Journal of Experimental Psychology: General

0096-3445/19/$12.00

2019, Vol. 148, No. 6, 943–961
http://dx.doi.org/10.1037/xge0000510

Capacity Limitations of Dishonesty

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Cognitive theories of dishonesty revolve around an automatic activation of honest response tendencies, which is assumed to impair response selection for the intended dishonest response. Clear-cut evidence for the claim is still limited, however. We therefore present a novel approach to dishonest responding that takes advantage of psychological refractory period methodology. Four experiments yielded evidence supporting the assumption of prolonged response selection during dishonest responding. Moreover, they also showed differences in early response activation and they revealed additional downstream consequences of this behavior that are currently not sufficiently covered by common theoretical models. Notably, these downstream consequences included increased monitoring relative to honest behavior. Our results thus provide an extensive coverage of the cognitive architecture of dishonest responses, informing current theorizing while simultaneously grounding the assumed processes in the framework of sensorimotor stage models of information processing.

Keywords: dishonesty, lying, capacity limitations, PRP, monitoring

Behaving dishonestly requires complex cognitive and emotional processing of agents before, during, and even after delivering a lie (e.g., Walczyk, Harris, Duck, & Mulay, 2014). On the cognitive level, the generation of dishonest responses has often been suggested to require a sequence of an initial activation and subsequent inhibition of the appropriate honest response (e.g., Debey, De Houwer, & Verschuere, 2014; Foerster, Wirth, Herbort, et al., 2017). When lying affords such an inhibition of a dominant response, it is considerably more difficult than honest responding, which is reflected in behavioral, electrophysiological, and hemodynamical measures (e.g., Bhatt et al., 2009; Debey, Liefooghe, De Houwer, & Verschuere, 2015; Johnson, Barnhardt, & Zhu, 2003; Pfister, Foerster, & Kunde, 2014; Spence et al., 2001; Suchotzki, Verschuere, Van Bockstaele, Ben-Shakhar, & Crombez, 2017). The presence of this two-step process in dishonest responding is well documented in the literature, however, an exact characterization in regard to the stages of information processing that are prolonged during lying still awaits examination. In the present study, we approached the cognitive consequences of dishonesty before, during, and also after delivering a lie systematically from the perspective of the psychological refractory period (PRP) paradigm (Pashler & Johnston, 1989; Welford, 1952). In what follows, we will first review current theoretical frameworks of how lies are processed, and we will then move on by discussing how these processes can be mapped to processing stages via PRP methodology.

Honest Response Activation in Dishonest Responding

The activation-decision-construction-action theory (ADCAT; Walczyk et al., 2014; Walczyk, Roper, Seemann, & Humphrey, 2003) brings together cognitive and emotional processes underlying dishonest processing. In particular, the theory states that in many cases, an honest response is automatically activated and that agents decide whether to lie in the face of this response activation. Decisions whether or not to lie are based on factors such as the present social context, expected consequences, and the agent's experiences. In case of a decision to lie, agents then need to inhibit the representation of the honest response to replace it with a suitable dishonest response. Finally, the theory also assumes that agents monitor and control their demeanor and that they monitor the behavior of the receiver of the deceptive message.

This article was published Online First November 26, 2018.

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Data, commented analysis scripts, preregistrations and animations of the experimental activities are publicly available (osf.io/dfgx4). Anna Foerster presented Experiment 1 and 3 at the 60th Conference of Experimental Psychologists (2018) in Marburg, Germany and at the 3rd Psychonomics International Meeting (2018) in Amsterdam, the Netherlands.

We conducted the current set of experiments to provide a precise theoretical and empirical description of the cognitive architecture of responding dishonestly. Interestingly, the mechanics proposed by contemporary cognitive theories on dishonesty had not yet been put to test properly as most research focused on the development of lie detection methods and thus confined itself to the general finding that lying can be cognitively more demanding (i.e., tends to take longer) than responding honestly (for a rare exception, see Debey et al., 2014). Even though this approach seems viable against an applied background, the mere observation of longer responding during dishonesty is not satisfying when it comes to elucidating which cognitive operations are actually affected by lying. The combination of sophisticated experimental approaches such as the PRP paradigm with common ways to study the cognitive architecture of lying appears to be a very promising strategy in this regard. We also believe that it will likely allow for further scrutinizing the cognitive underpinnings of motivated lying (as well as rule-breaking) in future work.

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The assumption of an initial activation of an honest response representation and its inhibition are typically examined in instructed intention paradigms, where participants are prompted to respond honestly and dishonestly with yes or no to autobiographical or semantic questions. These paradigms reliably produce strong intention effects, as participants are slower and less accurate when delivering dishonest compared to honest responses (e.g., Duran, Dale, & McNamara, 2010; Furedy, Davis, & Gurevich, 1988; Spence et al., 2001). Recent studies began to investigate the cognitive foundations of such intention effects by using a modified version of the instructed intention paradigm that featured honest and dishonest distractors (Debey et al., 2014; Foerster, Wirth, Herbort, et al., 2017, Experiments 3–4). Distractors (*yes* or *no*) appeared simultaneously with the question. If the honest response to a question is *yes*, the same distractors would constitute honest distractors, whereas *no* distractors would constitute dishonest distractors. The opposite is true for questions with an honest *no* response. Assuming that the honest response is initially activated, the presentation of honest distractors should complement this initial response activation and, thus, facilitate honest responding. Because the initial activation of the honest response is also assumed to occur during dishonesty, honest (rather than dishonest) distractors should also expedite the processing of dishonest responses. This unique prediction of the two-step hypothesis was indeed confirmed, with lower response times (RTs) and error rates with honest than with dishonest distractors when responding honestly and, crucially, also when responding dishonestly.

Findings in the instructed intention paradigm thus indicate that selecting, planning, and initiating a dishonest response can occur in the face of the activated truthful response. This describes the processing of dishonest responses as being inherently conflicting, effortful, and resource demanding, and such processes are commonly located within a certain stage of information processing, that is, the central bottleneck of response selection (Ferreira & Pashler, 2002; Paelecke & Kunde, 2007; Wirth, Pfister, Janczyk, & Kunde, 2015). However, additional findings have also suggested a profound impact of dishonest processing on response execution, which becomes evident in continuous movement trajectories when participants respond by moving their hands or a cursor toward a *yes* or *no* response location (Duran et al., 2010; Foerster, Wirth, Herbort, et al., 2017). Such movements are slower and more curved toward locations that signal dishonest rather than honest responding, which may be taken to suggest that dishonest processing also affects processes after a response has already been selected (for related findings on rule-breaking, see Pfister, Wirth, Schwarz, Steinhauser, & Kunde, 2016; Wirth, Pfister, Foerster, Huestegge, & Kunde, 2016). Scrutinizing these speculations requires advanced experimental setups as we will describe in the following.

Localizing the Two-Step Process

Sensorimotor approaches mostly assume that information processing can be described as stages of (mainly perceptual) precentral processing, a central process that is concerned, among other things, with response selection, and postcentral, motoric processing (e.g., McClelland, 1979; Smith, 1968; Sternberg, 1969). Vast empirical evidence supports the assumption that the central process is capacity-limited and cannot run at all, or not with the same efficiency, in two tasks at a time, whereas processes before and after this central process can mostly run in parallel with all other stages of another task (e.g., Massaro & Cowan, 1993; Meyer & Kieras, 1997; Pashler, 1984, 1994a; Pashler, & Johnston, 1989). Most part of the two-step process should draw upon this response selection stage, rendering the inhibition of an honest response and the generation of a dishonest response a central, capacity-limited operation.

However, as outlined above, there is evidence suggesting a unique signature of dishonest responding also after a response has been selected (Duran et al., 2010; Foerster, Wirth, Herbort, et al., 2017). Speculatively, these findings might indicate the operation of a late capacity-limited process that monitors responses and their consequences (Jentzsch, Leuthold, & Ulrich, 2007; Welford, 1952). Such a monitoring process seems to be especially engaged when response selection or execution create conflicts. This happens when producing errors (i.e., conflict between erroneous and correct response; Jentzsch, & Dudschig, 2009; Steinhauser, Ernst, & Ibald, 2017) or incompatible response effects (i.e., when a left response had produced a right stimulus; Wirth, Janczyk, & Kunde, 2018; Wirth et al., 2015; Wirth, Steinhauser, Janczyk, Steinhauser, & Kunde, 2018). To the extent that dishonest responding comes with conflict between honest and dishonest representations, it might invoke such monitoring as well (Foerster et al., 2018).

The PRP paradigm provides an established tool to disentangle the involvement of dishonest processes in the stages of information processing (e.g., Pashler, 1984, 1994a; Pashler, & Johnston, 1989). In this paradigm, participants work on two tasks in close temporal succession (see Figure 1). The temporal proximity of the two tasks varies via the manipulation of the stimulus onset asynchrony (SOA) of the task stimuli. According to the model, the temporal overlap between the two tasks should not affect performance of the first task. Performance of the second task, however, should worsen with increasing temporal overlap of the tasks; this impact of the SOA on RTs and error rates is referred to as PRP effect. From the introduction of an experimental manipulation of interest, separately in Task 1 or Task 2, and from its impact on RTs of both tasks, experimenters draw inferences about the localization of these effects in sensorimotor stages.

The Present Experiments

The current experiments offer a comprehensive inspection of cognitive effects of dishonesty in the stages of information processing by combining established methods from theories on dishonesty and from sensorimotor approaches to information processing. Therefore, the current experiments featured a (dis)honest task in combination with a tone classification task. The order of the two tasks varied between experiments, with the locus-of-slack logic (Experiment 1 and 2) employing the tone task first and the (dis)honest task second, and with the effect propagation logic (Experiment 3 and 4) employing the reversed order of tasks (for detailed descriptions of both methodological approaches, see Jentzsch, & Dudschig, 2009; Kunde, Pfister, & Janczyk, 2012; Miller & Reynolds, 2003).

