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Taking shortcuts: Cognitive conflict during motivated rule-breaking

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A B S T R A C T

Deliberate rule violations have typically been addressed from a motivational perspective that asked whether or not agents decide to violate rules based on contextual factors and moral considerations. Here we complement motivational approaches by providing a cognitive perspective on the processes that operate during the act of committing an unsolicited rule violation. Participants were tested in a task that allowed for violating traffic rules by exploiting forbidden shortcuts in a virtual city maze. Results yielded evidence for sustained cognitive conflict that affected performance from right before a violation throughout actually committing the violation. These findings open up a new theoretical perspective on violation behavior that focuses on processes occurring right at the moment a rule violation takes place.

1. Introduction

Human agents are motivated to minimize the energy they have to invest in performing a task at hand, and reaching this goal sometimes implies that agents come up with solutions that do not necessarily comply with accepted protocols, norms, and rules.

Such deliberate rule violations have been recognized as a prevalent issue in the context of workplace- and safety-related behavior, and previous studies aimed at uncovering the organizational, personal, and situational factors that give rise to rule violations (Berry, Ones, & Sackett, 2007; Jacobsen, Fosgaard, & Pascual-Ezama, 2018; Reason, 1990; Yap, Wazlawek, Lucas, Cuddy, & Carney, 2013). A prominent class of violation-producing conditions includes moral considerations like moral licensing, misperceptions of possible hazards and inattention to moral standards, thus highlighting psychological processes that may bias decision-making toward rule violations (Mazar, Amir, & Ariely, 2008; Moore & Gino, 2015; Reason, 1995).

Research that aims at predicting rule violations as a function of certain violation-producing conditions focuses on the binary outcome of observing whether or not a given agent violates a given rule. This approach has been highly successful in applied studies on rule-violation behavior because it can inform decision-making in the field (Mazar & Ariely, 2006; Parker, Reason, Manstead, & Stradling, 1995; Runciman, Merry, & Walton, 2007). At the same time, however, this approach does not allow for a precise and

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comprehensive understanding of rule violations from a psychological perspective because it does not address the cognitive, motivational, and affective processes that are at work for an individual agent right at the moment that they violate a rule. Recent studies have therefore begun to explore an *agent-centered approach* on deliberate rule violations (Pfister, Wirth, Schwarz, Steinhauser, & Kunde, 2016a; Wirth, Pfister, Foerster, Huestegge, & Kunde, 2016).[1] These studies have documented sustained cognitive conflict during rule-violation behavior that arises due to a continued representation of the rule. Conflict became evident in analyses of movement trajectories that were attracted to the rule-based response option in case of rule violations, and also in electrophysiological measures that suggested less direct response retrieval for rule violations than for rule-based responses (Pfister et al., 2016b). Measures of cognitive conflict were further correlated with the likelihood of deciding for rule violations across participants, with larger costs going along with fewer rule violations.

Previous studies on cognitive conflict during deliberate rule violations focused on the violation of simple classification rules (Jusyte et al., 2017; Pfister et al., 2016a; Wirth et al., 2016). This focus allowed for studying the minimal defining feature of rule violations; that is: knowing the behavior that is prescribed by a rule but deliberately performing an alternative course of action.[2] Participants in these studies classified targets based on an arbitrary mapping rule by moving the mouse cursor from a home area in the bottom center of the computer screen to a target area in the upper-left or upper-right corner of the screen. The mapping rule indicating the correct response to each stimulus was instructed at the beginning of the experiment, but participants were encouraged to break this rule from time to time during the experiment by deliberately performing an incorrect movement. Such a setup provides a principled approach to cognitive processing during rule-violation behavior, but at the same time this design choice comes with the limitation of omitting motivational contributions to rule-breaking (with rule violation being embedded in the "meta-rule" of breaking the existing mapping rule at times; Gozli, 2017).

