


True grit? The perception of a partner's effort boosts cognitive control to sustain commitment in joint action[☆]

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ABSTRACT

Recent research has produced evidence that the perception of a partner's effort increases people's sense of commitment to joint actions, leading to increased effort, persistence and performance on boring and effortful tasks (Székely & Michael, 2018; Chennells & Michael, 2018). However, the cognitive and motivational processes underlying these effects remain unclear. The current study was designed to test the hypothesis that the perception of a partner's effort leads to the increased engagement of executive control mechanisms (inhibitory control and supervisory attentional control) to maintain task focus and to avoid temptations and distractions. To this end, we manipulated the perception of a partner's effort using the same stimuli as in Székely & Michael (2018), and measured how participants responded to the commission of errors (post-error reaction time) on a go/no-go task. The results showed that participants decelerated more after errors in the High Perceived Effort condition than in the Low Perceived Effort condition. Insofar as deceleration after an error is a marker of increased supervisory attentional control, our findings suggest that the perception of a partner's effort may boost cognitive control to shield off the temptation to abandon the joint action.

1. Introduction

We humans cooperate more flexibly and in a wider variety of contexts than other species, even setting aside short-term interests to maximize the benefits to our interaction partners and our larger social groups. (e.g. Konvalinka et al., 2010; Melis & Semmann, 2010; Silk et al., 2009). Given the centrality of cooperation for human sociality, it is plausible that evolutionary selection pressures have given rise to prosocial motivations, which lead us to contribute to others' goals and to shared goals even when we may not individually be so inclined (Henrich & Henrich, 2007; Tomasello, 2009; West et al., 2007). Such prosocial motivations ensure that we are viewed by others as reliable and valuable partners, and that we are accordingly selected to benefit from mutually beneficial opportunities to cooperate in the future (Barclay & Willer,

2007; Baumard et al., 2013).

This does not mean that we contribute to the goals of others indiscriminately – such a general tendency would lead to an excessive expenditure of time, energy and other resources, making it impossible to contribute adequately when valuable relationships and our reputation is at stake. Instead, it has been suggested that humans have evolved heuristics for identifying instances where contributing to others' goals or shared goals is important for their reputation and/or for a valuable relationship. Such heuristics motivate contributions even as the individual cost increases or the individual reward value decreases (Heintz et al., 2015). In this vein, Michael et al. (2016a, 2016b) hypothesized that the motivation to remain engaged in joint actions and to resist tempting alternative options and distractions is governed by an implicit sense of commitment which is modulated by the amount of effort that

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one's partner has invested in the joint action. Imagine, for example, that you have agreed to attend a cocktail party at your colleague's apartment but, on the occasion, find yourself tired or otherwise tempted to leave after only a short time. If your colleague has obviously invested a great deal of effort in preparing the hors d'oeuvres and decorations, you might find that a sense of commitment leads you to stick around for a few hours after all.

And indeed, this hypothesis has been supported by evidence from previous research. Székely and Michael (2018), for example, reported that the perception of a partner's effort increases people's sense of commitment to joint actions, leading to increased effort, persistence and performance on boring and effortful tasks. Using the same stimuli as in Székely and Michael's (2018) study, Chennells and Michael (2018) found that participants were willing to invest more effort and also earned greater joint rewards when they perceived what they believed were cues of a partner's high effort than when they perceived cues which they were led to interpret as indicating a low degree of effort. In addition, recent studies (Székely, Butterfill, & Michael, 2024; McEllin et al., 2023; McEllin & Michael, 2022) demonstrated that under certain circumstances, people are more motivated to exert effort (or contribute money) when they perceive others exerting a higher level of effort rather than a lower level of effort - even when it is irrational to do so within the context of the task.

Consistent with this, recent research has also provided evidence that other contextual factors, which may be perceived as indicative of effort investment, may also boost the sense of commitment in joint action. One study, for example, revealed evidence that a high degree of *spatiotemporal coordination* within joint action (i.e. the two agents form a chain in cleaning up a pile of sand, with one agent scooping and the other pouring) can engender a greater sense of commitment than would be present if there were only a low degree of spatiotemporal coordination (i.e. the same two agents do not form a chain but, rather, work in parallel) (Michael et al., 2016b; Ooi, Francóva, Székely, & Michael, 2019). Similarly, Bonalumi et al. (2019) reported evidence that the mere repetition of a joint action increases individuals' sense of being committed to continuing and/or repeating the task.