Experiment 1

The first experiment used the locus-of slack logic to elaborate whether dishonest responding relates to precentral or later stages

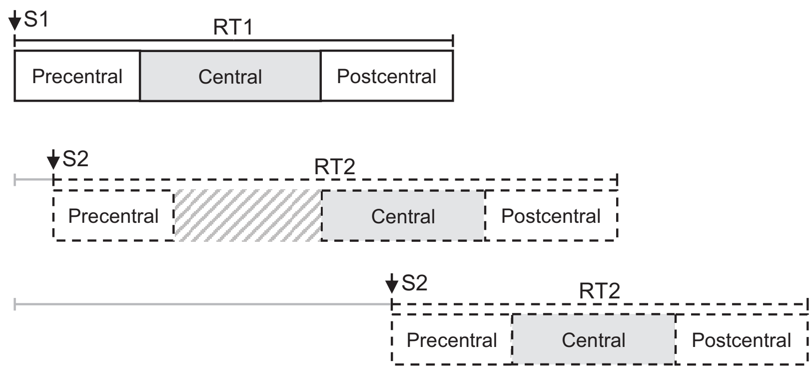

Figure 1. Illustration of the processing stages of a Task 1 (solid black lines) and a Task 2 (dashed black lines) in the psychological refractory period paradigm. The stimulus of Task 1 (S1) and the stimulus of Task 2 (S2) appear with short (middle row) or long (bottom row) stimulus onset asynchrony (SOA; gray lines). Central stages of response selection are assumed to be capacity-limited and therefore unable to operate in parallel, leading to a cognitive slack (shaded gray area) when response selection of Task 2 has to wait for response selection of Task 1 to finish. This inevitably prolongs response times of Task 2 (RT2; dashed lines) to a larger degree with short SOAs than with long SOAs, whereas RTs of Task 1 (RT1; solid lines) are mostly unaffected by manipulations of SOA. As such, experimental manipulations of precentral and central stages of Task 1 should also become visible in performance of Task 2 for relatively short SOAs (effect propagation). Manipulations in the precentral stage of Task 2 should affect RT2 to a larger degree at long SOAs than at short SOAs, as longer precentral processing can stretch into the cognitive slack in the latter case, whereas manipulations of central and postcentral stages in Task 2 should affect RT2 to the same degree at all SOA levels (locus-of-slack logic).

of information processing. Previous work on the cognitive basis of effects of responding dishonestly suggests that these effects should mostly draw upon the later stages, that is, response selection, motor execution, and/or monitoring rather than on the precentral stage (e.g., Debey et al., 2014; Duran et al., 2010; Walczyk et al., 2014). From the background of sensorimotor theories, however, there is evidence that suggests a contribution of precentral response activation processes (e.g., Hommel, 1998; Miller, 2006) that may also be affected in dishonest responding.

In particular, these studies suggested the existence of early response activation processes by showing that response characteristics of a Task 2 can facilitate or hamper responding of a Task 1. These results are plausible under the assumption that a stimulus already heightens activation of its associated response, despite ongoing response selection of another task, and only the final selection of a response is subject to capacity-limitations. Following this logic, the presentation and processing of a question in a (dis)honest task could activate its associated honest response. At the same time, the dishonest cue could already boost activation of the very opposite response as the activated response of the question is not the appropriate one to be delivered. As such, part of the difference between honest and dishonest responding could be the result of precentral processing.

These considerations lead to specific predictions for the data pattern of Experiment 1 (e.g., Pashler, 1994a). First, capacity-limited response selection processes should be mirrored in increased RTs and error rates for the short SOA compared to the long SOA of the (Dis)honest Task 2 but not of the Tone Task 1. Second, dishonest responding should be more difficult than honest responding, producing longer RTs and higher error rates in the (Dis)honest Task 2 (i.e., intention effects). Finally, if precentral processes contribute to delays of dishonest responding, these delays should be smaller for the short SOA than for the long SOA (see Figure 2A). Delays due to dishonest as compared to honest responding in later processing stages would affect Task 2 performance independently of the SOA (see Figure 2B). As such, similar intention effects for both SOA conditions would contradict the assumption of precentral processing as a source of the intention effect.

Method

Participants. Thirty-two participants took part in this experiment. This sample size ensures a high power to observe performance differences between honest and dishonest responses as these differences are usually large (for a recent meta-analysis, see Suchotzki et al., 2017). All participants gave informed consent and received monetary compensation or course credits.

Apparatus and stimuli. Participants sat in front of 17″ TFT monitors with a display resolution of 1,680 × 1,050 and a refresh rate of 60 Hz. For the tone task, participants had to classify a 300 Hz and an 800 Hz tone of 100 ms duration as low and high by pressing *K* and *L* with the index and middle fingers of their right hand. For the (dis)honest task, questions were chosen randomly out of a set of 72 questions about daily activities (see Table A1 in Appendix A). We adapted these questions from previous work (Van Bockstaele et al., 2012), translated them and modified them slightly to make them accessible for German participants (see also Foerster, Wirth, Kunde, et al., 2017). Participants pressed *S* and *D* on a standard German QWERTZ keyboard with the middle and index fingers of their left hand to respond to questions with *yes* and *no*. The font color of the questions indicated whether to respond honestly or dishonestly in each trial. The assignment of font color to intention was counterbalanced across participants as was the key assignment within each task.

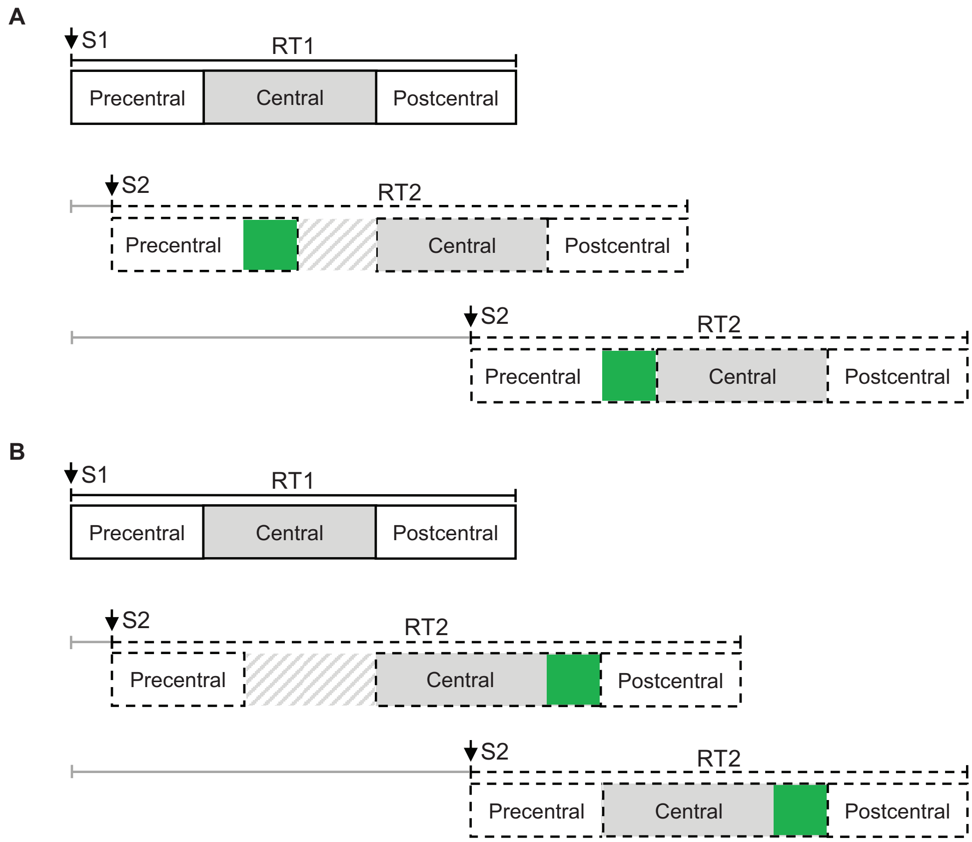

Figure 2. Illustration of the idea that increased RTs of dishonest responses (dark green [dark gray] areas) occur in precentral response activation (A) or central, capacity-limited response selection (B) and its impact on response times of the Tone Task 1 (solid black lines; RT1) and of the (Dis)honest Task 2 (dashed black lines; RT2) for the short and the long stimulus onset asynchrony (SOA; gray lines) of Experiment 1. Note that the effect of dishonest responding could also be involved in both, the precentral and the central stage and that the current paradigm cannot differentiate between effects in central and postcentral stages (see Experiment 3). See the online article for the color version of this figure.

Procedure. Participants started the experiment by responding honestly to a random set of questions from the prepared question pool. Participants had to indicate whether they performed these actions during the same day until 10 questions had been negated and 10 questions affirmed. If participants affirmed (negated) more than 10 questions before negating (affirming) 10 other questions, these surplus questions were discarded. Participants were strongly encouraged to consult the experimenter if they were uncertain how to respond or if they had delivered a false response.

Afterward, they learned that they would execute the tone task and the (dis)honest task in close temporal succession during the experiment. They received instructions about both tasks and went through three practice blocks, practicing only the Tone Task 1, only the (Dis)honest Task 2 and then both tasks. Crucially, participants received the instruction to always respond to the tone first without waiting for the question and to deliver a response to the question afterward, and we also stressed both speed and accuracy (cf. Pashler, 1994b; Pashler & Johnston, 1989).

A trial started with the presentation of a central fixation cross for 500 ms. Afterward, the tone played and a question appeared on screen 150 ms (short SOA) or 1,500 ms (long SOA) after tone onset. Participants had to deliver both responses within 4,000 ms from tone onset. The next trial started after 500 ms. If participants gave an early response before stimulus onset, delivered a false response (commission errors) or failed to deliver a response in any of the two tasks, or responded to the question before providing a response in the Tone Task 1, an error-specific feedback appeared for 1500 ms. The combination of 20 questions × 2 intentions (honest vs. dishonest) × 2 SOA (short vs. long) × 2 tones (low vs. high) resulted in 160 individual trial combinations in a block. Participants went through three of these blocks with self-paced breaks after each 40th trial.

Results

Data and the commented analysis scripts of all experiments are publicly available on the Open Science Framework (OSF; osf.io/dfgx4).