Experimental approaches that aim at isolating elementary process components such as cognitive conflict come with a lasting tradition in psychology, though recent work has called for a more holistic approach to the phenomena under investigation (Gozli & Deng, in press; Kingstone, Smilek & Eastwood, 2008). The present study followed the latter spirit and aimed at investigating cognitive conflict during unsolicited, motivated rule violations, thus providing a bridge between basic, cognitive approaches and applied and economic approaches (cf. van Kleef, Wanders, Stamkou, & Homan, 2015; Verschuere & Shalvi, 2014).

Rule violations can be motivated by a broad range of factors. Economic studies of rule-violation behavior have typically focused on cheating by investigating situations in which individuals can violate a rule or norm in order to attain monetary advantages (Dai, Galeotti, & Villeval, 2018; Fischbacher & Föllmi-Heusi, 2013; Gächter & Schulz, 2016; Gneezy, 2005; Hilbig & Hessler, 2013). Participants are thus motivated to either increase their payoffs or to prevent monetary losses in these situations (Schindler & Pfattheicher, 2017). Studies in workplace- and safety-related settings, by contrast, have often focused on non-monetary motives by investigating shortcutting behavior that is typically labelled as a routine or optimizing violation (Dommes, Granié, Cloutier, Coquelet, & Huguenin-Richard, 2015; Kimbrough & Vostroknutov, 2015; Reason, 1990; Runciman et al., 2007). Routine and optimizing violations both describe behavior in which agents depart from an operating procedure or rule to render the task more enjoyable. Routine violations mainly comprise situations in which the agent shortcuts one or more steps that would be required by a protocol to expedite task performance, whereas optimizing violations typically describe situations in which the agent performs unusual actions to enrich a low-demand task ("violations for kicks"; Reason, 1995; Runciman et al., 2007). We will use a broader connotation of the term *optimizing violations* in the following to refer to both situations.

As a first step towards investigating cognitive conflict for motivated rule violations, we opted to study optimizing violations in an applied setting: taking forbidden shortcuts while navigating in traffic. An advantage of studying such rule violations is that traffic rules are explicitly defined, which renders forbidden shortcutting a salient event. To measure this type of rule-related shortcutting behavior, we asked our participants to take control of a virtual bicycle courier delivering a pizza in a two-dimensional city map as shown in Fig. 1. The only instruction was to deliver the pizza as quickly as possible and participants were informed that their task was completed as soon as the last pizza had been delivered. Crucially, we implemented one-way roads in some of the maps, and violating these one-way roads could speed up the delivery at times. Accordingly, we expected participants to be motivated to use these shortcuts (i.e., to perform optimizing violations) and studied whether they would experience cognitive conflict in these situations. We further expected participants to differ substantially regarding their frequency of rule violations, following findings on rule and norm violations in terms of cheating and lying (DePaulo, Kashy, Kirkendol, Wyer, & Epstein, 1996, Halevy, Shalvi, & Verschuere, 2014; Kimbrough & Vostroknutov, 2015; Mazar & Ariely, 2006). This difference in frequency should be related to cognitive conflict, with strong cognitive conflict going along with fewer decisions in favor of violating rules.

2. Experiment 1

The main question of Experiment 1 was whether cognitive conflict during rule violation would emerge for unsolicited, motivated rule violations such as taking a forbidden shortcut (Hypothesis 1). Cognitive conflict can be assessed in the current experimental paradigm by analyzing the participants' inter-keystroke intervals while performing the tasks: Entering a one-way road in the

[1] We have previously labeled the two approaches to rule violations as adopting either a third-person or a first-person perspective, with "third-person" referring to studies that assess predictors and precursors of rule-violation behavior as well as its observable consequences, and "first-person" referring to the study of psychological processes during the act of committing a rule violation (Jusyte et al., 2017; Wirth, Foerster, Rendel, Kunde, & Pfister, 2018). The label of an agent-centered approach for the latter type of studies is used here following suggestions that were raised in the review process.