However, the cognitive and motivational processes underlying these effects remain unclear. To address this, Michael (2022) has recently proposed a distinction between two forms of commitment which may underpin these effects. The first form of commitment may be dubbed *grittled teeth commitment*. This is the form of commitment you experience when you find yourself bored or distracted, or otherwise tempted to abandon a goal, but nevertheless force yourself to persevere, and to resist temptations and distractions. For example, you may be highly committed to the task of painting the walls of a room in the sense that you turn off the volume on your phone so as not to be distracted by messages, and close the windows so that you are not tempted to listen to the conversations on the street outside. The second form of commitment may be dubbed *engaged commitment*. This is the form of commitment you experience when you are so immersed in pursuing a goal that you do not notice temptations or distractions in the first place, and therefore do not need to force yourself to ignore or resist them. For example, you may be highly committed to the task of painting the walls of a room in the sense that you find yourself so immersed in painting that you do not even notice the messages arriving on your phone or on the conversations taking place outside the open window.

Following on this distinction between two forms of commitment, we may distinguish two separate hypotheses regarding the mechanisms by which the perception of a partner's effort may boost commitment to a joint action: the *grittled teeth commitment hypothesis* and the *engaged commitment hypothesis* (Kaufmann et al., 2025). The former relies on the deployment of executive control mechanisms (inhibitory control and supervisory attentional control) to maintain task focus and to avoid temptations and distractions (Aron et al., 2004; Friedman & Miyake, 2004). Accordingly, it may be associated with 'response inhibition' (Bunge et al., 2001), and involve the activation of a number of regions in

PFC, including bilateral ventrolateral (R BA 44/45, L BA 44) and dorsolateral (BA 9/46) regions; also anterior and posterior cingulate cortices (BA 32, 30/23), left superior and inferior parietal lobules (BA 7, 39), bilateral precuneus (BA 19), right temporal lobe (BA 39, 21), and right cerebellum. In contrast, the latter boosts the relative salience and attractiveness of task-relevant information, making task-irrelevant stimuli in the environment and task-irrelevant thoughts less tempting or distracting than they otherwise would be. Accordingly, engaged commitment may depend upon interference suppression, which is the capacity to selectively manage and mitigate the impact of external and internal distractions that interfere with the execution of intended actions (Cf. Interference suppression (Bunge et al., 2001): right-lateralized ventrolateral PFC (BA 44, 45, and 47) and insula (BA 13) and bilateral inferior parietal lobule (BA 40) and putamen.

We believe that the gritted teeth/engaged commitment distinction provides a useful scaffold for exploring the mechanisms which may underlie the sense of commitment. However, we would like to emphasize that we do not see engaged and gritted teeth commitment as mutually exclusive or as two dichotomous mechanisms. On the contrary, they are likely to be sustained by partly overlapping cognitive and motivational mechanisms. In addition, people may easily shift between them even within one context. For example, you may begin the task of painting the walls of a room with low intrinsic motivation and a sense of boredom. To persist and resist the temptation of choosing immediately more rewarding activities (such as reading messages on your phone), you need effortful control such as the inhibition of your impulse to reach for your phone (cf. synchronic self-control; Bermúdez, 2021). Alternatively, to persist, you may remove foreseeable but not currently dominant temptations, e.g., by turning off your phone (cf. diachronic self-control; Bermúdez, 2021). So far these are examples of gritted teeth commitment. However, later this may shift toward engaged commitment. You may spontaneously discover aspects of the task that align with personal interests, and you may also find an immediate pleasure from the activity itself. Alternatively, you may facilitate this shift with effortful control by reappraising the task, e.g., by imagining that you paint your dream vacation on the walls.

The present study was designed to test the gritted teeth commitment hypothesis, i.e. to probe whether the perception of a partner's effort (high or low) in a joint action boosts the deployment of executive control mechanisms (inhibitory control and supervisory attentional control) to maintain task focus and to avoid temptations and distractions. To this end, we developed a social version of the sustained attention to response task (SART) developed by Robertson and colleagues (1997; see also Manly et al., 1999; Smallwood et al., 2004). The SART is a go/no-go task: participants must respond with a spacebar press whenever a digit appears on the screen, unless that digit is a '3', in which case they must withhold their response. Since the '3' is displayed relatively infrequently (the frequency can be varied), participants are inclined to forget about this component of the task and to fall into a routine of pressing the spacebar whenever any digit appears. Indeed, the longer the period of time/number of trials without a '3', the more likely such false alarms become. In order to avoid such mistakes, participants must actively hold the task instructions in mind (indeed, it is in this sense that the SART is a test of top-down supervisory attentional control). And when participants do incorrectly respond on no-go trials, they tend to decelerate on subsequent trials and to register fewer false alarms, which indicates the engagement of executive control to re-establish the task set in working memory.

