult than the nondepleting task, as it should be, but the two conditions did not differ on other variables, such as ease of recall of subject matter (Study 1) or self-perceived quality of performance on the initial, depleting task (Study 2).

To be sure, the present results have some of the standard limitations of laboratory experiments. Although we sought to make the testing situation feel real and important to participants, it is unlikely that a nonbinding and confidential test taken in a laboratory study can have as much impact as an important test in daily life. Still, this would most likely mean that effects would if anything be stronger outside the laboratory. Another issue is that the sample consisted of young adults in a modern, Western, rich democracy. We would be reluctant to assume that exactly the same patterns would occur in radically different cultural contexts.

Concluding Remarks

Performing well on cognitive tests is an important part of success in schools and universities, as well as in some other domains of modern life. The uncertainties, pressures, and evaluative implications of these tests can often give rise to anxiety. Although the tests are intended to measure knowledge and ability, many people perform below the level of their knowledge and ability because of anxiety. On other occasions, however, people manage to perform well despite anxiety.

Anxiety can impair test performance by distracting the test taker's mind with worries. Our findings have confirmed that anxiety can impair performance. On a more optimistic note, however, we have found that these impairments need not happen, even for highly and chronically test-anxious persons. The human capacity for self-control, when functioning properly, can eliminate the ravages of anxiety on test performance. Impairments occur mainly when self-control resources are at a low point. By recognizing this connection and taking steps to ensure that one's powers of self-control are ready for the test, more people may be able to ensure that their test performance is a valid measure of their abilities and effort. Given the pervasive importance of testing in modern life, such changes and improvements may help produce a fairer society and a better life for many people.

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