Data treatment. The practice blocks and each trial following a self-paced break were excluded from statistical analyses. Error rates were computed as the proportion of commission errors to commission errors plus correct responses. One participant had to be excluded because of delivering false responses during the selection of questions at the beginning of the experiment. The participant informed the experimenter after completing the experiment. All remaining participants committed less than 50% commission errors in all experimental cells and could be considered for all statistical analyses.

Trials following an incorrect trial were excluded (17.5%). Other errors than commission errors in the Tone Task 1 were excluded before analyzing error rates of the Tone Task 1 (0.5%). Error rate analysis of the (Dis)honest Task 2 was restricted to trials with correct tone responses and we then excluded other errors than commission errors of the (Dis)honest Task 2 (1.3%). Only correct trials with inter-response intervals above 100 ms (0.1% excluded) and RTs within 2.5 *SD*s of the corresponding cell mean (4.3% excluded) entered reaction time (RT) analyses of both tasks.

Data analyses. RTs and error rates of both tasks were analyzed in separate analyses of variances (ANOVAs) with the within-subjects factors SOA (150 ms vs. 1500 ms) and intention (honest vs. dishonest). Significant two-way interactions were scrutinized in planned two-tailed paired-samples *t*-tests. Descriptive statistics of the error rates are presented in Table B1 of Appendix B and of the RTs in Table B2 of Appendix B and in Figure 3.

Tone Task 1. Tone RTs were slower with subsequent dishonest than honest responses ($\Delta = 16$ ms), $F(1, 30) = 4.74$, $p = .037$, $\eta_p^2 = .14$, and with short compared to long SOAs ($\Delta = 136$ ms), $F(1, 30) = 25.68$, $p < .001$, $\eta_p^2 = .46$. The interaction of both factors was not significant, $F(1, 30) = 2.05$, $p = .163$, $\eta_p^2 = .06$. The main effects and the interaction were not significant in error rates, Fs < 1.

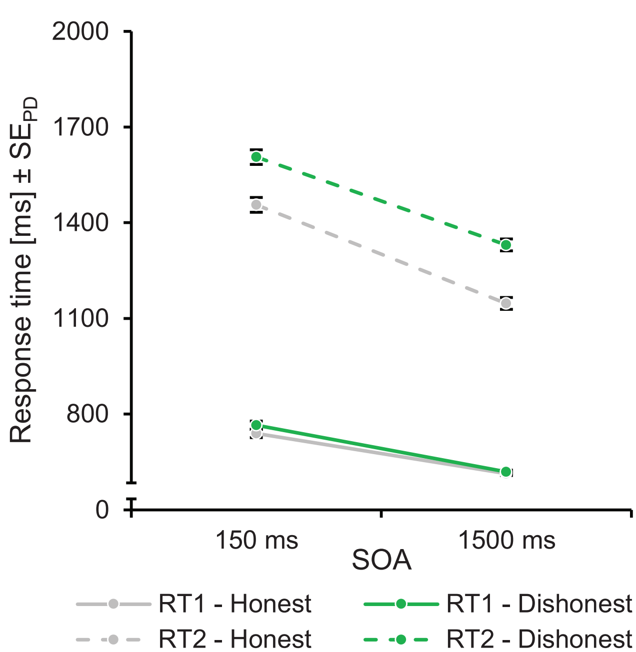

Figure 3. Mean RTs of the Tone Task 1 (RT1; solid lines) and of the (Dis)honest Task 2 (RT2; dashed lines) of Experiment 1. Light gray lines constitute honest trials and dark green (dark gray) lines dishonest trials. Error bars represent standard errors of paired differences (SE_{PD}; Pfister & Janczyk, 2013), computed separately for each stimulus onset asynchrony (SOA) and task. See the online article for the color version of this figure.

(Dis)honest Task 2. Responses were slower when they were dishonest than honest ($\Delta = 167$ ms), $F(1, 30) = 78.68$, $p < .001$, $\eta_p^2 = .72$, and with short SOAs than with long SOAs ($\Delta = 292$ ms), $F(1, 30) = 108.49$, $p < .001$, $\eta_p^2 = .78$. There was a nonsignificant trend toward an interaction of both factors, $F(1, 30) = 3.13$, $p = .087$, $\eta_p^2 = .09$, pointing toward descriptively smaller intention effects with a short ($\Delta = 150$ ms) than with a long SOA ($\Delta = 183$ ms). Responses were less accurate for dishonest than for honest responses ($\Delta = 5.1\%$), $F(1, 30) = 23.33$, $p < .001$, $\eta_p^2 = .44$. The main effect of SOA and the interaction were not significant in error rates, Fs < 1.

Discussion

Experiment 1 used the locus-of-slack logic to disentangle the involvement of precentral processes from later processes in dishonest responding. As expected, performance measures of the (dis)honest task were worse with short than with long SOAs and participants had more difficulties with responding dishonestly than honestly. With the (dis)honest task following the tone task, the intention effect was evident for all SOA levels, but there was a nonsignificant trend toward larger effects with the long SOA.[1] The results of the current experiment point toward a recruitment of central or postcentral stages in dishonest responding, which will be disentangled in Experiment 3.

The pattern of results hints toward an impact of response grouping, as RT1 was slower with the short than with the long SOA and in dishonest compared to honest trials, even though we took countermeasures to response grouping. We instructed participants to respond to Task 1 without waiting for Task 2 and to respond as fast and accurate as possible (cf., Pashler, 1994b; Pashler & Johnston, 1989). We further excluded temporally close responses. Note, that such a main effect of SOA in Task 1 was not evident with the reversed task order in Experiment 3, hinting toward a crucial role of task difficulty or task dominance in these phenomena. Whereas the tone task seems to be easily queued up, the (dis)honest task might be too imposing to be completely ignored while processing the tone task.

The current results demonstrate that the contribution of precentral processes to dishonest responding could be at best small while later, possibly capacity-limited processes predominantly account for intention effects. We corroborated these findings in the following experiments; before using suitable methodology for inferring capacity limitations, we first addressed a potential limitation of the employed stimulus material in the following experiment.

Experiment 2

In Experiment 1, we had provided our participants with a set of questions at the beginning of the session in order to learn about activities they had or had not performed on the day of the experiment. This procedure is used routinely in research on the cognitive architecture of dishonesty, because it is easily applicable and does not require the participants to engage in mock activities before the actual experiment (Foerster, Wirth, Kunde, et al., 2017, 2018; Spence et al., 2001; Van Bockstaele et al., 2012). Despite its

[1] In Experiment 2, this interaction was significant, and we will discuss its implications in the corresponding discussion section.

widespread use, this procedure may come with several limitations as past instances of the inquired actions (e.g., during the preceding days) may affect responding during the inquiry. To address this limitation, Experiment 2 closely replicated the former locus-of-slack logic but introduced a set of activities in the laboratory to apply the same set of questions about these activities in the (Dis)honest Task 2 for all participants (for a similar procedure, see Foerster, Wirth, Herbort, et al., 2017). In particular, participants performed one set of activities but did not perform another set of activities and responded to questions about both sets honestly and dishonestly. The same theoretical assumptions as in Experiment 1 hold for this conceptual replication but with a higher control of the item set, thus, a similar pattern of results as in Experiment 1 should emerge.[2]

Method

We preregistered this experiment (osf.io/367xw) and invited a new sample of 32 participants. Apparatus, design and procedure were as for Experiment 1 with the following modifications. For the (dis)honest task, we prepared two sets of 10 activities and corresponding questions (see Table A2 in Appendix A). We counterbalanced across participants which set of activities had to be performed and provided participants with a box that contained the relevant objects for these activities (each object appeared only for one but not the other set of activities). For example, one half of participants took apart two bricks that were stuck together with hook-and-loop fasteners. We asked participants to perform each of the actions carefully and presented them consecutively in a random order on the computer screen. Participant proceeded through the instructions by key press (with a forced pause of 5 s between actions). After the completion of all actions, the experimenter checked their accuracy and continued the experiment if all actions were performed correctly or presented action instructions again if an action had not been executed properly. In the (dis)honest task, participants responded to 10 questions about performed actions honestly with yes and dishonestly with no whereas the opposite was true for the 10 questions about not performed actions.

Results

Data treatment and analyses. Data was treated and analyzed as in Experiment 1. We excluded two participants because they committed at least 50% commission errors in one of the design cells and, thus, performed at (or below) chance level. Two other participants had to be excluded because they had an unusually high rate of omissions (one participant never responded in the tone task and the other participant only responded to one of the two tones).

We excluded post-error trials (16.9%). Other errors than commission errors in the Tone Task 1 were excluded (0.4%) before analyzing error rates of the Tone Task 1. The error rate analysis of the (Dis)honest Task 2 was restricted to trials with correct tone responses and we then excluded other errors than commission errors of the (Dis)honest Task 2 (1.3%). Only correct trials with inter-response intervals above 100 ms (1.5% excluded) and RTs within 2.5 *SD*s of the corresponding cell mean (4.1% excluded) entered RT analyses of both tasks. Figure 4 shows the main results of the RT analyses. Descriptive statistics of the error rates are presented in Table B3 of Appendix B and detailed RT statistics are presented in Table B4 of Appendix B.

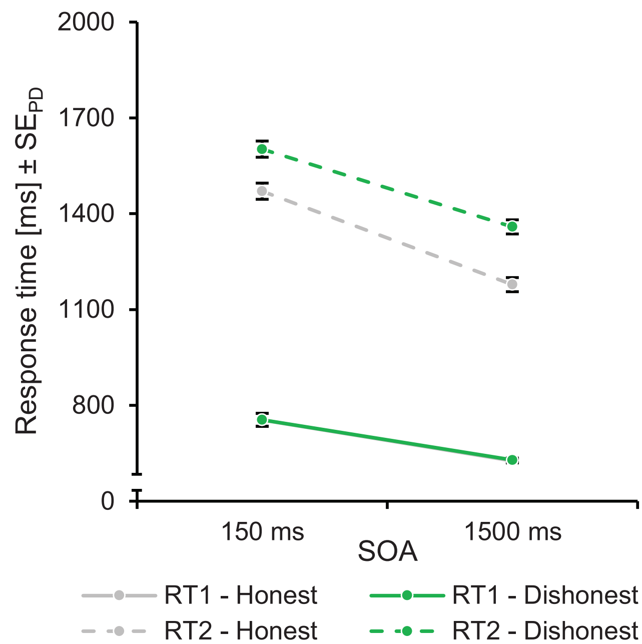

Figure 4. Mean RTs of the Tone Task 1 (RT1; solid lines) and of the (Dis)honest Task 2 (RT2; dashed lines) of Experiment 2. Light gray lines constitute honest trials and dark green (dark gray) lines dishonest trials. Error bars represent standard errors of paired differences (SE_{PD}), computed separately for each stimulus onset asynchrony (SOA) and task. See the online article for the color version of this figure.