[2] A similar argument can be made for studies that aim at isolating specific cognitive processes involved in lying (e.g., Debey, De Houwer, & Verschuere, 2014; Spence et al., 2001). We will get back to the topic of lying in the General Discussion.

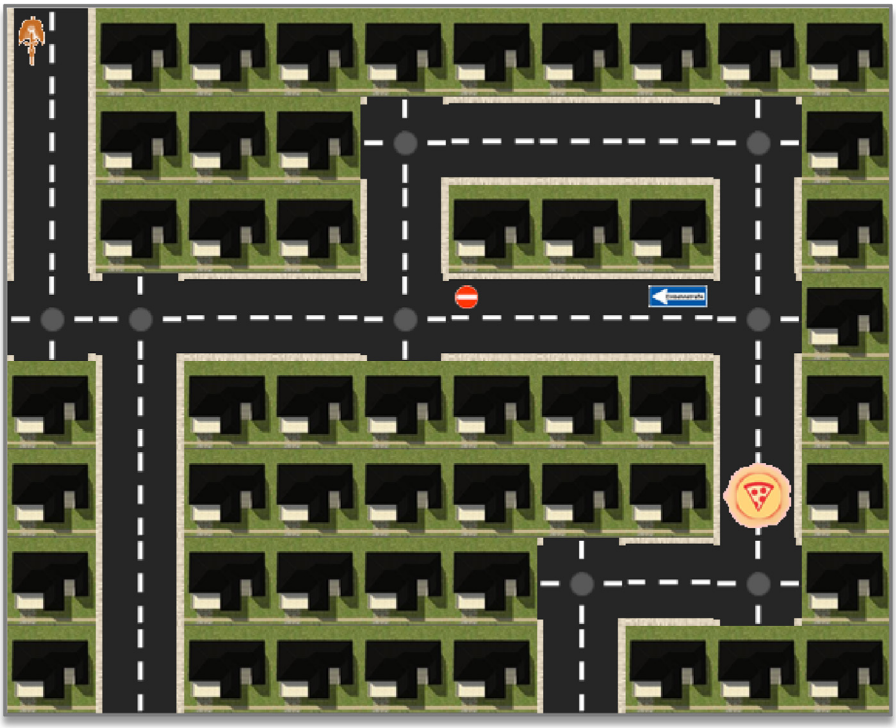

Fig. 1. Exemplar trial of the pizza task to measure rule-breaking behavior. Participants navigated a bicycle courier (here: top-left corner) to deliver a virtual pizza (goal location; bottom-right corner) and each keypress moved the courier on the road for one tile (10 × 8 tiles in total). Some roads could be designated as one-way and shortcutting these roads in the forbidden direction could speed up task performance.

forbidden direction should induce conflict which should temporarily slow down responding, indicated by prolonged inter-keystroke intervals (see Logan & Crump, 2010, for a similar method applied to typing behavior). As a second question, we assessed whether the strength of this conflict would be related to the individuals' tendency to violate rules (Hypothesis 2). Following previous findings on cognitive conflict during deliberate rule violations (Pfister et al., 2016a), we expected stronger conflict to go along with fewer rule violations, as assessed by a correlation of the conflict effects on inter-keystroke intervals with the frequency of rule-violation behavior across participants.[3]

2.1. Method

2.1.1. Participants and power analyses

Seventy-two undergraduate psychology students participated for course credit (61 females, 8 left-handers). Their mean age was 20.5 years (range: 18–29 years). This sample size ensured a high power of $1 - \beta > .99$ for the effect size reported in previous studies (e.g., $d_z = 0.95$ for the effect of rule compliance on initiation times in the "violation group" of Exp. 1 in Pfister et al., 2016a). Assuming that the less controlled setting of the present experiments reduces the effect size to a medium effect of $d_z \geq .50$, this sample would still imply a power of $1 - \beta \geq .99$ for detecting relevant conflict effects. Finally, the chosen sample sizes allowed for a power of $1 - \beta = .80$ for detecting correlations of at least medium size ($r \geq .30$). Power calculations were done using the native "power.t.test" and the "pwr.r.test" function of the "pwr" package version 1.1–3 running in R3.3.0. For all power analyses, we assumed $\alpha = .05$ and a directional test of our main hypotheses (note that we still report two-tailed rather than one-tailed tests to follow common reporting standards). One participant partly guessed the purpose of the experiment and was replaced. The study protocol was approved by the local ethics committee.

