

The effects of self-efficacy on physical and cognitive performance: An analysis of meta-certainty

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ABSTRACT

In the present research, we analyzed the effects of self-efficacy (SE) on physical and cognitive performance in real-world settings as a function of the metacognitive certainty in SE. In three studies, participants completed a measure of SE, which asked them to report how sure they were that they can achieve several specific results on various athletic and academic tasks. Moreover, general certainty in their own SE (i.e., SEC) was measured (Studies 1 and 3) or manipulated to be high versus low (Study 2). Relevantly, our studies aimed to obtain a high level of ecological validity by including athletes in natural, real-world settings (i.e., gymnasiums). Furthermore, we sought to extend the findings beyond physical performance by analyzing university students' cognitive performance in their actual academic setting (i.e., classrooms). Specifically, physical performance was assessed with pull-ups (Study 1) and vertical jump tests (Study 2), and cognitive performance was measured with grades on exams (Study 3). As expected, SE was positively related to performance. Most importantly, we predicted and found an interaction between SE and SEC on performance. That is, the effect of SE on physical and cognitive performance was greater for participants with higher (vs. lower) metacognitive certainty in their SE. In conclusion, to increase the explanatory and predictive power of efficacy beliefs across different domains, we propose that the assessment of SE should also include measures of one's metacognitive certainty in SE. In addition, we suggest that interventions on SE could benefit from the use of certainty inductions when including these inductions is possible and convenient.

1. Introduction

Perceived self-efficacy (SE) is defined as “beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments” (Bandura, 1997, p. 3). SE is a core construct of Social Cognitive Theory, as well as the “more central or pervasive” mechanism of Personal Agency Theory (Bandura, 1982, 1986, 1997). As published in numerous systematic reviews and meta-analyses across very different domains, prior research has found that SE influences human functioning through cognitive, motivational, affective, and decisional processes (Bandura, 1997, 2001). Specifically, research has typically shown that SE is positively related to physical (e.g., see Feltz et al., 2008; Samson & Solmon, 2011) and cognitive (e.g., see Honicke & Broadbent, 2016; Richardson et al., 2012) performance. However, several studies have found very low, null, or even negative relationships between SE and performance (e.g., Judge et al., 2007; Sitzmann & Yeo, 2013; Vancouver et al., 2001, 2002; Vancouver & Kendall, 2006; see Bandura, 2012;

Bandura & Locke, 2003; Vancouver & Purl, 2017; for a discussion). Relevantly, research has identified several critical moderators of the effects of SE on athletic (e.g., concordance between measures of SE and measures of performance; see Moritz et al., 2000) and academic (e.g., age; see Talsma et al., 2018) functioning. In the present studies, we propose and test a construct (i.e., the metacognitive certainty in SE) shown to have both theoretical value and practical utility, with the goal of reconciling conflicting results in past research on SE, as well as increasing the predictive validity of SE on performance.

A distinctive feature of Bandura’s Personal Agency Theory is the central role it assigns to one’s capability for *self-reflectiveness* (e.g., Bandura, 2018). This capability enables individuals to consider and reappraise their actions and beliefs, as well as to think about their own thoughts and thought processes (i.e., metacognition). According to Bandura (2018, p. 131), “The metacognitive capability to reflect on oneself and the adequacy of one’s capabilities, thoughts, and actions is the most distinctly human core property of agency.” In accord with this

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view, the recommended assessment of individuals' SE (e.g., Bandura, 1997, 2006) may already be measuring a *metacognitive* judgment that reflects a person's *certainty* in (i.e., the strength of) their efficacy beliefs regarding the achievement of specific results (i.e., "How certain are you that you can do ... ?," e.g., "I am moderately certain that I can do six pull-ups").¹ In the present studies, we go one step further in this metacognitive analysis by examining whether individuals *also* consider their *metacognitive certainty* in their own SE strength-related judgments (i.e., 'certainty about certainty' or *meta-certainty*), and if so, the consequences meta-certainty has for the predictive validity of their SE beliefs on their physical and cognitive performance.²

1.1. Metacognitive certainty

Metacognitive certainty (or simply, certainty) refers to "a person's metacognitive assessment that a thought, feeling, belief, or attitude is valid, clear in one's mind, or correct" (DeMarree et al., 2020, p. 1239; see also Petrocelli et al., 2007; Petty et al., 2007). For instance, an individual might think "I like doing exercise," yet at the same time, this individual can also think about their own attitude: "I am extremely certain that I like doing exercise," or "I am certain that my attitude toward exercise is valid." According to prior theory and research (e.g., Petty et al., 2007), certainty is metacognitive in nature (i.e., 'thinking about thinking') because it is separable from first-order or *primary* cognition (e.g., the belief that "I can jump 20 cm in a vertical jump task"), about which an individual is certain to some degree (e.g., "I am highly certain in this belief," which reflects second-order or *secondary* cognition).

Previous research has extensively studied certainty (also referred to as confidence or conviction) in the realm of attitudes (see Rucker et al., 2014; Tormala & Rucker, 2018; for a review), as well as in the domain of self-concept and self-esteem (see DeMarree et al., 2007; Petty et al., 2007; for a review). For instance, studies have shown that thoughts that are held with certainty are better predictors of attitudes (e.g., Horcajo et al., 2020; Petty et al., 2002), and attitudes that are held with certainty better predict behaviors (e.g., Fazio & Zanna, 1978; Kraus, 1995). In addition, certainty has recently been studied in relation to other individual characteristics such as needs (e.g., Need for Cognition, and Need to Evaluate; see Shoots-Reinhard et al., 2015) and traits (e.g., Santos et al., 2019). For example, Santos et al. (2019) found that participants' trait aggressiveness predicted their aggressive intentions and behavior to a greater extent as certainty in their trait aggressiveness increased.

To our knowledge, the effects of certainty regarding efficacy beliefs remain unexplored. Thus, with the current studies, we extend prior research by analyzing certainty in SE (i.e., the most relevant construct

for personal agency; Bandura, 1997), and more relevantly, examining its effects on performance in real-world physical and cognitive tasks. Importantly, because the recommended assessment of SE (Bandura, 1997, 2006) already involves certainty judgments to some extent (i.e., the strength of SE), the present research analyzes for the first time the role of metacognitive certainty about certainty judgments, and its effects on performance. In short, we measured (Studies 1 and 3) and also manipulated (Study 2) participants' certainty in their SE (namely, 'SE certainty' – SEC), and analyzed the effects of SEC on performance in various *physical* (i.e., pull-ups and vertical jump) and *cognitive* (i.e., exams) tasks in real-world contexts (i.e., in their athletic and academic settings).

In accordance with our theoretical framework, we made two main predictions:

H1. In line with most prior research on SE and performance, we predicted a main effect of SE on physical (Studies 1 and 2) and cognitive (Study 3) performance, such that higher levels of SE would be associated with higher performance.