Tone Task 1. Tone RTs were slower with short SOAs compared to long SOAs (Δ = 127 ms), $F(1, 27) = 43.22$, $p < .001$, $\eta_p^2 = .62$. The main effect of intention and the interaction of both factors were not significant, $F\text{s} < 1$. The main effects and the interaction were not significant in error rates, $F\text{s} \leq 1.46$, $p\text{s} \geq .237$.

(Dis)honest Task 2. Responses were slower when they were dishonest than honest (Δ = 156 ms), $F(1, 27) = 48.49$, $p < .001$, $\eta_p^2 = .64$, and with short SOAs than with long SOAs (Δ = 268 ms), $F(1, 27) = 70.28$, $p < .001$, $\eta_p^2 = .72$. There was also a significant interaction of both factors, $F(1, 27) = 9.49$, $p = .005$, $\eta_p^2 = .26$, as intention effects were smaller with a short (Δ = 132 ms), $t(27) = 5.18$, $p < .001$, $d_z = 0.98$, than with a long SOA (Δ = 181 ms), $t(27) = 8.18$, $p < .001$, $d_z = 1.55$. Responses were less accurate for dishonest than for honest responses (Δ = 8.2%), $F(1, 27) = 58.04$, $p < .001$, $\eta_p^2 = .68$. The main effect of SOA and the interaction were not significant in error rates, $F\text{s} < 1$.

Discussion

Experiment 2 conceptually replicated the setup of Experiment to differentiate the contribution of precentral from later processes to dishonest responding. Again, we found a considerable PRP effect and intention effect in the (Dis)honest Task 2. The difference

[2] Note that we conducted this experiment after Experiments 1, 3, and 4, following suggestions of the editor. We thank Nelson Cowan for pointing out this possible limitation and for stimulating a suitable control experiment.

between honest and dishonest responding was pronounced also at the short SOA though it was significantly smaller than with a long SOA. This finding qualifies the descriptive trend observed in Experiment 1 and it points toward somewhat prolonged precentral processing for dishonest compared to honest responses.

One possible explanation for this modulation is that response activation in dishonest responding differed from honest responding (e.g., Hommel, 1998). Although the question itself should have led to honest response activation in both conditions, the dishonest cue could also have triggered dishonest response activation. Speculatively, these stimuli did not only produce response activation but also honest response inhibition. Previous results from a PRP paradigm with a two-choice Task 1 and a go/no-go Task 2 demonstrated an impact of Task 2 responding on Task 1 responding with slower responses in no-go trials (Miller, 2006). Such an impact of Task 2 on Task 1 processing was, however, not evident in the data of the current experiment.

A second, more speculative explanation relates to a general change in response threshold. The color cue to dishonesty was salient and might have alerted participants toward more cautious processing because of the difficulty of dishonest responding. Accordingly, they could already have been more cautious when they were reading the question. Such an automatic impact of task cues on processing speed has been demonstrated before (Reuss, Kiesel, Kunde, & Hommel, 2011). A more cautious response criterion would result in longer RTs and less errors, thus, mirroring the effects of the two-step process in RTs but counteracting them in error rates. Usually, intention effects are indeed smaller in error rates than in RTs, but this could also be the result of higher variance in errors because of less observations for errors than for RTs in an experiment. Note that this explanation would predict an intention effect in the Tone Task 1 for the short SOA but not for the long SOA. However, such an interaction did not emerge even though responses again show a pattern of grouping as SOAs affected Task 1 responding as in Experiment 1.

Importantly, the data indicate that precentral processes cannot be the sole source of the difference between dishonest and honest responses. RTs of the (Dis)honest Task 2 differed between the short and long SOA by 268 ms, that is, capacity-limited central processing of Task 2 should have waited for this time period at the short SOA (see Figure 1). Dishonest responding was 181 ms slower than honest responding in trials with a long SOA and assuming that this effect is precentral in nature would predict that it would fall entirely into this waiting period at the short SOA. The same logic applies to the data of Experiment 1 where the intention effect of 183 ms at the short SOA was smaller than the PRP effect of 292 ms.[3]

Taken together, the results so far suggest a contribution of precentral processes to dishonest responding, but they point toward a more dominant role of later processes. The following experiment reversed the order of the tasks to disentangle exactly which of these late processes (capacity-limited response selection vs. postcentral processing) contribute to responding dishonestly.

Experiment 3

As stated earlier, theoretical assumptions and empirical evidence suggest that dishonest responding could rely on central, capacity-limited processes but also on postcentral, motoric processes or late, capacity-limited response monitoring processes (e.g., Debey et al., 2014; Duran et al., 2010; Jentzsch et al., 2007). Experiment 3 therefore assessed the degree of propagation of the intention effect from the (Dis)honest Task 1 to the following Tone Task 2 to differentiate the contribution of these processes to dishonest responding (e.g., Jentzsch et al., 2007; Pashler, 1994a).

Response selection cannot proceed for the Tone Task 2 before it has finished for the (Dis)honest Task 1. Prolonged precentral or central processing for a dishonest response compared to an honest response should lead to an even longer idle time in the Tone Task 2 (see Figure 5). As such, the intention effect should propagate to the following Tone Task 2, especially with the short SOA.

Crucially, the degree of propagation with the short SOA is informative to whether motoric or monitoring processes contribute to intention effects. We picked a short SOA of 150 ms, and with this close temporal succession, response selection in the (Dis)honest Task 1 should never be finished before the presentation or start of response selection of the Tone Task 2. As such, the intention effect should fully propagate to the Tone Task 2 if it originates from premotor stages entirely. If postcentral processes contribute to the intention effect, a smaller intention effect should emerge in the Tone Task 2 than in the (Dis)honest Task 1 as this stage is supposed to operate in parallel with all other stages of another task (see Figure 5A). On the other hand, the intention effect of the Tone Task 2 might even be larger than in the (Dis)honest Task 1 if dishonest responding prolongs not only precentral and central stages but also response monitoring (Figure 5B). This monitoring process would not affect responding in the (Dis)honest Task 1 but would delay central processing of the Tone Task 2.

Method

A new sample of 32 participants took part in this experiment. We only list methodological details where this experiment deviated from Experiment 1. Participants went through three practice blocks, practicing only the (Dis)honest Task 1, then only the Tone Task 2 and then both tasks. Participants always had to respond to the question first without waiting for the tone and to deliver a response to the tone afterward. After the presentation of a fixation cross for 500 ms, the question appeared on screen and a tone played after 150 ms (short SOA) or 1,500 ms (long SOA). Participants had to deliver both responses within 4000 ms from tone onset. The next trial started after 500 ms.

Results

Data treatment. The same exclusion criteria as in Experiment 1 and 2 were applied. We excluded three participants because they committed at least 50% commission errors in one of the design cells and, thus, performed at (or below) chance level.

Post-error trials were excluded (16.7%) for all statistical analyses. To analyze error rates of the (Dis)honest Task 1, we excluded trials with an erroneous (dis)honest response that did not constitute

[3] To strengthen this argument, we conducted another experiment that used the same setup as Experiment 2 but with SOAs of 0 ms and 150 ms. Dishonest responses were slower than honest responses, and this effect did not differ between SOAs. Appendix C features a detailed description of this experiment.

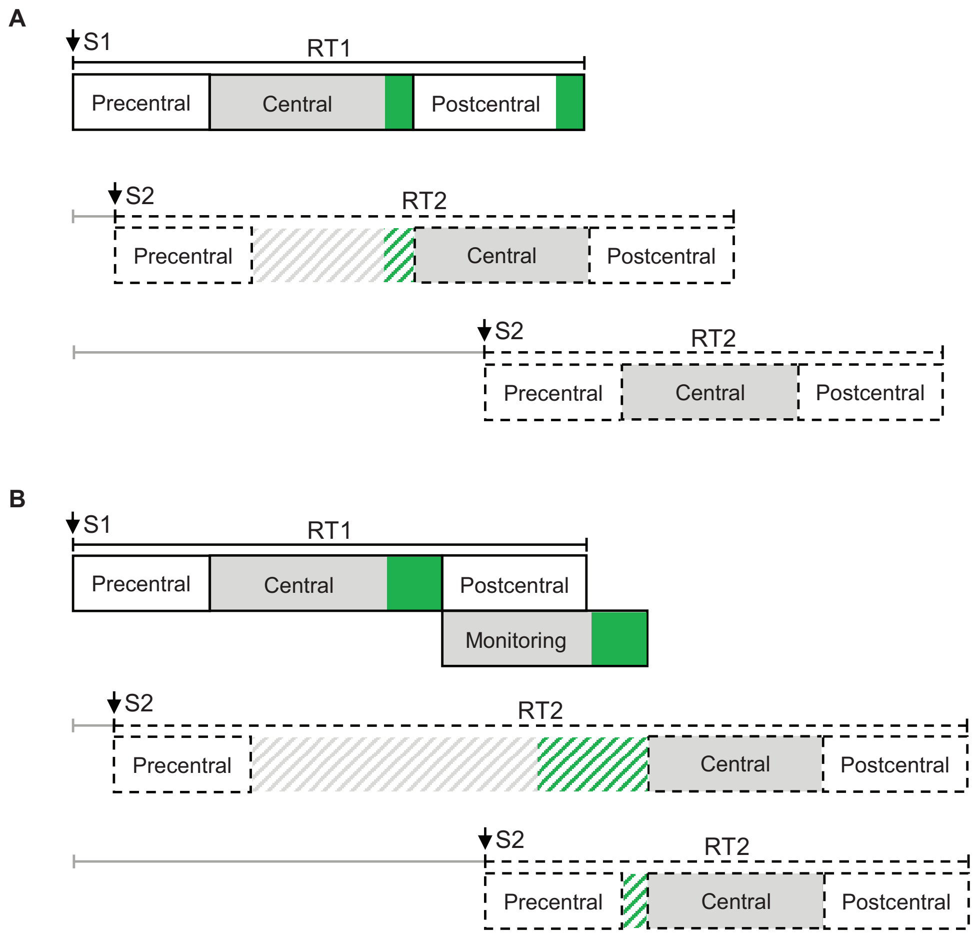

Figure 5. Illustration of the idea that increased RTs of dishonest responses (dark green [dark gray] areas) occur in central, capacity-limited response selection and postcentral, motor execution (A) or in central, capacity-limited response selection and response monitoring (B) and its impact on response times of the (Dis)honest Task 1 (solid black lines; RT1) and of the Tone Task 2 (dashed black lines; RT2) for the short and the long stimulus onset asynchrony (SOA; gray lines) of Experiment 3. See the online article for the color version of this figure.

a commission error (0.8%). For the error rate analyses of the Tone Task 2, we selected trials with a correct (dis)honest response and a tone response that was correct or constituted a commission error (1.1% other errors excluded). For all RT analyses, we only considered correct trials. We further excluded trials where both responses appeared to be grouped (inter-response interval within 100 ms; 0.6%) and any RT that deviated more than 2.5 *SD*s from the corresponding cell mean (3.2%).