2.1.2. Pizza task: Measuring optimizing violations

For the pizza task, participants responded with the four arrow keys of a standard German QWERTZ keyboard to navigate a bicycle courier through city-like 2D-mazes (see Fig. 1). Mazes consisted of 10 × 8 tiles (1.5 cm × 1.5 cm each) and each map contained roads, non-passable houses, and a goal location that was signaled by a pizza icon. Some maps additionally contained one or more designated one-way roads.

[3] As an additional research question, we explored whether the individual proneness to commit rule violations in the pizza task could be predicted by the individual's tendency to employ cognitive shortcuts as measured in an unrelated categorization task (Pashler & Bayliss, 1991). This was not the case. A more detailed theoretical justification and description of these analyses can be found in the Supplementary Material.

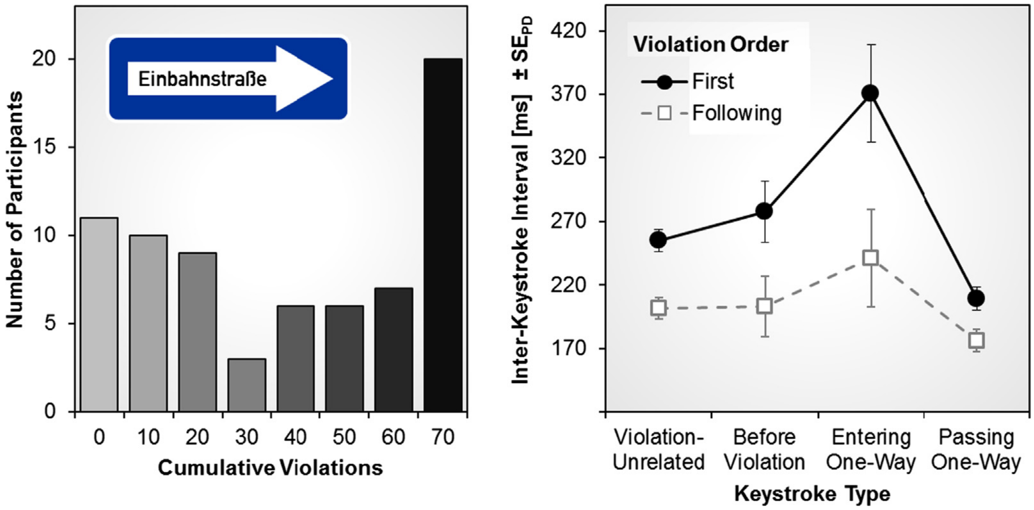

Fig. 2. Central results of the pizza task to measure cognitive conflict during motivated rule-violation behavior in Experiment 1. Left panel: Histogram of the individual proneness to violate rules, accompanied by the German road sign for one-way roads. Bins are labelled in terms of their upper boundary and the experimental design permitted up to a maximum of 70 violations. Right panel: Inter-keystroke intervals at four different positions during a violation trial of the pizza task. First violation data refer to the very first violation committed in the experiment (when participants did not yet know what to expect when entering the one-way road) whereas the data labeled as "following violations" represents the mean of all subsequent violations. Keystroke types are coded for different responses within a trial in which the participant had committed a violation. Error-bars are standard errors of paired differences (SE_{PD}), computed separately for each keystroke type. For additional data and analyses, see Fig. S1 in the Supplementary Material.