H2. Most importantly, we predicted an interaction between SE and SEC on measures of physical and cognitive performance. That is, the effect of SE on performance would be greater for participants with higher (vs. lower) levels of SEC.

1.2. Study 1

In the first study, we analyzed the effects of SE and SEC (as predictors) on *physical* performance (i.e., the number of pull-ups, as the dependent variable) in an athletic task during an actual CrossFit®³ training session at a gym.

2. Method

Permission to conduct the three studies of the present research was granted by the university institutional ethics committee. Moreover, we also received permission from gymnasium managers and CrossFit® trainers (Studies 1 and 2), in addition to which all participants were required to read and sign an informed consent form before the studies began.⁴

Participants. Because no prior research had specifically examined our key predicted interaction (i.e., hypothesis 2), an a priori power analysis was performed using G*Power (Faul et al., 2009), which assumed a generic medium value for the interaction effect size (Cohen's $f = 0.25$). Results of this analysis suggested that the desired sample size for a two-tailed test ($\alpha = 0.05$) with .80 power was $N = 128$. Our final sample ($N = 166$) exceeded this goal due to the high turnout in the number of individuals who attended the planned training sessions. Thus, one hundred and sixty-six CrossFit® athletes (30.1% females), from two different gymnasiums located in a metropolitan area of a European city (i.e., Madrid), participated anonymously in this study as part of their actual training. The age of the participants ranged from 18 to 48 ($M_{age} = 32.52$, $SD = 6.91$). Participants' number of months practicing CrossFit® ranged from less than a month to 72 months ($M_{months} = 19.39$, $SD = 16.97$).

Procedure and Variables. Our first study was presented to participants as research on physical performance. All participants first completed the SE measure regarding a relatively well-known pull-ups test (i.e., maximum number of pull-ups until exhaustion). We used a 10-item

¹ SE beliefs differ on some dimensions (i.e., level, generality, and strength) that have important implications for performance. According to Bandura (1997), the relationship between SE and performance varies as a function of the strength of the beliefs in one's capabilities. Thus, in the recommended methodology for assessing SE (i.e., the single-judgment format), individuals are presented with items portraying different levels of task demands, and they rate the *strength* of their SE for every item; for example, ranging in 10-units intervals from 0 ("Cannot do at all"); through intermediate degrees of assurance, 50 ("Moderately certain can do"); to complete assurance, 100 ("Highly certain can do"). A measure of SE *level* can be extracted by selecting a cut-off value below which individuals would judge themselves incapable of executing the task demands. Importantly, because SE strength incorporates SE level, as well as gradations of *certainty* above any threshold value, SE *strength* is generally a more sensitive and informative measure than SE *level* (Bandura, 1997, pp. 42–46; see also; Bandura, 2006).

² To simplify, and in line with most prior research, throughout this manuscript we refer to measures of SE strength simply as *self-efficacy* (SE), and to certainty in measures of SE strength as metacognitive certainty (or simply, *certainty*) in self-efficacy (SEC). In the General Discussion, we further elaborate on the concept of *meta-certainty*.

³ CrossFit is a registered trademark of CROSSFIT, LLC.

⁴ In each of our three studies, we have reported all dependent variables or measures that were analyzed for our target research question. Likewise, all levels of all predictors or manipulations, whether successful or not, have been reported. Finally, the excluded observations or participants (if any) and the reasons for making those exclusions (if any) have also been reported.

measure of SE constructed following the methodological guidelines provided by Bandura (1997, 2006). In line with these guidelines, each participant had to rate “How sure are you that you can successfully perform at each specified level?” from 2 to 20 pull-ups, with increases of 2 pull-ups per item (i.e., 2, 4, 6, 8 pull-ups, etc.). Specifically, they rated their SE from 0 to 10 for every item using single unit intervals from 0 (“Cannot do at all”); through intermediate degrees of assurance, 5 (“Moderately sure can do”); to high assurance, 10 (“Highly sure can do”). Item-ratings were intercorrelated ($\alpha = 0.94$), thus averaged to form a single measure ($M = 3.78$; $SD = 2.72$), where higher scores reflected higher SE.⁵

Next, participants were asked to report their general certainty and confidence in their responses to the SE assessment (i.e., SEC). Specifically, SEC was assessed using two items on an 11-point scale anchored at 0 (“Not at all certain/Not at all confident”) and 10 (“Extremely certain/Extremely confident”). That is, participants were asked “Overall, how *certain* are you in the responses you just gave about the performance you are about to have on the pull-ups test?” and “Overall, how *confident* are you in the responses you just gave?” This measure of SEC was adapted from prior research (e.g., Barden & Petty, 2008; Shoots-Reinhard et al., 2015; Tormala & Petty, 2002).⁶ Ratings were highly correlated, $r(163) = 0.70$, $p < .001$, thus were averaged to create a composite SEC index. Higher scores on this index indicated greater certainty in SE ($M = 8.43$, $SD = 1.28$).

The dependent variable in this study was a physical testing measure in which the number of pull-ups was computed. Participants were asked to perform the maximum number of pull-ups possible ($M = 9.54$; $SD = 7.03$). For each pull-up, they were required to start with fully extended arms and finish with their chin above the bar. Participants were asked to perform the pull-ups until they could not successfully complete another pull-up (e.g., Jones et al., 2018; Vigouroux et al., 2019). Higher values indicated higher physical performance. Finally, each participant provided sociodemographic information (sex, age, and CrossFit® experience as measured by the number of months practicing CrossFit®), and was debriefed by receiving clarifying information about the purpose of the study.⁷

⁵ According to an anonymous reviewer’s recommendation, we analyzed the dimensionality of the SE measures by conducting exploratory factor analyses (EFAs). These EFAs showed the adequacy of the unidimensional structure assumed in this research (see Bateman, Myers, Chen, & Lee, in press; Myers & Feltz, 2007; for a discussion). Specifically, the one-factor solution accounted for sufficient variance (i.e., 62.4% in Study 1; 61.6% in Study 2; and 55.3% in Study 3), as well as revealed item factor loadings above .54 in Study 1, above .32 in Study 2, and above .48 in Study 3 (see Supplementary Materials for additional information regarding dimensionality of SE measures).

⁶ In this study, we also included a third item to assess SEC: “Overall, how *sure* are you about the responses you just gave?” Because this item was not included in the next two studies, to increase consistency between all our studies, we computed the SEC index including only two items (i.e., certainty and confidence). Importantly, all results predicted and found with this two-item measure are replicated when a three-item measure is used (interaction: $B = 0.148$, $t(161) = 2.303$, $p = .023$, 95% CI: 0.021, 0.275). We started this line of studies by including three items because they are the most commonly used in the literature on certainty (e.g., Barden & Petty, 2008). However, the reason we did not include this third item in Studies 2 and 3 was because we noticed that it was measuring the SEC variable with the same wording (i.e., “sure”) used for the SE measure. Thus, in order to avoid a potential overlap between the two measures, as well as a potential bias based on lexical matching, we decided not to include this specific item in the following studies.