Data analyses. Error rates and RTs of both tasks were analyzed in separate ANOVAs with the within-subjects factors SOA (short vs. long) and intention (honest vs. dishonest). Significant two-way interactions were scrutinized in planned two-tailed paired-samples *t*-tests.

In case of significant intention effects in both tasks, these intention effects were compared between both tasks in planned two-tailed paired-samples *t*-tests to assess the extent of propagation from the (Dis)honest Task 1 to the Tone Task 2. These comparisons were made separately for the two SOAs in case of a significant interaction of SOA and intention in one or both of the two tasks. Descriptive statistics of the error rates are presented in Table B5 of Appendix B and of the RTs in Table B6 of Appendix B and in Figure 6.

(Dis)honest Task 1. Dishonest response were slower than honest responses (Δ = 193 ms), $F(1, 28) = 63.53$, $p < .001$, $\eta_p^2 = .69$, and also more error-prone (Δ = 4.0%), $F(1, 28) = 21.92$, $p < .001$, $\eta_p^2 = .44$. Neither the main effect of SOA nor the interaction of both factors was significant in RTs, Fs ≤ 1.85, ps $\geq .185$, or error rates, Fs < 1.

Tone Task 2. Tone responses were slower with the short than with the long SOA (Δ = 1053 ms), $F(1, 28) = 1480.05$, $p < .001$, $\eta_p^2 = .98$, and with dishonest than with honest responses in the (Dis)honest Task 1 (Δ = 161 ms), $F(1, 28) = 50.01$, $p < .001$, $\eta_p^2 = .64$. The interaction of both factors was significant in RTs, $F(1, 28) = 17.05$, $p < .001$, $\eta_p^2 = .38$, as the intention effect was larger with the short SOA (Δ = 211 ms), $t(28) = 6.96$, $p < .001$, $d_z = 1.29$, than with the long SOA (Δ = 111 ms), $t(28) = 5.45$, $p < .001$, $d_z = 1.01$. Tone responses were less accurate with the short than with long SOA (Δ = 2.8%), $F(1, 28) = 27.62$, $p < .001$, $\eta_p^2 = .50$. The main effect

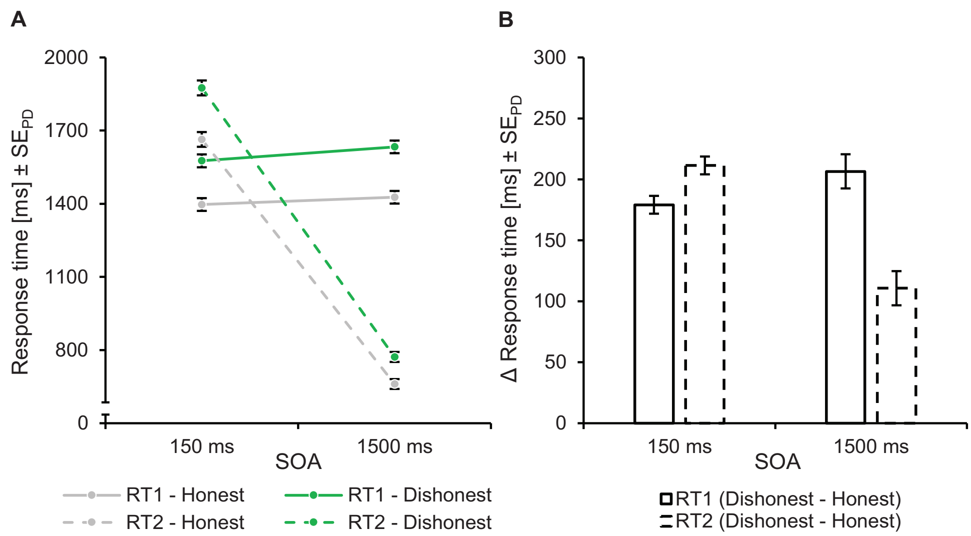

Figure 6. Mean RTs (A) and mean RT intention effects (B) of the (Dis)honest Task 1 (RT1; solid lines) and of the Tone Task 2 (RT2; dashed lines) of Experiment 3. In the left panel, light gray lines constitute honest trials and dark green (dark gray) lines dishonest trials. In the right panel, RT intention effects were computed as the mean differences between dishonest and honest trials. Error bars represent the standard errors of paired differences (SE_{PD}), computed separately for each stimulus onset asynchrony (SOA) and task in the left panel and for each SOA in the right panel. See the online article for the color version of this figure.

of intention and the interaction of both factors were not significant in error rates, $Fs \leq 1.23$, $ps \geq .277$.

Propagation of intention effects. As intention effects were not significant in error rates of the Tone Task 2, we limited our propagation analyses to RTs. Intention effects were smaller in the (Dis)honest Task 1 than in the Tone Task 2 with the short SOA ($\Delta = -32$ ms), $t(28) = -4.43$, $p < .001$, $d_z = -0.82$, but the opposite was true with the long SOA ($\Delta = 96$ ms), $t(28) = 6.84$, $p < .001$, $d_z = 1.27$.

Discussion

Experiment 3 used a PRP paradigm with the effect propagation logic to locate processing differences between honest and dishonest responding in postcentral stages of information processing. Participants executed a (dis)honest task shortly before responding to a tone and the temporal distance between question and tone onset was either short or long. In line with the assumption that responses have to be selected consecutively because of capacity limitations (e.g., Pashler, 1994a; Welford, 1952), tone responses were slower and less accurate with the short SOA than with the long SOA, whereas (dis)honest responses were not affected by the SOA manipulation.

More importantly, the current data delivers strong support for a recruitment of precentral and central processes as well as monitoring. The intention effect of the (Dis)honest Task 1 propagated to the Tone Task 2, supporting the assumption that dishonest responding relies more on precentral and central, capacity-limited processing than honest responding. For the short SOA, the propagated intention effect even exceeded the intention effect of the (Dis)honest Task 1, pointing to a stronger recruitment of monitoring processes during dishonest than during honest responding (Jentzsch et al., 2007; Wirth et al., 2015). Preceding descriptions of monitoring processes diverge in their assumptions about the localization of the monitoring process, assuming that it either starts right after response selection (Jentzsch et al., 2007), or at one point during response execution (Kunde, Wirth, & Janczyk, 2017). For dishonest responding, the conflict between the activated honest response and the necessary dishonest response should already be evident during response selection and could initiate response monitoring right after response selection. If these monitoring processes also outlive all motor execution processes, effects in motor execution would be masked and not detectable in the current paradigm (see Figure 5B). Against this background, we assessed the extent of monitoring processes in Experiment 4.

Experiment 4

The former three experiments used traditional PRP paradigms that originally did not include assumptions about a monitoring process, but evidence for monitoring can be found in effect propagation designs anyway, in terms of propagated effects that exceed their original effects (e.g., Wirth et al., 2015). Monitoring processes can also be studied in designs where the stimulus in one trial appears only after the response in a preceding trial (e.g., Jentzsch & Dudschig, 2009; Wirth et al., 2018). Such a sequential task arrangement allows for an assessment of monitoring processes that outlive all other stages traditionally assumed in stage models. If monitoring after dishonest responding lasts until response selection of the following task, they should hinder these selection processes as both are capacity-limited (Jentzsch et al., 2007; Welford, 1952).

Experiment 4 examined the extent of capacity-limited monitoring processes in dishonest responding and therefore, the experiment again featured the (Dis)honest Task 1 and the Tone Task 2 as in Experiment 3. Crucially, the sequential arrangement of the two tasks did not come with a manipulation of SOAs, that is, the temporal distance between both task stimuli, but employed a variation of the temporal distance between the delivery of the (dis)honest response in Task 1 and the onset of the tone of Task 2 instead (response-stimulus interval; RSI). The tone played either simultaneously with (dis)honest responding (short RSI of 0 ms) or with a brief temporal delay (long RSI of 1000 ms). Extensive monitoring processes should interfere with response selection of the tone task, leading to a propagation of the intention effect for the short RSI but not for the long RSI.

Method

The experimenter collected data of 33 participants to compensate for the abort of data collection of one participant before the end of the experiment. The experimenter noticed that this participant went through trials that did not feature a question because this participant had responded with *no* only to two of the 72 questions.

Experiment 4 was very similar to the preceding experiments. Accordingly, we only refer to methodological details where this experiment deviates from the former one. Again, the (dis)honest task preceded the tone task, but crucially, the tone always played after the (dis)honest task had been executed. In case of an error in the (Dis)honest Task 1, an error-specific feedback immediately appeared for 1,500 ms. The Tone Task 2 only followed after a correct response in the preceding (Dis)honest Task 2. The RSI between the (dis)honest response and tone onset amounted to either 0 ms (short RSI) or 1,000 ms (long RSI). Participants had to deliver the (dis)honest response within 3,000 ms after question onset and the tone response within 1,000 ms after tone onset.