Pressing a key moved the courier forward one tile and the bicycle movement was always coded relative to the (global) map rather than the (local) courier orientation, i.e., pressing the left arrow moved the bicycle one tile to the left on the screen, irrespective of the bicycle's orientation. The program logged responses, inter-keystroke intervals, and corresponding bicycle locations throughout the trial. The trial ended as soon as the bicycle reached the goal location. The final map stayed on screen for 500 ms and the next trial started after an additional interval of 1000 ms.

The experiment started with a training block of five maps that did not contain any one-way roads and participants were not informed about these upcoming stimuli. Then, the experimenter left the room and the participant worked through two blocks of 60 trials each. The two blocks used the same maps in a fixed sequence. Overall, the participants thus completed 120 trials, 30 of which did not contain any one-way roads, 20 contained one-way roads that did not help to cut short to the goal location if used in the forbidden direction, and 70 contained one-way roads that helped to cut short to the goal location by violating the indicated direction.

Participants further performed a short additional task to measure their tendency to employ cognitive shortcuts in a categorization task (Pashler & Baylis, 1991) and they completed an ad-hoc questionnaire targeting their subjective views on rule-violation behavior after completing the experimental task (see the Supplementary Material for details).

2.2. Results

2.2.1. Cognitive conflict during one-way violations

A first analysis aimed at characterizing the distribution of one-way violations across participants (Fig. 2, left panel).[4] Descriptively, this distribution exhibited two separate modes, one at each end of the scale. To quantify this visual impression, we computed two statistics: The bimodality coefficient and Hartigan's dip test (Freeman & Dale, 2013; Pfister, Schwarz, Janczyk, Dale, & Freeman, 2013). The bimodality coefficient amounted to $b = .679$, clearly exceeding the cut-off value of $b_{\text{crit}} = .555$ that would be expected for a uniform distribution (Knapp, 2007). Furthermore, the dip test for unimodality (Hartigan & Hartigan, 1985) was significant, $dip = 0.095$, $p < .001$, indicating a non-unimodal distribution.

To test Hypothesis 1, i.e., to probe for cognitive conflict as assessed via inter-keystroke intervals, we distinguished between the very first violation trial and all following violation trials. This was done, because we had chosen not to inform the participants about existence and function of one-way roads during the introduction so that the first act of violation likely involved uncertainty of what to expect when entering the one-way road in the forbidden direction. The analysis could thus only be run for participants who committed at least two violations across the experiment and did not produce any missing data during the first violation, e.g., by reversing direction right after entering the one-way. This procedure resulted in $n = 48$ usable data-sets, thus providing a power of $1 - \beta = .96$ (or $1 - \beta = .92$ when assuming a two-tailed test).

[4] Note that this analysis only included trials in which passing through the one-way road in the forbidden direction served as a shortcut (70 trials per participant). One-way roads for which a violation did not help to shorten the path were used too rarely to allow for meaningful analyses.

Table 1
Mean inter-keystroke intervals in milliseconds for both experiments and all experimental conditions. Standard errors of paired differences (SE_{PD}) show the within-subject standard error when comparing each condition to the baseline condition of violation-unrelated responses (cf. Pfister & Janczyk, 2013).

		Keystroke type				SE_{PD}		
	Violation order	Violation-unrelated	Before violation	Entering one-way	Passing one-way	Before violation	Entering one-way	Passing one-way
Exp. 1	First	255	278	371	209	23	40	14
	Following	202	203	241	176	4	7	2
Exp. 2	First	293	271	349	241	19	22	17
	Following	208	221	263	173	12	15	4

For all participants of the final sample, we calculated mean inter-keystroke intervals for four conditions: (1) keystrokes during a violation trial that were unrelated to the violation itself (i.e., keypresses that were not performed in or right before entering a one-way), (2) keystrokes right before entering a one-way in the forbidden direction, (3) keystrokes that initiated the violation (i.e., entering the one-way), and (4) keystrokes while heading through the one-way in the forbidden direction (see Fig. 2, right panel). Of main interest was the comparison of inter-keystroke intervals when entering a one-way in the forbidden direction as compared to violation-unrelated keystrokes, which provides a direct test for Hypothesis 1. The two remaining keystroke types were mainly included for exploratory analyses. Keystrokes right before entering a one-way allow for evaluating cognitive conflict in a situation in which participants could still turn around and take a rule-conform route. Keystrokes while heading through the one-way, by contrast, allow for assessing behavior while performing a series of consecutive rule-breaking actions (as compared to measures of one instance of rule-violation behavior; e.g., Pfister et al., 2016a).