In the current study, we capitalized on this phenomenon of post-error deceleration to test the gritted teeth commitment hypothesis. We decided to focus on post-error slowing because we reasoned that this may be a unique marker of gritted teeth commitment insofar as it indicates an effort to *reestablish* a task set after one's attention has begun to wane or one has succumbed to distractions. In contrast, we expected that both forms of commitment may increase participants' performance (fewer errors and/or faster responses). If so, then we should see a more

pronounced post-error deceleration when the partner invested a lot of effort into the joint action (i.e., the High Perceived Effort condition) compared to when they invested only a little effort into the joint action (i.e., the Low Perceived Effort condition). To manipulate the perception of a partner's effort, we used the same stimuli as in Székely and Michael (2018, 2023a, 2023b) (see Fig. 1).

2. Method

2.1. Transparency and openness

The hypotheses, sample sizes, methods, and initial analyses were all pre-registered before data collection. The pre-registration can be accessed at: <https://aspredicted.org/blind.php?x=3kw9rm>. All data and analysis code are available at https://osf.io/d5qya/?view_only=d0bb5ec4393c4680921167f1ffcc0a25.

2.2. Participants

Using G*Power 3.1 (Faul et al., 2009) we determined that a sample size of 37 would provide 80% statistical power for detecting a medium-sized effect ($d = 0.475$) equivalent to what we observed in a previous study using the same stimuli (Székely & Michael, 2018), assuming a two-tailed paired samples t -test and an alpha level of 0.05. We recruited 38 participants as we tested in groups of 2. Nine participants were excluded as per our pre-defined exclusion criteria, leaving 29 participants in our sample (18 women; age range: 18-36, $M = 23.51$, $SD = 4.76$). This sample was the basis of our analyses (see further power analyses in Results). For recruitment, we used the participant database at the University of Warwick (UK), where the experiment was conducted. All participants were naïve to the purpose of the study, reported normal or corrected to normal vision, and gave informed consent prior to the experiment. The experiment was conducted in accordance with the Declaration of Helsinki and was approved by the Humanities & Social Sciences Research Ethics Sub-committee (HSSREC) at the University of Warwick. All participants were given the full bonus payment of £2 in addition to the show-up fee of £6, and thus £8 in total for their participation.

2.3. Apparatus and stimuli

The experiment was displayed on a 13-inch computer screen (resolution: 2560 x 1600 pixels, refresh rate: 60 Hz). The program for the experiment was written in Python (Peirce, 2007), with a framerate of 17 frames per second.

2.4. Procedure

Test sessions were conducted between 7:00 and 9:00 in order to maximize the number of errors that participants made, since previous research (Manly et al., 2002) has shown that participants are less alert and commit more errors on the sustained attention to response task (SART) in the early morning than at other times during the day. For each session, two participants were recruited. At the beginning of each session, participants were first introduced to the other participant who had signed up for that slot, and told that this other participant would be their partner for the experiment, and would be participating in the adjacent room. They were informed that the task consisted of two distinct roles, one for Player A and one for Player B. They were told that they would first receive some general information about each role, and then be randomly assigned to one role or the other. They were informed that Player A would have the task of monitoring a computer screen and responding as quickly and accurately to targets as they appeared, whereas Player B would have the task of solving a captcha before each round in order to unlock the round.

Participants were then escorted to individual rooms, where they were informed of the role which they would be playing in the experiment. In reality, all participants were assigned the role of Player A. The captcha task (i.e. the role of Player B) was performed by an algorithm. At the beginning of each block, a video was presented in which stars progressively appeared to indicate that the partner was solving a captcha, and finally the completed captcha key was displayed (See Fig. 1). This unlocked the next phase of the block, which the participant initiated with a key press. On the SART, participants had to respond with a spacebar press whenever a digit appeared on the screen, unless that digit was a '3', in which case they had to withhold their response.