⁷ At the very end of each of our three studies, after all planned, relevant measures had been completed, participants were asked to respond to a few additional measures that had different exploratory purposes for future research (e.g., perceived internal versus external origin of efficacy beliefs, see Gascó et al., 2018). None of these additional measures significantly influenced our dependent variables nor moderated the effects predicted and found in our studies. Therefore, these measures are not reported in this manuscript because they had other, very different research objectives.

3. Results

Physical performance (i.e., the number of pull-ups) was regressed onto the predictors (i.e., SE and SEC), as well as their interaction term (i.e., $SE \times SEC$), using a regression analysis which included SE and SEC in the first step, followed by the two-way interaction in the second step. As recommended by Cohen and Cohen (1983), in each of our three studies, all main effects and interactions were interpreted in the first step in which they appeared in the regression analyses.⁸

Consistent with our first hypothesis, the results revealed a main effect of SE, $B = 2.373$, $t(164) = 28.684$, $p < .001$, 95% CI: 2.209, 2.536 ($R^2 = 0.834$), indicating that individuals higher in SE had higher physical performance.⁹ There was no main effect of SEC, $B = 0.270$, $t(164) = 1.539$, $p = .126$, 95% CI: 0.077, 0.617 ($R^2 = 0.014$). Most importantly, the predicted interaction between SE and SEC was significant, $B = 0.181$, $t(161) = 2.996$, $p = .003$, 95% CI: 0.062, 0.300 ($R^2 = 0.056$). As illustrated in Figure 1, among those participants with higher SEC scores (+1SD), SE was positively associated with physical performance, $B = 2.561$, $t(161) = 25.032$, $p < .001$, 95% CI: 2.359, 2.763. However, for those with lower SEC scores (−1SD), a smaller (yet significant) positive relationship emerged between SE and physical performance, $B = 2.099$, $t(161) = 17.192$, $p < .001$, 95% CI: 1.857, 2.340. That is, we predicted and found that SE was more positively associated with physical performance when participants were highly certain in their reported SE. Therefore, as certainty in one’s SE increased, so too did the ability of SE measures to predict physical performance as assessed by the number of pull-ups.

Analyzed differently, this interaction showed that, among participants with higher levels of SE (+1SD), those with higher SEC scores performed significantly better than did those with lower SEC scores, $B = 0.813$, $t(161) = 3.259$, $p = .001$, 95% CI: 0.321, 1.306. In contrast, for participants with lower levels of SE (−1SD), no significant differences were found between those with higher SEC scores and those with lower SEC scores, $B = -0.169$, $t(161) = -0.749$, $p = .455$, 95% CI: 0.615, 0.277.

Additional analyses showed that the $SE \times SEC$ interaction was not further moderated by sex ($B = -0.024$, $t(157) = -0.124$, $p = .902$, 95% CI: 0.406, 0.358), age ($B = -0.006$, $t(157) = -0.671$, $p = .503$, 95% CI:

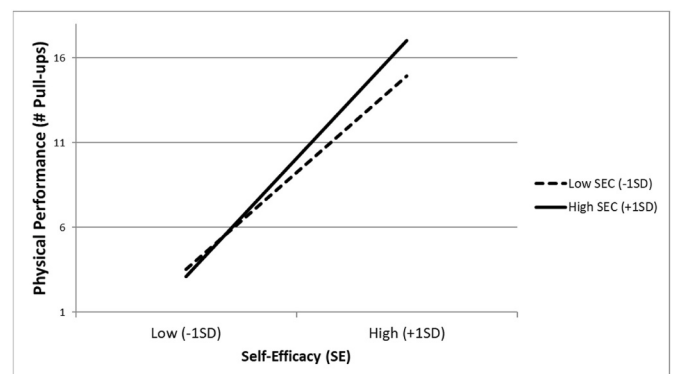


Figure 1. Study 1. Physical Performance (i.e., number of pull-ups) as a function of Self-Efficacy (SE) and Self-Efficacy Certainty (SEC).

⁸ In each of our three studies, the continuous predictor variables were mean-centered to reduce multi-collinearity concerns when computing interaction terms. In addition, the critical two-way interactions were tested using the PROCESS add-on for SPSS (model 1; 1000 bootstrap samples, see Hayes, 2018). This procedure enabled us to compute the simple slopes to plot the graphs.

⁹ In each study, the degrees of freedom might vary as a function of the missing values in some of the variables included in each analysis.

0.025, 0.012), nor CrossFit® experience ($B = 0.007$, $t(157) = 1.632$, $p = .105$, 95% CI: 0.002, 0.016). Furthermore, when each of these variables was included as a covariate to control for its effect, the SE $\times$ SEC interaction remained significant (i.e., with sex, $B = 0.176$, $t(161) = 2.903$, $p = .004$, 95% CI: 0.056, 0.296; age, $B = 0.18$, $t(161) = 2.993$, $p = .003$, 95% CI: 0.060, 0.300; and CrossFit® experience, $B = 0.179$, $t(161) = 2.975$, $p = .003$, 95% CI: 0.060, 0.298).

3.1. Study 2

Because in Study 1 SEC was measured, it is possible that other, unmeasured factors could have been confounded with reported SEC. Thus, in this second study we assessed SE, and SEC was *manipulated* (i.e., certainty vs. uncertainty) in order to more accurately infer its causal role. Physical performance was assessed with a *different task* (i.e., vertical jump in centimeters, as the dependent variable) during another actual CrossFit® training session at a gym. In addition, this study included both baseline and post-intervention assessments to obtain within-participant comparisons with relevant practical implications, as well as measures of other potential moderators (e.g., knowledge about and experience with the vertical jump test).

4. Method

Participants. Assuming a medium SE $\times$ SEC interaction effect of Cohen's $f = 0.24$ (obtained in Study 1), the desired sample size for a two-tailed test ($\alpha = 0.05$) with .80 power was $N = 135$ (as indicated by an a priori power analysis using G*Power, see [Faul et al., 2009](#)). Our final sample ($N = 132$) was slightly below this number because our data collection was limited by the number of participants that were training in the gym for the planned sessions. One hundred and thirty-two CrossFit® athletes (29.5% females), from two different gymnasiums located in a metropolitan area of a European city (i.e., Madrid; both gymnasiums were different than those used in Study 1 to collect that sample), participated anonymously in this study as part of their actual training. The age of the participants ranged from 21 to 53 ($M_{age} = 33.89$, $SD = 7.23$). Participants' number of months training in CrossFit® ranged from less than a month to 120 months ($M_{months} = 30.19$, $SD = 23.83$).