Results

Data treatment and analyses. We used the same exclusion criteria and statistical analyses as in the former experiment with two exceptions: the temporal factor was the RSI (short vs. long) instead of SOA, and we did not have to filter grouped responses because grouping was not possible in the current design. One participant committed at least 50% commission errors in one of the experimental cells and could not be considered for any statistical analyses.

All post-error trials were excluded before computing further analyses (20.9%). To analyze error rates of the (Dis)honest Task 1, we excluded errors (0.7%) except commission errors. The Tone Task 2 only followed correct (dis)honest responses, and for the error rate analysis of the Tone Task 2, we excluded other erroneous tone responses than commission errors (3.3% other errors excluded). For RT analyses of both tasks, we excluded all errors and outliers (4.7% outliers excluded). Descriptive statistics of the error rates appear in Table B7 of Appendix B and descriptive statistics of the RTs in Table B8 of Appendix B and in Figure 7.

(Dis)honest Task 1. Dishonest response were slower (Δ = 143 ms), $F(1, 30) = 62.66$, $p < .001$, $\eta_p^2 = .68$, and more error-prone (Δ = 6.7%), $F(1, 30) = 34.54$, $p < .001$, $\eta_p^2 = .54$, than honest responses. Neither the main effect of RSI, nor the interaction of both factors was significant in RTs, $F\text{s} \leq 2.25$, $p\text{s} \geq .144$, or in error rates, $F\text{s} < 1$.

Tone Task 2. Tone responses were slower (Δ = 20 ms), $F(1, 30) = 187.98$, $p < .001$, $\eta_p^2 = .86$, and less accurate, (Δ = 1.7%), $F(1, 31) = 10.11$, $p = .003$, $\eta_p^2 = .25$, with the short RSI compared

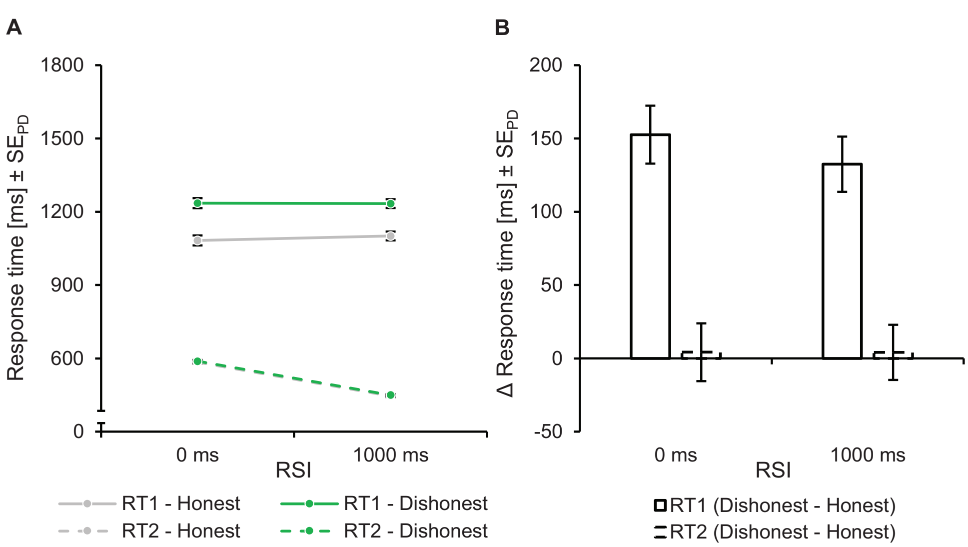

Figure 7. Mean RTs (A) and mean RT intention effects (B) of the (Dis)honest Task 1 (RT1; solid lines) and of the Tone Task 2 (RT2; dashed lines) of Experiment 4. Note that scaling of the y-axes differs from the former experiments. In the left panel, light gray lines constitute honest trials and dark green (dark gray) lines dishonest trials. In the right panel, RT intention effects were computed as the mean differences between dishonest and honest trials. Error bars represent the standard errors of paired differences (SE_{PD}), computed separately for response-stimulus interval (RSI) and task in the left panel and for RSI in the right panel. See the online article for the color version of this figure.

to the long RSI. The main effect of intention and the interaction of both factors were neither significant in RTs, $Fs \leq 1.43$, $ps \geq .241$, nor in error rates, $Fs < 1$.

Discussion

The preceding Experiment 3 provided evidence for the notion of prolonged late, capacity-limited monitoring process for dishonest compared to honest responses but did not allow for inferences about the extent of this monitoring process. Experiment 4 featured an adapted effect propagation paradigm where the tone task commenced always after the (Dis)honest Task 1 had been finished to assess the extent of dishonest monitoring. The intention effect in the (Dis)honest Task 1 did not propagate to the Tone Task 2. This could mean two things: There was no monitoring process or there was a monitoring process that had been finished before response selection processes of the tone task began. When taking into account the results of Experiment 3 and 4, the latter explanation appears to be the more plausible one.

In a preceding study, contrast effects in one task were entirely absorbed into the cognitive slack of monitoring processes triggered by an error in the preceding task, even with an RSI of 50 ms (Jentzsch & Dudschig, 2009). If these perceptual processes could fall entirely into the monitoring process, this monitoring process must have been relatively enduring. An important difference between the cited and the current study is the presentation of external feedback. Participants received feedback if they did not provide a correct (dis)honest response and in this case, another (Dis)honest Task 1 instead of a Tone Task 2 followed. The presentation of the tone, thus, served as an explicit signal of a correct response and might have rendered further response monitoring obsolete.

Accordingly, monitoring processes would only be beneficial if there is uncertainty about the appropriateness of the monitored response. Whether monitoring indeed operates this flexibly could be assessed by presenting error feedback either immediately after each response as in the current design or only after the delivery of both tasks' responses. A propagation of monitoring effects should be more probable in the former than in the latter feedback condition.

General Discussion

Four experiments aimed at uncovering the stages of information processing at which inhibition of honest responding and the generation of dishonest responding takes place. Therefore, we combined two powerful and established experimental tools, the instructed intention paradigm from the lying literature and the PRP paradigm with its effect propagation and locus-of slack logic from sensorimotor stage theories (e.g., Debey et al., 2014; Pashler, 1994a). The resulting data pattern is in line with a strong involvement of capacity-limited processes of response selection and a relatively weaker contribution of precentral processes of response activation (Experiment 1 to 3) as well as capacity-limited processes of monitoring (Experiment 3) in dishonest responding. These monitoring processes are either short-lived and targeted for the intended response or they could be adaptive in length depending on feedback (Experiment 4).

Revisiting the Cognitive Basis of Lies

Empirical research pinpointed the two-step process of truth-inhibition and lie-activation as the basis of dishonest responding when this particular response could not have been rehearsed or prepared in form of a false alibi (e.g., Debey et al., 2014; Foerster, Wirth, Herbort, et al., 2017). The current study characterized most of this process as capacity-limited but also as precentral processing. Together, the cue and the question might have already triggered an automatic, activation and/or inhibition of the honest and dishonest response (e.g., Hommel, 1998; Miller, 2006). More speculatively dishonest cues might signal adaptations in response criterion (Reuss et al., 2011). Examining the role of such speed–accuracy trade-offs in dishonest responding should be the aim of future research. Observing effects of response criteria would call for an implementation of these mechanisms in established theories of dishonest processing as the ADCAT (e.g., Walczyk et al., 2014).

ADCAT already accounts for prolonged monitoring of own behavior when lying, assuming that liars strive to appear convincing and thus increase monitoring and control of their demeanor. The current results suggest that prolonged monitoring in dishonesty can occur on a basic cognitive level of response selection, either specifically because of the presence of response conflict, or more generally because of the difficulty that arises from such conflict. In other words, monitoring own behavior might increase when response selection is difficult, and decrease when it is easy. This perspective on response selection and monitoring suggests that whenever dishonest responding becomes easier as, for example, when rehearsing specific dishonest responses (Hu, Chen, & Fu, 2012; Hu, Rosenfeld, & Bodenhausen, 2012), monitoring should also diminish, allowing subsequent tasks to run more smoothly.

Uncovering Hidden Postcentral Processes

Experiment 4 of the current study did not show any residual monitoring effects when the Tone Task 2 did no longer temporally overlap with the (dis)honest task but rather followed the (dis)honest response in time. If there were monitoring processes at work, they might either have been finished before interfering with the processing of the tone task, or they might have been stopped by the tone as a signal for correct responding. In the interim discussion of Experiment 3, we already mentioned that monitoring effects could overshadow any intention effects in motor execution. As such, monitoring effects would need to be eliminated to get a grasp on potential motor effects.

Potentially overlapping effects are not only an issue for the examination of dishonest processes but they pertain to basic mechanisms within the PRP paradigm and its assumptions in general (Kunde et al., 2017). A challenge for future studies in this paradigm will thus be to control for monitoring processes when aiming to localize an effect clearly within the motor execution stage.

Open Challenges

The PRP paradigm as used in the present studies proved fruitful to map the cognitive architecture of dishonesty to different stages of information processing. In order to employ such methodology, however, our setup intentionally boiled down dishonest responding to the cognitive aspect of truth activation and inhibition. In this setting, participants did not have to make up own lies or practice particular responses. They also did not have to fear any positive or negative consequences from lying. Motivational and emotional aspects as for example, the expectancy of loss or gain (Schindler & Pfattheicher, 2017), the accessibility of justifications for being dishonest (Shalvi, Eldar, & Bereby-Meyer, 2012), or the extent of reward (Hilbig & Thielmann, 2017) can affect the prevalence of lies and could alter the way lies are processed. Experimental rigor often calls for the instruction of dishonesty as in the current experiments whereas such commands certainly are rare and a special instance of lying when it comes to real-word communication. We would argue, however, that whenever truth activation and inhibition accompany dishonest responding, these processes should prolong mostly response selection but also response activation and monitoring processes. Whenever truth activation and inhibition take a smaller or no role in dishonest responding, these processes should also be recruited to a lesser extent. To scrutinize such assumptions, research should not only confine to the identification of multiple moderators of lying, but should also strive to pinpoint their impact on cognitive processing in clear-cut experiments. PRP paradigms deliver a tried-and-tested method to pinpoint the contribution of experimentally manipulated variables to information processing. Implementing different instances of lying in such systematic investigations will be a challenge and we hope that the current study can be a stepping stone for such approaches.