Inter-keystroke intervals deviating by more than 2.5 standard deviations from their cell mean were considered outliers (3.1%). Because the very first violation of each participant was treated separately, the inter-keystroke interval data were analyzed by a 4×2 repeated-measures analysis of variance (ANOVA) with the factors keystroke type (as described above) and violation order (first vs. following violations; see Table 1 for complete descriptive statistics).

Most importantly, the described ANOVA revealed a main effect of keystroke type, $F(3, 141) = 12.95$ ($\varepsilon = .51$), $p < .001$, $\eta_p^2 = .22$, driven by slow responses when initiating the violation on the one hand, and short inter-keystroke intervals while passing through the one-way on the other hand (as compared to violation-unrelated responses). Additionally, keystrokes during the first violation trial were overall slower than those of the remaining trials, $F(1, 47) = 33.75$, $p < .001$, $\eta_p^2 = .42$, and the effect of keystroke type was stronger for the first violation than for the remaining violations, $F(3, 141) = 3.23$ ($\varepsilon = .59$), $p = .048$, $\eta_p^2 = .07$. Separate pairwise comparisons indicated that the inter-keystroke interval when entering the one-way was significantly longer than violation-unrelated inter-keystroke intervals for the first violation ($\Delta = 115$ ms), $t(47) = 2.90$, $p = .006$, $d = 0.42$, as well as for the following violations ($\Delta = 40$ ms), $t(47) = 5.94$, $p < .001$, $d = 0.86$. Similarly, inter-keystroke intervals while passing the one-way were significantly shorter than unrelated ones for the first violation ($\Delta = -49$ ms), $t(47) = -3.31$, $p = .002$, $d = -0.48$, and also for the following violations ($\Delta = -25$ ms), $t(47) = -11.10$, $p < .001$, $d = -1.60$. The difference between unrelated inter-keystroke intervals and inter-keystroke intervals right before the violation did not approach significance for either comparison ($ps > .320$).

2.2.2. Correlation of cognitive conflict and violation frequency

To test Hypothesis 2, i.e., to probe for the hypothesized negative correlation of cognitive conflict during deliberate rule violations and the individual's proneness to violate rules, we computed a conflict index to capture the net effect of rule-violation behavior on performance. To this end we subtracted the mean inter-keystroke interval when passing through a one-way road from the mean interval when entering the road for the repeated violation condition of each participant. To further account for confounds due to variation in overall response speed, we normalized this difference by dividing it by the participant's mean inter-keystroke interval averaged across all four conditions. The conflict index was correlated with the number of one-way violations across participants, $r = -0.29$, $t(46) = 2.05$, $p = .045$ (see Figure S1 in the Supplementary Material). Follow-up tests revealed that this correlation was mainly due to systematically prolonged inter-keystroke intervals when entering the one-way road: When computing separate correlations for the comparison of inter-keystroke intervals when entering the one-way road relative to the baseline of violation-unrelated responses, and for the comparison of inter-keystroke intervals when passing through the one-way, we observed a significant correlation only for the former case (i.e., entering), $r = -0.35$, $t(46) = 2.52$, $p = .015$, but not for the latter case (i.e., passing), $r = 0.03$, $t(46) = 0.20$, $p = .846$.

2.3. Discussion

The findings of Experiment 1 lend support to both hypotheses of the present study: Participants showed reliable signs of cognitive conflict when entering a one-way road in the forbidden direction (Hypothesis 1), and the strength of this conflict was negatively correlated with the frequency of rule-violation choices across participants (Hypothesis 2). Based on these initial findings, we attempted to replicate and extend the pattern of results in a second experiment.