Procedure and Variables. This study was also described to participants as research on physical performance. First, all participants performed a vertical jump test as a baseline measure ($M_{pre} = 30.30$ cm; $SD_{pre} = 7.53$ cm). Second, they completed a SE measure that was specifically tailored to the vertical jump test, as recommended by [Bandura \(1997, 2006\)](#). Specifically, on 10 separate items, from a height of 5 cm–50 cm, in increments of 5 cm per item (i.e., 5, 10, 15 cm, etc.), each participant had to indicate “How sure are you that you can successfully perform at each specified level?,” using single unit intervals from 0 to 10 (see Study 1). Item-ratings were highly intercorrelated ($\alpha = 0.93$), thus averaged to form a single measure ($M = 6.42$; $SD = 2.00$). Higher scores reflected higher SE.

After completing the SE measure, participants were randomly assigned to one of two experimental conditions: certainty vs. uncertainty. That is, as a supposed activity about prototypical situations, participants were asked to describe two past personal episodes regarding a prototypical situation they faced as athletes on a daily basis.¹⁰ On the one hand, in the certainty condition, participants were asked to write down two past instances in which they felt *certainty* and *confidence* during their athletic life. Examples of episodes described in the certainty condition included: “Last Saturday I went wakeboarding for the first time and I was very sure that I would be able to do it with the appropriate instructions,” “I am confident when I climb and I am focused on

the grips, and I'm not afraid,” “When I train squats at the gym,” or “Every time I go into the water to dive.” On the other hand, in the uncertainty condition, participants were asked to write down two past instances in which they felt *uncertainty* and *doubt* during their athletic life. Examples of episodes described in the uncertainty condition included: “Last week when I was weightlifting, I was worried that it was going to hurt, so I did not give the maximum effort,” “When I did my first mountain bike marathon race, I wasn't sure I could do it,” “When I try to lift a weight that I still don't know if I can lift,” or “When I played my first official game in water polo.”¹¹ This manipulation was strengthened by asking participants to indicate either “At this moment, how certain or confident are you?” (i.e., the certainty condition) using a scale anchored by 1 (“Very certain”) to 5 (“Extremely certain”), or “At this moment, how uncertain or doubtful are you?” (i.e., the uncertainty condition) using a scale anchored by 1 (“Very uncertain”) to 5 (“Extremely uncertain”). That is, in each of two experimental conditions, the items and the response options for these items were worded in a different way with the goal of biasing participants' responses in the intended direction (i.e., to lead participants to perceive that they were certain versus uncertain at this moment). It is important to note that the researcher who carried out this study was blind to the certainty (vs. uncertainty) manipulation conditions while applying the intervention.¹²

Immediately after this manipulation, participants were asked to respond to the same two items used in Study 1 as a manipulation check of SEC. That is, “Overall, how *certain/confident* are you in the responses you gave about the performance you are about to have in the next vertical jump test?” Ratings were highly correlated, $r(130) = 0.79$, $p < .001$, thus were averaged to create a composite manipulation check index. Higher scores on this index indicated greater certainty in SE ($M = 7.33$, $SD = 1.61$).

The main dependent variable in this study was assessed using a different operationalization of physical performance than in Study 1; that is, a vertical jump test in which jump height in centimeters was

¹¹ Prior research has shown that similar manipulations have been successful at inducing certainty and uncertainty on the available mental constructs (e.g., [Petty et al., 2002](#); [Requero et al., 2020](#)). For instance, studies on the self-validation theory have demonstrated that, in addition to measuring it, metacognitive certainty can also be manipulated. In the third study of [Petty et al.'s \(2002\)](#) research, participants were asked to carefully read a proposal regarding a university issue and list their thoughts. Next, participants were required to think about past instances in which they experienced either confidence or doubt. Participants who remembered past situations of confidence indicated more certainty in the validity of their thoughts about the proposal than those who remembered situations of doubt, which was consequential for subsequent attitudes towards the proposal. That is, the confidence (vs. doubt) manipulation influenced metacognitive thought confidence. Therefore, we assumed the same theoretical and empirical foundations to manipulate metacognitive certainty in SE.

¹² To randomize participants to conditions, two research assistants unfamiliar with the variables analyzed in the study ordered the questionnaires for the two experimental conditions randomly. After randomization had been established, questionnaires were administered to the participants in the location where each of them was participating. To check for randomization, we compared the sex distribution between the certainty (37.9% male) and the uncertainty (32.6% male) conditions (see [Barkoukis et al., 2015](#); [Horcajo, Paredes, et al., 2019](#), [Horcajo et al., 2020](#); for a similar analysis). The results of a chi-square test indicated no significant difference in the proportions of males and females randomized to the experimental groups, $\chi^2(1) = 0.068$, $p = .794$. In addition, we ran a series of t -tests with age, knowledge-experience with the task, and CrossFit® experience to ensure that the groups did not differ in these other sociodemographic and relevant measures. The results of the t -tests revealed that there were no significant differences in age ($M_c = 33.11$, $SD_c = 7.22$; $M_u = 34.76$, $SD_u = 7.20$; $t[130] = 1.307$, $p = .194$), knowledge-experience with the task ($M_c = 3.87$, $SD_c = 2.56$; $M_u = 3.80$, $SD_u = 2.12$; $t[130] = -0.177$, $p = .860$), and CrossFit® experience ($M_c = 28.06$, $SD_c = 24.49$; $M_u = 32.64$, $SD_u = 23.01$; $t[129] = 1.099$, $p = .274$) across experimental conditions.

¹⁰ Those participants who did not complete this manipulation in the questionnaire were not included in the database, thus their data were not included in the analyses.

computed (e.g., Horcajo, Paredes, et al., 2019). Following Balsalobre-Fernández et al. (2015), the *MyJump2* app was used to measure participants' counter-movement jump (CMJ) performance. Each participant performed a single CMJ as a baseline, and two CMJ in the post-intervention assessment. Participants jumped with hands on their hips, starting from a static standing position and with their legs straight during the flight phase of the jump (e.g., Haekkinen & Komi, 1985). The landing was performed simultaneously with both feet maintaining ankle dorsiflexion. Participants were instructed to jump as high as possible. Scores in the two post-intervention CMJ were highly correlated, $r(130) = 0.96, p < .001$, thus were averaged to compute the dependent variable reflecting physical performance ($M_{post} = 31.03$ cm; $SD_{post} = 7.73$ cm). Higher scores represented a higher vertical jump in centimeters (i.e., higher physical performance).