The experiment commenced with one practice block consisting of a

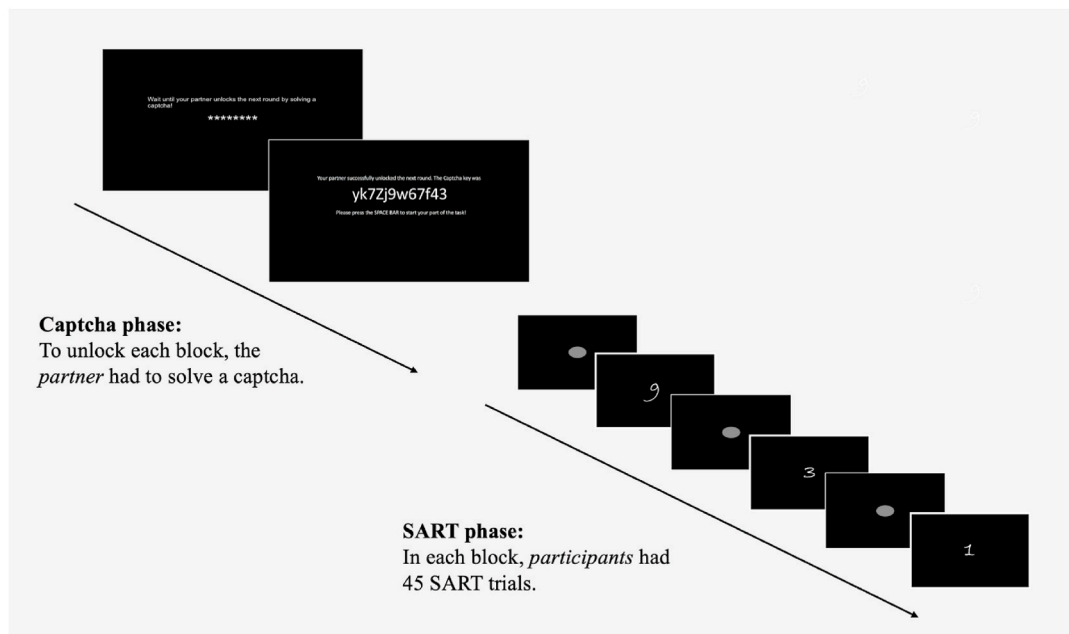


Fig. 1. Block and Trial Structure. Each test block began with the perceived effort investment (high or low) of the partner (captcha phase) followed by 45 SART trials. Each trial commenced with the presentation of a circular grey mask in the center of the screen for 1500ms. For each trial, a digit (1-9) was displayed at the center of the screen for 500ms.

captcha phase followed by 18 trials. This was followed by 16 test blocks. Each test block began with a captcha phase followed by 45 SART trials. In a within subjects design, all participants were presented with 8 blocks in the High Effort condition and 8 blocks in the Low Effort condition, in randomized order. The easy captchas (Low Perceived Effort condition) consisted of 3 characters and were deciphered in 4 s, while the difficult captchas (High Perceived Effort condition) consisted of 12 characters and were deciphered in 16 s. The captcha before the practice round was of intermediate length (8 characters), taking 12 s to decipher.

2.5. Data preparation and analysis

The data were prepared and analysed in rStudio (Team, R., 2016) using R 4.0.0 (R Core Team, 2024), tidyverse (v1.3.0; Wickham et al., 2019), and ggplot2 (v3.5.1; Wickham, 2016).

We computed the post-error slowing effect trial-wise by comparing response times in correct post-error trials to the corresponding correct pre-error trials. We computed the pre-error reaction time by averaging 4 (correct) trials before each error. We computed the post-error reaction time by averaging 4 (correct) trials after each error. Then we computed the post-error slowing scores by subtracting the post-error reaction time from the corresponding pre-error reaction time.

3. Results

3.1. Pre-registered analysis

To assess the adequacy of the pre-registered paired-samples *t*-tests after participant exclusion, we conducted a post-hoc power analysis with the relevant parameters from the a priori analyses, including the target effect size $d = 0.475$, but entering the actual *N* of 29. This showed a power of 69,48% to detect the target effect size, making the study underpowered to observe our effect of interest.

We predicted that we would observe a higher post-error slowing effect in the High Perceived Effort condition than in the Low Perceived Effort condition. A paired-samples *t*-test was conducted to compare the post-error slowing scores between the two conditions. The results indicated that the post-error slowing scores were similar in the High Perceived Effort ($M = -0.01650$, $SD = 0.08947$) and Low Perceived Effort ($M = -0.002884$, $SD = 0.04314$) conditions, $t(28) = 1.0739$, $p = 0.292$, *Cohen's d* = 0.20, 95% CI [-0.17, 0.57].