Conclusion

The current study set out to isolate and localize the activation and inhibition of the truthful response in dishonest responding within specific stages of information processing. First and foremost, the results suggested prolonged response selection when responding dishonestly. Furthermore, our studies pinpointed additional processes to precentral response activation, as well as late capacity-limited response monitoring. Together, the current results demonstrate a pervasive adaptation of information processing in order to produce dishonest responses. To get a full picture of the cognitive underpinnings of dishonest responding, potential contributions of motor execution need to be disentangled from monitoring and different instances of lying need to be taken into account in future studies.

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(*Appendices follow*)

Appendix A

Question Sets

Table A1

Question Set of Experiment 1, 3 and 4 With German Originals and English Translations

German original	English translation
Warst du Joggen?	Did you go for a run?
Bist du eine Treppe herunter gegangen?	Did you go down a staircase?
Bist du eine Treppe hoch gegangen?	Did you go up a staircase?
Hast du getankt?	Did you buy petrol?
Hast du Schokolade gegessen?	Did you eat chocolate?
Bist du Bus gefahren?	Did you take a bus?
Bist du Zug gefahren?	Did you take a train?
Hast du einen Mülleimer benutzt?	Did you use a dustbin?
Hast du ein Bad genommen?	Did you take a bath?
Hast du ein Toast zubereitet?	Did you make a sandwich?
Hast du einen Brief geschrieben?	Did you post a letter?
Hast du eine Tür geschlossen?	Did you close a door?
Warst du duschen?	Did you take a shower?
Hast du eine Zeitung gekauft?	Did you buy a newspaper?
Hast du eine Zeitschrift gekauft?	Did you buy a magazine?
Hast du ein Messer benutzt?	Did you use a knife?
Hast du einen Regenschirm benutzt?	Did you use an umbrella?
Hast du ein Medikament genommen?	Did you take a pill?
Hast du mit einem Polizisten gesprochen?	Did you speak to a police officer?
Hast du einen Apfel gegessen?	Did you eat an apple?
Hast du ein Fenster zerstört?	Did you break a window?
Hast du telefoniert?	Did you use a telephone?
Hast du eine SMS erhalten?	Did you receive a text?
Hast du einen Saft getrunken?	Did you drink fruit juice?
Hast du Radio gehört?	Did you listen to the radio?
Warst du im Internet?	Did you use the internet?
Hast du in einer Schlange angestanden?	Did you stand in a queue?
Hast du in einem Warteraum gesessen?	Did you sit in a waiting room?
Hast du dein Bett gemacht?	Did you make your bed?
Hast du deine Hände gewaschen?	Did you wash your hands?
Hast du ein Dokument unterzeichnet?	Did you sign a document?
Hast du Kaffee getrunken?	Did you drink coffee?
Hast du mit einem Kind gesprochen?	Did you speak to a child?
Hast du Fernsehen geschaut?	Did you watch television?
Hast du Zwiebeln gegessen?	Did you eat onions?
Hast du Wasser getrunken?	Did you drink water?
Hast du an einer Ampel gehalten?	Did you stop at a traffic light?
Warst du im Supermarkt?	Did you go to a supermarket?
Hast du Blumen gekauft?	Did you buy some flowers?
Hast du abgewaschen?	Did you do the dishes?
Bist du Fahrstuhl gefahren?	Did you take an elevator?
Hast du ein Fenster geputzt?	Did you clean a window?
Hast du eine Verabredung verschoben?	Did you reschedule an appointment?
Hast du ein Buch gelesen?	Did you read a book?
Hast du ein Moped abgestellt?	Did you park a moped?
Hast du eine Zitrone ausgepresst?	Did you squeeze a lemon?
Hast du eine Email verschickt?	Did you send an e-mail?
Hast du ein Tier gestreichelt?	Did you stroke a pet?

(*Appendices continue*)

Table A1 (*continued*)

German original	English translation
Hast du einen Mantel getragen?	Did you wear a coat?
Hast du einen Kühlschrank geöffnet?	Did you open a fridge?
Hast du einen Computer eingeschaltet?	Did you switch on a computer?
Hast du eine Zigarette geraucht?	Did you smoke a cigarette?
Hast du auf eine Uhr geschaut?	Did you look at a watch?
Hast du einen Wasserhahn geöffnet?	Did you open a water tap?
Hast du einen Toilettendeckel geöffnet?	Did you lift a toilet seat?
Bist du über einen Zebrastreifen gelaufen?	Did you use a pedestrian crossing?
Hast du einen Geldautomaten benutzt?	Did you use an ATM?
Hast du Geld gewechselt?	Did you change money?
Hast du einen Teppich abgesaugt?	Did you vacuum a carpet?
Hast du Hustensaft getrunken?	Did you drink cough syrup?
Hast du jemanden gegrüßt?	Did you greet someone?
Hast du geputzt?	Did you clean the house?
Hast du in deinen Briefkasten geschaut?	Did you check your mailbox?
Hast du deine Zähne geputzt?	Did you brush your teeth?
Hast du Musik gehört?	Did you listen to music?
Bist du Fahrrad gefahren?	Did you ride on a bicycle?
Hast du auf einer Leiter gestanden?	Did you stand on a ladder?
Hast du auf einem Stuhl gesessen?	Did you sit on a chair?
Hast du ein Stück Papier abgerissen?	Did you rip a piece of paper?
Hast du Blumen gegossen?	Did you water the plants?
Hast du deine Schlüssel benutzt?	Did you use your keys?
Hast du Wasser gekocht?	Did you boil some water?

Table A2
Question Sets of Experiment 2 With German Original and English Translation

Set	German original	English translation
1	Hast du die Würfel gestapelt?	Did you stack the dice?
	Hast du die Bausteine getrennt?	Did you take apart the bricks?
	Hast du auf das Blatt gestempelt?	Did you stamp the piece of paper?
	Hast du die Stiftkappen vertauscht?	Did you swap the caps of the pens?
	Hast du in das Papiertuch getackert?	Did you staple the paper towel?
	Hast du die Klammer am Cent befestigt?	Did you clip the peg on the cent?
	Hast du den Kaffeefilter durchstochen?	Did you puncture the coffee filter?
	Hast du den Sticker auf den Teller geklebt?	Did you put the sticker on the plate?
	Hast du die Fliege [aus Papier] in die Schachtel gepackt?	Did you put the [paper] fly into the container?
	Hast du eine Schleife um die Gabel gebunden?	Did you tie a bow to the fork?
2	Hast du die Nudel zerbrochen?	Did you break the noodle?
	Hast du die Karte zerschnitten?	Did you cut the card?
	Hast du den Helikopter ausgemalt?	Did you color a helicopter?
	Hast du Reis in die Dose umgefüllt?	Did you decant the rice into the container?
	Hast du die Watte zur Kugel gerollt?	Did you form a ball from the cotton wool?
	Hast du den Draht vom Deckel entfernt?	Did you detach the wire from the cap?
	Hast du die Murmel in die Folie getan?	Did you put the marble into the transparent envelope?
	Hast du den Magneten aus der Kapsel geholt?	Did you take the magnet from the capsule?
	Hast du die Mutter von der Schraube gedreht?	Did you loosen the nut from the screw?
	Hast du Papier aus der Zeitschrift gerissen?	Did you rip paper from the magazine?

Note. Explanations in brackets were not part of the question.

(*Appendices continue*)

Appendix B

Descriptive Statistics

Table B1

Mean Error Rates and Mean Error Rate Intention Effects (Δ = Dishonest–Honest) in Percent With Respective Standard Deviations for Each Combination of Task, Stimulus Onset Asynchrony (SOA), and Intention of Experiment 1

Task	SOA	Intention	Mean error rate (*SD*)	Mean Δ error rate (*SD*)
Tone Task 1	150 ms	Honest	2.1 (2.57)	−0.1 (1.83)
		Dishonest	2.0 (3.08)	
	1500 ms	Honest	1.9 (1.86)	0.1 (1.70)
		Dishonest	1.9 (2.04)	
(Dis)honest Task 2	150 ms	Honest	10.0 (5.99)	5.4 (6.58)
		Dishonest	15.4 (8.21)	
	1500 ms	Honest	9.7 (7.43)	4.8 (7.62)
		Dishonest	14.5 (8.81)	

Table B2

Mean Reaction Times (RTs) and Mean RT Intention Effects (Δ = Dishonest–Honest) in Milliseconds With Respective Standard Deviations for Each Combination of Task, Stimulus Onset Asynchrony (SOA), and Intention of Experiment 1

Task	SOA	Intention	Mean RT (*SD*)	Mean Δ RT (*SD*)
Tone Task 1	150 ms	Honest	740 (201.4)	26 (73.1)
		Dishonest	765 (231.2)	
	1500 ms	Honest	614 (133.5)	5 (31.6)
		Dishonest	619 (149.8)	
(Dis)honest Task 2	150 ms	Honest	1,456 (309.7)	150 (128.8)
		Dishonest	1,606 (308.5)	
	1500 ms	Honest	1,147 (184.7)	183 (104.0)
		Dishonest	1,331 (215.3)	

Table B3

Mean Error Rates and Mean Error Rate Intention Effects (Δ = Dishonest–Honest) in Percent With Respective Standard Deviations for Each Combination of Task, Stimulus Onset Asynchrony (SOA), and Intention of Experiment 2

Task	SOA	Intention	Mean error rate (*SD*)	Mean Δ error rate (*SD*)
Tone Task 1	150 ms	Honest	2.7 (4.46)	0.3 (3.18)
		Dishonest	3.0 (3.54)	
	1500 ms	Honest	2.2 (1.95)	0.1 (2.42)
		Dishonest	2.3 (3.17)	
(Dis)honest Task 2	150 ms	Honest	8.7 (9.74)	7.7 (6.57)
		Dishonest	16.4 (9.26)	
	1500 ms	Honest	7.8 (8.96)	8.8 (7.09)
		Dishonest	16.6 (11.74)	