In this study, other potential moderators were included. Specifically, *knowledge about and prior experience with the vertical jump test* were measured with two items on an 11-point scale anchored at 0 ("Not at all knowledge about/Not at all experience with the vertical jump test") and 10 ("A lot of knowledge about/A lot of experience with the vertical jump test"). Ratings on these two items were significantly correlated, $r(130) = 0.52, p < .001$, thus were averaged to create a composite index. As expected, this physical test was not very familiar or well-known to participants in general ($M = 3.84, SD = 2.36$), with scores ranging from 0 to 10.¹³ *Effort* exerted in the vertical jump test was measured with a 9-point scale (from 1 = "I made little effort" to 9 = "I made a lot of effort"), with scores ranging from 4 to 9 ($M = 7.77, SD = 1.14$). *Attention* paid to the tasks was also measured with a 9-point scale (from 1 = "I paid little attention" to 9 = "I paid a lot of attention"), with scores ranging from 3 to 9 ($M = 7.74, SD = 1.28$).¹⁴ Finally, each participant provided sociodemographic information (sex, age, and CrossFit® experience as measured by the number of months practicing CrossFit®), and was debriefed by receiving information clarifying the purpose of the study.

5. Results

Similar to the first study, a regression analysis was conducted, including SE (mean-centered continuous variable), SEC manipulated (dummy coded), and their interaction term as predictors, the two post-intervention CMJ averaged as the criterion variable, and the baseline measure (mean-centered) as a covariate.¹⁵ As expected, the results revealed a main effect of SE, $B = 2.023, t(129) = 7.089, p < .001, 95\% \text{ CI: } 1.459, 2.588 (R^2 = 0.024)$, indicating that individuals higher in SE had higher physical performance in the vertical jump test. We also found

a main effect of SEC, $B = 2.926, t(129) = 2.571, p = .011, 95\% \text{ CI: } 0.675, 5.178 (R^2 = 0.004)$, indicating that participants in the certainty condition ($M = 32.23, SD = 8.00$) had higher physical performance than participants in the uncertainty condition ($M = 29.68, SD = 7.24$). There was also an effect of baseline performance on post-intervention performance, $B = 0.928, t(127) = 27.151, p < .001, 95\% \text{ CI: } 0.860, 0.996 (R^2 = 0.891)$, indicating that participants who had higher baseline scores also had higher post-intervention scores.

Most importantly, the predicted $SE \times SEC$ interaction was significant, $B = 0.464, t(127) = 2.118, p = .036, 95\% \text{ CI: } 0.031, 0.898 (R^2 = 0.025)$.¹⁶ As illustrated in Figure 2, among those participants assigned to the certainty condition, SE was positively associated with physical performance, $B = 0.482, t(127) = 2.852, p = .005, 95\% \text{ CI: } 0.148, 0.816$. However, for those assigned to the uncertainty condition, no significant relationship between SE and physical performance was found, $B = 0.017, t(127) = 0.103, p = .919, 95\% \text{ CI: } 0.314, 0.348$. Analyzed differently, this interaction showed that, among participants with higher levels of SE (+1SD), those in the certainty condition performed significantly better than did those in the uncertainty condition, $B = 1.402, t(127) = 2.236, p = .027, 95\% \text{ CI: } 0.161, 2.643$. In contrast, for participants with lower levels of SE (−1SD), physical performance did not vary across conditions of SEC, $B = -0.454, t(127) = -0.728, p = .468, 95\% \text{ CI: } 1.686, 0.779$.¹⁷

In addition, a regression analysis including the same predictors revealed a main effect of the SEC manipulation on self-reported certainty (i.e., the manipulation check) as the criterion variable in the expected direction, $B = 0.891, t(129) = 3.743, p < .001, 95\% \text{ CI: } 0.420, 1.362$, indicating that participants in the certainty condition ($M = 7.71, SD = 1.46$) had higher certainty in SE than participants in the

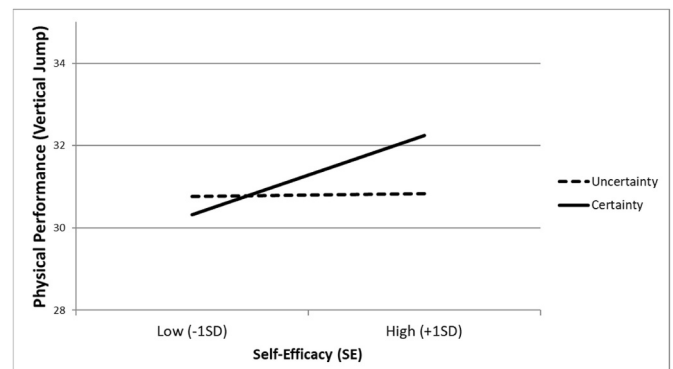


Figure 2. Study 2. Physical Performance (i.e., vertical jump in cm) as a function of Self-Efficacy (SE) and manipulated Self-Efficacy Certainty (SEC).

¹³ The vertical jump test was expected to be less familiar for participants than the pull-ups test (a well-known task in CrossFit®) used in Study 1. In fact, participants reported low knowledge-experience with the vertical jump test, exhibiting a mean of 3.84 on a scale from 0 to 10, which is significantly lower than the mid-point of the scale, $t(131) = -5.670, p < .001$.

¹⁴ We decided to include these measures on *knowledge about and experience with the vertical jump test* as potential moderators because prior experience with a task is "the most influential source of efficacy information" (Bandura, 1997, p. 80). Likewise, within the attitude certainty literature, previous research has demonstrated that attitudes formed via direct experience (e.g., behavioral interaction with the attitude object) are stronger (e.g., held with more certainty) than attitudes formed via indirect experience (e.g., non-behavioral experience; Fazio & Zanna, 1978). In addition, we included measures of *effort* exerted in the vertical jump test, and *attention* paid to the tasks. Obviously, differences in athletes' motivation can have effects on the effort exerted, and as a consequence, that difference in effort can influence performance. Finally, perceived attention is a valid measure of elaboration (e.g., Petty et al., 2002), and elaboration is consequential for metacognition (see Petty et al., 2007).

¹⁵ The critical two-way interaction was again tested using the PROCESS add-on for SPSS (model 1; 1000 bootstrap samples, see Hayes, 2018), while controlling for the baseline measure.

¹⁶ A regression analysis, including the baseline measure as another predictor variable, revealed a non-significant three-way interaction, $B = 0.049, t(126) = 1.545, p = .125, 95\% \text{ CI: } 0.014, 0.111$.