We predicted that we would observe a higher post-error RT in the High Perceived Effort condition than in the Low Perceived Effort condition. A paired-samples *t*-test was conducted to compare the post-error RTs between the two conditions. The results indicated that the post-error RTs were similar in the High Perceived Effort ($M = 0.2297$, $SD = 0.3471$) and Low Perceived Effort ($M = 0.2367$, $SD = 0.3422$) conditions, $t(28) = 0.9376$, $p = 0.3565$, *Cohen's d* = 0.17, 95% CI [-0.19, 0.54].

3.2. Exploratory analysis

Next, we wanted to investigate whether the post-error slowing effect depends on Perceived Effort (High vs Low) and on whether we look at the 1st, 2nd, 3rd, or 4th correct trial after the error (see Fig. 2.). We performed a mixed-effects ANOVA with Perceived Effort (High vs Low) and post-error trials (1st–4th trial) as fixed factors, and random intercepts for subjects. A mixed-effects ANOVA revealed a significant main effect of Perceived Effort on the post-error slowing effect, such that participants decelerated more in the High Perceived Effort condition than in the Low Perceived Effort condition, $F(1, 6059.6) = 11.03$, $p < 0.001$, $\eta^2p = 0.00182$). The main effect of post-error trials was not significant, $F(3, 6039.4) = 0.60$, $p = 0.616$, $\eta^2p = 0.0002$, and the interaction between Perceived Effort and post-error trials was also not significant, $F(3, 6039.4) = 0.41$, $p = 0.745$, $\eta^2p = 0.0002$.

To assess the adequacy of the exploratory ANOVA analysis, we conducted a post-hoc power analysis by converting the pre-registered

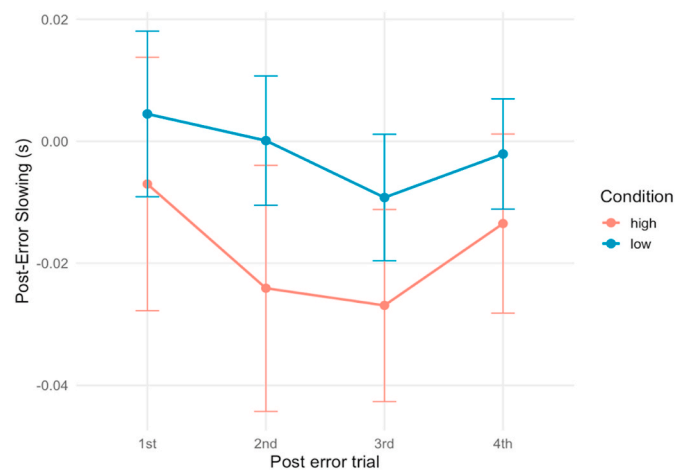


Fig. 2. Post-error slowing across conditions (High Perceived Effort vs Low Perceived Effort) and post-error trials (1st, 2nd, 3rd, 4th). Error bars represent ± 1 SEM.

target effect size $d = 0.475$ to $f = 0.237$, and entering the actual *N* of 29. This showed a power of 97,5% to detect the target effect size, making the study adequately powered to observe our effect of interest.

4. Discussion

We implemented a social version of the SART in order to test the prediction that the perception of a partner's effort elicits gritted teeth commitment – i.e. that it triggers the engagement of executive function to maintain focus on a joint task. The SART is well-suited for investigating this question because it is a tedious task requiring participants to actively maintain focus over relatively long periods, and in particular because the long predominance of go trials invites participants to fall into a routine of simply responding with a spacebar press to any stimulus, and therefore to registering false alarms on no-go trials. In order to successfully withhold response on no-go trials, participants must maintain in their working memory the full set of task instructions (i.e. including the instruction not to respond to '3's, despite responding as quickly as possible to all other digits). Previous research has shown that the longer the stretches last in between no-go trials (i.e. the more the go trials in between no-go trials), the faster do participants' responses become, and the more false alarms do they register (Manly et al., 1999). And indeed, when participants are probed to indicate what they are thinking about at unpredictable timepoints during the SART, they are more likely to indicate that they have been engaged in mindwandering at timepoints when they have been responding particularly quickly (Smallwood et al., 2004). Furthermore, it has been observed that when participants commit an error, they typically slow down their responses for the next several trials – possibly because they notice the error and engage their executive resources to re-establish the task set in order to prevent further errors.