(*Appendices continue*)

Table B4
Mean Reaction Times (RTs) and Mean RT Intention Effects (Δ = Dishonest–Honest) in Milliseconds With Respective Standard Deviations for Each Combination of Task, Stimulus Onset Asynchrony (SOA), and Intention of Experiment 2

Task	SOA	Intention	Mean reaction time (*SD*)	Mean Δ RT (*SD*)
Tone Task 1	150 ms	Honest	754 (197.1)	1 (106.9)
		Dishonest	755 (203.7)	
	1500 ms	Honest	626 (139.8)	3 (32.9)
		Dishonest	629 (141.4)	
(Dis)honest Task 2	150 ms	Honest	1,470 (287.1)	132 (134.4)
		Dishonest	1,602 (308.8)	
	1500 ms	Honest	1,178 (174.8)	181 (117.0)
		Dishonest	1,359 (207.6)	

Table B5
Mean Error Rates and Mean Error Rate Intention Effects (Δ = Dishonest–Honest) in Percent With Respective Standard Deviations for Each Combination of Task, Stimulus Onset Asynchrony (SOA), and Intention of Experiment 3

Task	SOA	Intention	Mean error rate (*SD*)	Mean Δ error rate (*SD*)
(Dis)honest Task 1	150 ms	Honest	6.4 (6.06)	3.8 (4.66)
		Dishonest	10.2 (5.96)	
	1500 ms	Honest	6.6 (5.52)	4.1 (5.79)
		Dishonest	10.7 (7.32)	
Tone Task 2	150 ms	Honest	7.3 (4.31)	−0.6 (4.64)
		Dishonest	6.7 (4.79)	
	1500 ms	Honest	3.9 (4.89)	0.5 (3.39)
		Dishonest	4.4 (3.67)	

Table B6
Mean Reaction Times (RTs) and Mean RT Intention Effects (Δ = Dishonest–Honest) in Milliseconds With Respective Standard Deviations for Each Combination of Task, Stimulus Onset Asynchrony (SOA), and Intention of Experiment 3

Task	SOA	Intention	Mean RT (*SD*)	Mean Δ RT (*SD*)
(Dis)honest Task 1	150 ms	Honest	1,397 (282.3)	179 (142.0)
		Dishonest	1,576 (305.0)	
	1500 ms	Honest	1,426 (375.1)	207 (140.3)
		Dishonest	1,633 (398.8)	
Tone Task 2	150 ms	Honest	1,664 (296.9)	211 (163.6)
		Dishonest	1,875 (323.0)	
	1500 ms	Honest	661 (211.6)	111 (109.3)
		Dishonest	772 (258.3)	

(*Appendices continue*)

Table B7
Mean Error Rates and Mean Error Rate Intention Effects (Δ = Dishonest–Honest) in Percent With Respective Standard Deviations for Each Combination of Task, Response-Stimulus Interval (RSI), and Intention of Experiment 4

Task	RSI	Intention	Mean error rate (*SD*)	Mean Δ error rate (*SD*)
(Dis)honest Task 1	0 ms	Honest	8.6 (7.48)	7.0 (7.62)
		Dishonest	15.5 (10.80)	
	1000 ms	Honest	8.7 (7.25)	6.4 (7.10)
		Dishonest	15.1 (10.77)	
Tone Task 2	0 ms	Honest	4.4 (3.36)	−0.6 (3.10)
		Dishonest	3.9 (3.57)	
	1000 ms	Honest	2.5 (2.30)	0.0 (2.72)
		Dishonest	2.5 (2.50)	

Table B8
Mean Reaction Times (RTs) and Mean RT Intention Effects (Δ = Dishonest–Honest) in Milliseconds With Respective Standard Deviations for Each Combination of Task, Response-Stimulus Interval (RSI), and Intention of Experiment 4

Task	RSI	Intention	Mean RT (*SD*)	Mean Δ RT (*SD*)
(Dis)honest Task 1	0 ms	Honest	1,083 (239.2)	153 (113.2)
		Dishonest	1,235 (252.4)	
	1000 ms	Honest	1,101 (261.2)	132 (100.4)
		Dishonest	1,233 (259.4)	
Tone Task 2	0 ms	Honest	584 (89.4)	4 (29.4)
		Dishonest	588 (96.5)	
	1000 ms	Honest	445 (74.2)	4 (23.3)
		Dishonest	449 (72.1)	

Appendix C

Results of the Follow-Up Experiment

Data Treatment and Analyses

We preregistered this experiment publicly (osf.io/hdqyx). The intention effect for the short SOA of 150 ms in Experiment 2 amounted to $d_z = 0.98$. A sample size of about 13 participants ensures a power of 90% with an alpha of 5% to detect this effect size. Because of counterbalancing and potential exclusion of participants we recruited a sample of 16 participants. Data was treated and analyzed as in Experiment 2. One participant committed at least 50% commission errors in one of the design cells and was excluded. We excluded post-error trials (17.3%). Other errors than commission errors in the Tone Task 1 were excluded (0.3%) before analyzing error rates of the Tone Task 1. Error rate analysis of the (Dis)honest Task 2 was restricted to trials with correct tone responses and we then excluded other errors than commission errors of the (Dis)honest Task 2 (1.0%). Only correct trials with inter-response intervals above 100 ms (2.3% excluded) and RTs within 2.5 SDs of the corresponding cell mean (3.7% excluded) entered RT analyses of both tasks. Descriptive statistics of the error rates are presented in Table C1 and of the RTs in Table C2 and in Figure C1.

Tone Task 1

Tone RTs showed a nonsignificant trend toward slower responses in dishonest compared to honest trials (Δ = 36 ms), $F(1, 14) = 3.84$, $p = .070$, $\eta_p^2 = .22$, and the other effects were also not significant, *F*s < 1. Error rates were higher with short than long SOAs, $F(1, 14) = 6.12$, $p = .027$, $\eta_p^2 = .30$ (Δ = 1.1%). The main effect of intention and the interaction were not significant in error rates, *F*s ≤ 1.37, *p*s ≥ .261.

(Dis)honest Task 2

Dishonest responses were slower than honest responses (Δ = 204 ms), $F(1, 14) = 51.75$, $p < .001$, $\eta_p^2 = .79$, and with short SOAs than with long SOAs (Δ = 137 ms), $F(1, 14) = 77.57$, $p < .001$, $\eta_p^2 = .85$. The interaction of both factors was not significant, $F < 1$. Dishonest responses were less accurate than honest responses (Δ = 10.9%), $F(1, 14) = 66.67$, $p < .001$, $\eta_p^2 = .83$. The main effect of SOA and the interaction were not significant in error rates, *F*s < 1.

(*Appendices continue*)

Table C1
Mean Error Rates and Mean Error Rate Intention Effects (Δ = Dishonest–Honest) in Percent With Respective Standard Deviations for Each Combination of Task, Stimulus Onset Asynchrony (SOA), and Intention of the Additional Experiment

Task	SOA	Intention	Mean error rate (*SD*)	Mean Δ error rate (*SD*)
Tone Task 1	0 ms	Honest	3.1 (2.42)	0.2 (2.58)
		Dishonest	3.3 (3.85)	
	150 ms	Honest	1.8 (1.74)	0.5 (1.64)
		Dishonest	2.3 (2.18)	
(Dis)honest Task 2	0 ms	Honest	7.8 (3.41)	10.3 (6.12)
		Dishonest	18.1 (7.00)	
	150 ms	Honest	6.2 (3.03)	11.4 (6.09)
		Dishonest	17.6 (7.36)	

Table C2
Mean Reaction Times (RTs) and Mean RT Intention Effects (Δ = Dishonest–Honest) in Milliseconds With Respective Standard Deviations for Each Combination of Task, SOA and Intention of the Additional Experiment

Task	SOA	Intention	Mean RT (*SD*)	Mean Δ RT (*SD*)
Tone Task 1	0 ms	Honest	933 (305.1)	38 (97.6)
		Dishonest	971 (356.5)	
	150 ms	Honest	944 (334.6)	35 (73.8)
		Dishonest	979 (349.5)	
(Dis)honest Task 2	0 ms	Honest	1,682 (359.4)	199 (127.7)
		Dishonest	1,880 (413.8)	
	150 ms	Honest	1,539 (397.4)	208 (112.9)
		Dishonest	1,748 (419.5)	

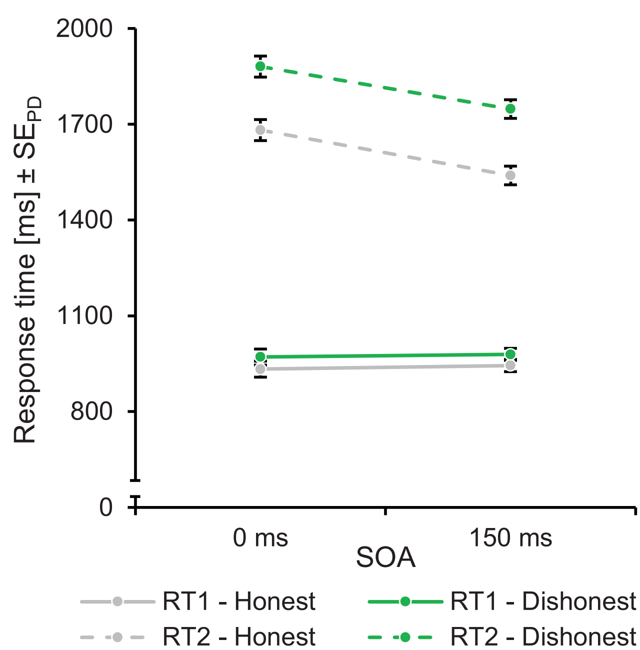

Figure C1. Mean RTs of the Tone Task 1 (RT1; solid lines) and of the (Dis)honest Task 2 (RT2; dashed lines) of the additional experiment. Light gray lines constitute honest trials and dark green (dark gray) lines dishonest trials. Error bars represent standard errors of paired differences (SE_{PD}), computed separately for each SOA and task. See the online article for the color version of this figure.

Received January 5, 2018
Revision received July 3, 2018
Accepted August 16, 2018 ■