¹⁷ When we used improvement in performance (post-intervention – baseline) as the dependent variable, the $SE \times SEC$ interaction was also significant, $B = 0.441, t(128) = 1.986, p = .049, 95\% \text{ CI: } 0.002, 0.880$. That is, among those participants assigned to the certainty condition, SE was positively associated with improvement, $B = 0.332, t(128) = 2.139, p = .034, 95\% \text{ CI: } 0.025, 0.640$. However, for those assigned to the uncertainty condition, no significant relationship between SE and improvement was found, $B = -0.109, t(128) = -0.684, p = .495, 95\% \text{ CI: } 0.422, 0.205$. Analyzed differently, this interaction showed that among participants with higher levels of SE (+1SD), those in the certainty condition tended to have higher improvement than did those in the uncertainty condition, $B = 1.165, t(128) = 1.863, p = .065, 95\% \text{ CI: } 0.073, 2.402$. In contrast, for participants with lower levels of SE (−1SD), improvement did not vary across conditions of certainty versus uncertainty, $B = -0.597, t(128) = -0.951, p = .344, 95\% \text{ CI: } 1.838, 0.645$.

uncertainty condition ($M = 6.90$, $SD = 1.68$). We also found a main effect of SE on this measure, $B = 0.390$, $t(129) = 6.537$, $p < .001$, 95% CI: 0.272, 0.508. No two-way interaction emerged, $B = -0.094$, $t(127) = -0.784$, $p = .435$, 95% CI: 0.332, 0.144. In short, results from our second study replicated and extended the findings found in the first study by using a SEC manipulation (which successfully influenced certainty in SE), a baseline measurement to account for within-subjects variability, as well as including a different physical task (i.e., the vertical jump test) as the dependent variable.

Moreover, the potential moderating role of the additional variables included in this study was analyzed, revealing that the critical SE $\times$ SEC interaction was not further moderated by sex ($B = -0.876$, $t(124) = -0.706$, $p = .481$, 95% CI: 3.331, 1.579), age ($B = -0.008$, $t(124) = -0.100$, $p = .921$, 95% CI: 0.166, 0.151), CrossFit® experience ($B = -0.036$, $t(124) = -1.499$, $p = .137$, 95% CI: 0.084, 0.012), knowledge-experience with the vertical jump test ($B = -0.173$, $t(124) = -0.708$, $p = .481$, 95% CI: 0.655, 0.310), effort ($B = -0.038$, $t(124) = -0.067$, $p = .947$, 95% CI: 1.147, 1.071), nor attention ($B = -0.650$, $t(124) = -1.521$, $p = .131$, 95% CI: 1.497, 0.196). Furthermore, when each of these variables was included as covariate to control for its effect, the SE $\times$ SEC interaction remained significant (i.e., with sex, $B = 0.449$, $t(126) = 2.037$, $p = .044$, 95% CI: 0.013, 0.886; age, $B = 0.461$, $t(126) = 2.089$, $p = .039$, 95% CI: 0.024, 0.897; CrossFit® experience, $B = 0.474$, $t(126) = 2.148$, $p = .034$, 95% CI: 0.037, 0.910; knowledge-experience with the vertical jump test, $B = 0.459$, $t(126) = 2.087$, $p = .039$, 95% CI: 0.024, 0.894; effort, $B = 0.470$, $t(126) = 2.177$, $p = .031$, 95% CI: 0.043, 0.897, which had a significant main effect on performance, $B = -0.438$, $t(126) = -2.262$, $p = .025$, 95% CI: 0.821, -0.055 ; and attention, $B = 0.464$, $t(126) = 2.109$, $p = .037$, 95% CI: 0.029, 0.900).¹⁸

5.1. Study 3

In the third study, we sought to generalize the effects found in our prior studies beyond physical to *cognitive performance* because cognitive functioning is also related to sports performance in different tasks (e.g., see Hernández-Mendo et al., 2019; Moran et al., 2019; for a review). Thus, to examine our hypotheses regarding cognitive performance in a context with high ecological validity, we assessed SE and SEC (as predictors), and measured performance through actual exam grades (as the dependent variable) in two different courses.

6. Method

Participants. Both of our prior studies found the predicted SE $\times$ SEC interaction effect on physical performance with a medium effect size (averaged $f = 0.201$). Assuming this averaged f , the desired sample size for a two-tailed test ($\alpha = 0.05$) with .80 power was $N = 199$. Our final

sample ($N = 197$) was slightly below this number because our data collection was limited by the number of students who were present the day of the exam. Thus, one hundred and ninety-seven undergraduate students (58.4% females), from a large public university located in a European city (i.e., Universidad Autónoma de Madrid), participated anonymously in this study. Participants were recruited in exchange for course credit, from two different courses within the second and third year of the Bachelor in Psychology, and all spoke the same language of the exam as their native language (i.e., Spanish). The age of the participants ranged from 19 to 28 ($M_{age} = 20.49$, $SD = 1.56$).

Procedure and Variables. This study was presented to participants as research on students' expectations in an academic context. As in our two prior studies, all participants first completed the SE measure on 10 separate items that were specifically tailored to grades on exams. That is, each participant had to rate "How sure are you that you can successfully perform at each specified level?," from 1 to 10 points on the exam, with increases of 1 point per item (i.e., 1, 2, 3 points, etc.). As in our prior studies, they rated their SE from 0 to 10 for every item ranging in single unit intervals. Item-ratings were intercorrelated ($\alpha = 0.92$), thus averaged to form a single measure ($M = 7.21$; $SD = 1.42$). Higher scores reflected higher SE.

Next, participants reported their general certainty and confidence in their responses to the SE measures by completing the same two items used in our prior studies. Ratings were highly correlated, $r(195) = 0.87$, $p < .001$, thus were averaged to create a composite measure of SEC. Higher scores on this index indicated greater certainty in SE ($M = 7.30$; $SD = 1.47$).

Participants' cognitive performance was assessed as their grades on the exams. Grades are one of the dominant measures to capture cognitive performance in academic settings (see Richardson et al., 2012). Both exams were multiple choice, with three different response options, where only one was correct. Exam scores could range from 0 (minimum) to 10 (maximum) points. Higher values on this measure indicated higher cognitive performance ($M = 7.09$; $SD = 1.94$). Finally, each participant provided sociodemographic information (sex and age), then was debriefed by receiving clarifying information about the study.

7. Results

Using a regression analysis, SE, SEC (both mean-centered), and the interaction term (i.e., SE $\times$ SEC) were entered as predictors, and cognitive performance (i.e., the exam grades) was entered as the criterion variable. As expected, the results revealed a main effect of SE, $B = 0.449$, $t(194) = 4.746$, $p < .001$, 95% CI: 0.263, 0.636 ($R^2 = 0.070$), indicating that participants higher in SE showed higher cognitive performance (i.e., better scores on the exam). We also found a main effect of SEC, $B = -0.337$, $t(194) = -3.697$, $p < .001$, 95% CI: 0.517, -0.157 ($R^2 = 0.066$), indicating that individuals lower in SEC had higher cognitive performance.