Against this background, we elected to focus on post-error deceleration as our dependent variable of interest. We reasoned that if the gritted teeth commitment hypothesis is correct, we should expect a more pronounced deceleration after errors in the High Perceived Effort condition than in the Low Perceived Effort condition, as the perception of a partner's effort investment gives a boost to executive function, helping participants to maintain or re-establish focus on a joint task. The results provide preliminary support for the prediction that participants decelerated more after errors in the High Perceived Effort condition than in the Low Perceived Effort condition. This is consistent with the hypothesis that the perception of a partner's effort leads participants to grit their teeth and utilize their executive resources to stay on task.

In particular, it is worth specifying that the SART is likely to target

two of the three components of executive function which have been distinguished in the literature: *inhibition* of dominant or prepotent responses and *updating and monitoring* working memory contents in response to changing situational demands – i.e. it is not designed to probe the capacity to *shift* flexibly between tasks (Miyake et al., 2000). To stabilize performance on boring tasks, inhibition may be especially important for resisting distractions and temptations, and updating and monitoring working memory contents may be important for maintaining task sets in working memory. These two components enable one to actively maintain task goals and strategies, and to focus on task-related information (goal-shielding; Shah et al., 2002; Dreisbach & Haider, 2009).

One limitation of the current study is that it specifically focused only on one of the two main forms of commitment which we have distinguished – i.e. it was designed to test for evidence of gritted teeth commitment only, not for evidence of engaged commitment. Further research should aim to explore possible relationships between these two forms of commitment. The most straightforward hypothesis concerning this relationship is that these two forms of commitment are mutually exclusive: either the intrinsic reward value of the task is enhanced (engaged commitment), in which case the need for executive control is reduced, or executive control is enhanced (gritted teeth commitment), stabilizing task focus and performance despite a reduction in the intrinsic reward value of a task. But as stated earlier, we do not assume that engaged and gritted teeth commitment as mutually exclusive or dichotomous mechanisms. Rather, they may be sustained by partly overlapping cognitive and motivational mechanisms, and there are also many ways in which the two forms of commitment may support each other. For example, gritted teeth commitment may work by focusing attention on aspects of a task which are rewarding, leading to an increase in the intrinsic reward value of a task. Indeed, it has been argued that executive control can serve to bias lower-level processing in working memory (Baddeley, 1986; Christensen et al., 2016). Likewise, by enhancing the intrinsic reward value of a task, engaged commitment may also lead to the recruitment of executive resources to stabilize or boost performance.

A second limitation of the study is that after applying the exclusion criteria the sample size was reduced to 29 from 37 participants. This reduced the statistical power of the study from the desired 80% to 69,48%, making the study underpowered to observe our effect of interest. This loss of power could have contributed to the non-significant results in the pre-registered analysis. This reasoning is supported by the exploratory analysis, which revealed a main effect of Perceived Effort and showed an achieved power of 97,5%.

A third limitation of the study is that we could not exclude participants who (correctly) thought that their partner was a computer algorithm because we did not perform any post-experiment suspicion probe. Our reasoning was that a suspicion probe (asking participants whether they believed that they performed the joint task together with their partner or a computer algorithm) may prompt participants to report being suspicious. In other words, a suspicion probe may have biased them to overreport being suspicious, although a recent study (Azaad & Echterhoff, 2025) provides reason to reconsider this point.

A fourth limitation of the study is that, in the captcha task, effort investment is indistinguishable from task difficulty. This raises the question whether participants were responding to the perception of task difficulty rather than the perception of their partner's effort. While this is possible (task difficulty may well elicit commitment even if that contribution is not perceived as highly effortful), it is important to note that we used the same stimuli as in Székely and Michael (2018, 2023a, 2023b). In Székely and Michael (2023b) participants were explicitly asked how much effort they thought it had taken the partner to solve a captcha. Participants consistently rated longer time on task as more effortful. Nevertheless, future research should manipulate effort investment and task difficulty orthogonally. Importantly, we should expect that people respond to a partner's effort independently of task

difficulty.

In sum, the current study constitutes a first step towards exploring the many possible ways in which a sense of commitment to a task can modulate cognitive control processes and thereby stabilize or enhance performance in joint action.

CRedit authorship contribution statement

Marcell Székely: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Data curation, Conceptualization. **Luke McEllin:** Writing – review & editing, Supervision, Conceptualization. **Stephen Butterfill:** Writing – review & editing, Methodology, Conceptualization. **John Michael:** Writing – review & editing, Writing – original draft, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization.

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Data availability

I have shared a stable link to the data in the paper.

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