Most importantly, the predicted SE $\times$ SEC interaction was significant, $B = 0.112$, $t(193) = 2.012$, $p = .046$, 95% CI: 0.002, 0.221 ($R^2 = 0.020$). As illustrated in Figure 3, among those participants with higher SEC scores (+1SD), SE was positively associated with cognitive performance, $B = 0.595$, $t(193) = 5.019$, $p < .001$, 95% CI: 0.361, 0.828. However, for those with lower SEC scores (-1SD), there was a smaller (yet significant) association between SE and cognitive performance, $B = 0.267$, $t(193) = 2.045$, $p = .042$, 95% CI: 0.010, 0.525. Analyzed differently, this interaction showed that, among participants with higher levels of SE (+1SD), no significant differences were found between those with higher SEC scores and those with lower SEC scores, $B = -0.155$, $t(193) = -1.212$, $p = .227$, 95% CI: 0.408, 0.097. In contrast, for participants with lower levels of SE (-1SD), those with lower SEC scores performed significantly better than those with higher SEC scores, $B = -0.471$, $t(193) = -4.194$, $p < .001$, 95% CI: 0.692, -0.250 . Therefore, these results showed that the effects found in our prior two studies can be generalized beyond physical to cognitive performance, as assessed by

¹⁸ As suggested by an anonymous reviewer, several additional analyses were performed. On the one hand, we included the measure of metacognitive certainty (i.e., the manipulation check for SEC) as the criterion variable, and the composite measure of task knowledge-experience along with self-efficacy (i.e., SE), as well as the interaction term (i.e., knowledge-experience $\times$ SE) as the predictors. The results of this regression analysis revealed that task knowledge-experience was not a significant predictor of the manipulation check for SEC, $B = 0.055$, $t(129) = 1.006$, $p = .316$, 95% CI: 0.053, 0.162. Likewise, the interaction between SE and knowledge-experience on metacognitive certainty was not significant, $B = -0.037$, $t(128) = -1.433$, $p = .154$, 95% CI: 0.089, 0.0614. On the other hand, experience with CrossFit® as a predictor (instead of task knowledge-experience) did not significantly predict metacognitive certainty (Study 1: $B = 0.004$, $t(162) = 0.617$, $p = .538$, 95% CI: 0.009, 0.017; Study 2: $B = 0.003$, $t(130) = 0.572$, $p = .569$, 95% CI: 0.007, 0.013). Moreover, the interaction between CrossFit® experience and SE on the reported certainty in SE was also not significant (Study 1: $B = 0.002$, $t(166) = 0.793$, $p = .429$, 95% CI: 0.003, 0.007; Study 2: $B = 0.001$, $t(127) = 0.216$, $p = .830$, 95% CI: 0.005, 0.006).

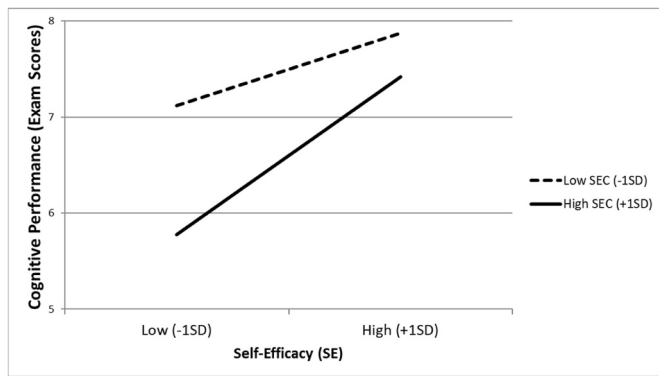


Figure 3. Study 3. Cognitive Performance (i.e., exam scores) as a function of Self-Efficacy (SE) and Self-Efficacy Certainty (SEC).

grades on actual exams for university students in their natural academic setting.

As in our prior studies, the SE $\times$ SEC interaction was not further moderated by sex ($B = -0.062$, $t(189) = -0.540$, $p = .590$, 95% CI: 0.290, 0.165), nor age ($B = 0.016$, $t(189) = 0.323$, $p = .747$, 95% CI: 0.081, 0.113). Furthermore, when each of these variables was included as a covariate, the SE $\times$ SEC interaction remained significant (i.e., with sex, $B = 0.127$, $t(192) = 2.313$, $p = .022$, 95% CI: 0.019, 0.236; and age, $B = 0.114$, $t(192) = 2.044$, $p = .042$, 95% CI: 0.004, 0.223).

8. General Discussion

Results from three studies supported our hypotheses showing that SE had a greater impact on performance for participants with higher (vs. lower) levels of SEC in both real-world athletic and academic contexts. These findings make a novel and meaningful contribution to the SE literature for several reasons. First, the role of certainty can help understand results from prior studies that have shown low (or null) relationships between SE and performance (e.g., Judge et al., 2007). For example, in Study 2, where certainty was manipulated, participants in the uncertainty condition showed no significant association between SE and performance. Thus, we suggest that to increase the explanatory and predictive power of SE beliefs across very different domains, the assessment of SE should also include measures of metacognitive certainty, such as the ones utilized in the present studies. Furthermore, we think that a strong and ‘resilient SE’ (i.e., enduring and impactful) would likely include high metacognitive certainty. Therefore, we suggest that interventions on SE could benefit from the use of certainty inductions when including these inductions is possible and convenient.

Second, metacognition is deeply embedded in Bandura’s theories (1986, 1997), and the present research has examined a metacognitive construct such as certainty in relation to efficacy beliefs. Thus, our

studies have analyzed for the first time the metacognitive role of certainty in one’s judgments of certainty (i.e., SE strength), demonstrating that *meta-certainty* is impactful when predicting both physical and cognitive performance.¹⁹ In line with our results, Petty et al. (2007, p. 256) proposed that “it is possible to consider third-order cognition in which people are asked to make one metacognitive judgment about another...,” but “no research to date has systematically examined third-order cognition.” In fact, the effects of meta-certainty examined in the present studies may be considered among the first pieces of empirical evidence of third-order or *tertiary* cognition. Most relevant to sport psychology, we demonstrated that meta-certainty was consequential for physical performance in two sports tasks (i.e., pull-ups and vertical jump), and these findings were extended to cognitive functioning in academic performance.

Although these results provided support for our hypotheses, the magnitude of the effect sizes was relatively moderate or small. Future research should explore new ways to increase the magnitude of the effects found in the present studies. Nevertheless, even small effects of one intervention can sometimes accumulate over time to be important (see Abelson, 1985). This is a very relevant question for SE research because prior experience is “the most influential source of efficacy information” (Bandura, 1997, p. 80). For example, if an intervention produces a small improvement in an individuals’ physical or cognitive performance, this improvement might subsequently increase their efficacy beliefs. In turn, this could yield a meaningful increase in future performance as a consequence of small effects accumulated over time. Most relevantly in the domain of sports, if an athlete jumps only 1 cm higher (i.e., a relatively small effect) as a result of an intervention on SE, this can make the difference between winning or losing in a competition. Therefore, even small statistical effects can be very relevant for SE and sports performance.

There remain several important issues that could be addressed through future studies. Notably, future research should examine the main effect of SEC on performance because it varied widely through our studies. For example, future studies could focus on examining potential moderating variables that can shed light on *when* one can expect either a main effect in one direction or the other, or a null effect.²⁰ Most importantly, our research did not include an analysis of the *mediating processes* that accounted for the effects found in our studies. That is,

¹⁹ The measures of self-efficacy recommended by Bandura (1997, 2006) include an assessment of SE level, as well as gradations of certainty (i.e., SE strength). Thus, we cannot be sure about the extent to which these SE measures assess a metacognitive component. Our contribution revolves around the fact that we add an actual metacognitive assessment in relation with the SE beliefs. That is, we propose to specifically assess what individuals think about their own responses regarding their SE beliefs. Furthermore, as predicted and found in the present research, it is consequential for their physical and cognitive performance. In sum, because the recommended assessment of SE implies to some extent certainty in how one can reach specific results, we propose the ‘meta-certainty’ concept to refer to the general certainty in one’s responses to *those* SE measures. However, when SE measures are assessing only SE level (but not SE strength/certainty; see Bandura, 1997), then it would be more appropriate to say simply ‘certainty in SE’ (i.e., SEC), such as it is used in the attitude certainty literature.

²⁰ We did not provide a hypothesis for the main effect of metacognitive certainty in SE because it was not entirely clear what to expect. That is, previous research on the moderating role of certainty on different traits in some cases found a null main effect of certainty (e.g., *trait aggressiveness*, Santos et al., 2019), but in other cases found a positive or a negative main effect (e.g., *identity fusion*, Paredes et al., 2020). Thus, we did not have a clear a priori prediction for SEC. Furthermore, in the present studies, we found three possible outcomes for this variable: a null main effect in Study 1, a positive main effect in Study 2, and a negative main effect in Study 3. Although we did not propose a specific hypothesis regarding the main effect of SEC, we would like to emphasize that our clear prediction was the interaction between SE and SEC. Therefore, our key prediction for SEC was an interaction effect rather than a main effect.

meta-certainty could influence the relationship between SE and performance through some more concrete cognitive, motivational, affective, or decisional processes (see Bandura, 1997). We suggest that the specific mediating process would likely arise as a function of the specific realm of activity and the individuals' capabilities involved in a specific task. Future research should examine this very relevant question.

In addition, we did not assess the sources of individuals' SE (e.g., enactive experience, vicarious experience, etc., see Bandura, 1997). Because prior research has found that those different sources can differentially affect the levels of SE in some realms of functioning (e.g., Ashford et al., 2010; Byars-Winston et al., 2017), we suggest that future research should analyze whether distinct sources of SE beliefs produce distinct levels of SEC under some specific circumstances (i.e., for *who*, *when*, and *why*). Likewise, variables such as task relevance, personal responsibility or importance of the consequences could influence the effects found in our studies. According to prior research on metacognition (e.g., Horcajo et al., 2014; Petty et al., 2002), the extent of elaboration (i.e., deliberative thinking) is a key moderator indicating when metacognitive processes are likely to occur (see Petty et al., 2007). In addition, prior research has shown that relevance, responsibility or importance can influence the motivation to elaborate (see Petty & Cacioppo, 1986). The accumulated research on metacognition suggests that for secondary cognition processes to matter, individuals need to have some available thoughts or mental constructs (i.e., primary cognition) to think about, as well as some motivation to think about them. In our studies, telling participants (i.e., athletes) that physical performance was going to be assessed likely increased the perceived relevance/importance of the physical tasks (Studies 1 and 2). Obviously, we assumed that the exam was relevant/important for participants (i.e., university students) in Study 3. Nevertheless, future research should empirically analyze whether these (and other) variables influencing the extent of elaboration can affect certainty in SE, and whether it is consequential for individuals' physical and cognitive performance. To examine this question, future research could benefit from including measures and manipulations of elaboration, as used in the attitude literature (e.g., Horcajo & De la Vega, 2014; Horcajo, Santos, et al., 2019; Horcajo & Luttrell, 2016).

Moreover, future studies should also examine the moderating role of other aspects related to the task (e.g., familiarity or complexity). Thus, future research should analyze whether the effects found in our studies can be generalized to extremely novel or complex tasks. In addition, other physical and cognitive (especially, more related to sports) measures of performance should be examined in future research. Furthermore, future studies should also analyze whether the effects found in the present studies are generalizable (or whether they have different consequences) beyond performance to other relevant domains of human functioning (e.g., health-related behaviors, organizational behavior, etc.), other tasks beyond the sport and academic context, and with other populations beyond athletes and students, to further test the generalizability of these findings. Nonetheless, when our findings are taken together, the results have supported our predictions using a variety of tasks (i.e., pull-ups, vertical jump, and exam grades), which already speaks to the generalizability of the effects across a number of different tasks and settings.

Finally, future research should also test whether our findings extend to other efficacy beliefs such as *collective efficacy* (e.g., Bandura, 1997; 2000) and its effects on collective functioning (e.g., Stajkovic et al., 2009). Moreover, other potential (individual and situational) moderating factors should be explored, such as, for instance, individual differences in the propensity to hold efficacy beliefs with certainty (see DeMarree et al., 2020, for an example on attitude certainty), as well as cultural/societal differences responsible for the levels of SE and its changes over time (see Jiao et al., 2021), should be analyzed in future studies. In sum, we think that the construct of 'metacognitive certainty about efficacy-related certainty judgments' (or herein called *meta-certainty*) is a valuable conceptual (as well as "procedural" regarding its

assessment) contribution to the study of efficacy beliefs and its effects on human functioning. Specifically, we propose that this contribution is relevant and consequential for sport and exercise psychology as predicted and found in our studies. Therefore, we encourage sports researchers to use certainty measures as a moderator of SE effects because of their ease of application and their impact on the predictive validity of SE measures on physical and cognitive performance (and beyond). Furthermore, including an assessment of metacognitive certainty requires only a few extra items, thus has a minimal effect on the length of the research protocol or the intervention, in addition to which participants find it easy to respond to items about certainty (Santos et al., 2019).

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.psychsport.2021.102063>.

Declaration of competing interest

Authors declare not conflicts of interest.

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Availability of data and material

Access to data and/or material can be sought via contacting the corresponding author.

Authors' contributions

"JH developed the studies concept. All authors contributed to the studies design. Testing and data collection were performed by JH and GH. JH and DS performed the data analysis and interpretation. JH and DS drafted and revised the manuscript, and GH provided revisions. All authors approved the final version of the manuscript for submission."

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