3. Experiment 2

Experiment 1 had focused on optimizing violations that are motivated solely by the desire to expedite task completion. Even though strong effects of cognitive conflict emerged in this setting, it is not clear whether the observation of cognitive conflict would also generalize to other types of motives, especially when rule violations are committed in the face of monetary temptations (Dai et al., 2018; Fischbacher & Föllmi-Heusi, 2013; Gneezy, 2005; Hilbig & Thielmann, 2017). Findings on choice behavior have often suggested monetary incentives to exert a strong motivational pull towards cheating behavior, creating spontaneous impulses toward rule violation (Bereby-Meyer & Shalvi, 2015; Shalvi, Eldar, & Bereby-Meyer, 2012). These observations could be taken to suggest that the promise of monetary incentives reduces or even overrides cognitive conflict. At the same time, cognitive accounts suggest conflict to arise at a considerably shorter time-scale than motivational processes so that cognitive conflict may also prevail in the presence of monetary temptations (Foerster, Pfister, Schmidts, Dignath, & Kunde, 2013). Experiment 2 therefore replicated the setup of the preceding experiment but introduced monetary incentives – tips for fast deliveries – to study cognitive conflict in such tempting situations.[5]

Hypotheses were as for Experiment 1 and we thus probed for cognitive conflict as measured via inter-keystroke intervals (Hypothesis 1) as well as a negative correlation of the strength of this conflict with the frequency of rule violations across participants (Hypothesis 2).

3.1. Method

We performed a direct replication of the pizza task of Experiment 1 with the only addition that participants could earn tips for fast deliveries. Instructions did not mention this added manipulation, and the program decided between fast (tipped) and slow (non-tipped) trials based on an adaptive algorithm. This algorithm ensured that participants were able to receive tips regardless of whether or not they violated rules, though violating improved the chances of obtaining tips in a given trial. To this end, the two experimental blocks were further divided into sub-blocks of 10 trials. For every sub-block, the mean delivery time was computed upon completion, and deliveries were tipped if a delivery was completed faster than the mean minus 1 SD of the previous sub-block. After a tipped delivery, the experiment displayed “You were quick and got a tip” plus their accumulated tip that they earned during the whole experiment. To allow for this feedback, the inter-trial-interval was changed from 1000 ms to 3000 ms. Participants earned 1.85 € in tips on average.

Seventy-two new participants were recruited and received either course credit or monetary reimbursement of 5 € (before tips). This sample size ensures a power of $1 - \beta > .99$ for detecting cognitive conflict effects as observed in the inter-keypress intervals of Experiment 1 when assuming similar drop-out as in the preceding experiment. The sample comprised 65 females, 6 left-handers (one participant did not disclose handedness) and the participants’ mean age was 26.3 years (range: 19–61 years).

3.2. Results

3.2.1. Cognitive conflict during one-way violations

As for Experiment 1, we first examined the distribution of one-way violations across participants (Fig. 3, left panel). This distribution again exhibited two separate modes, one at the lower end of the scale and one at the upper end, though markedly fewer participants opted not to commit a single rule violation. Statistical assessment showed the distribution not to be unimodal as indicated by a bimodality coefficient of $b = .673$, supported by a significant dip-test, $dip = 0.082$, $p < .001$.

To test Hypothesis 1, i.e., to probe for cognitive conflict as captured via inter-keystroke intervals, we again performed a 4 × 2 repeated-measures ANOVA with the factors keystroke type (violation-unrelated, before violation, entering one-way, passing through one-way) and violation order (first vs. following violations; see Fig. 3 and Table 1 for corresponding descriptive statistics). A subsample of 52 participants was available for this analysis following the same criteria as described for Experiment 1, and we excluded 2.8% of the inter-keystroke intervals as outliers.

Like in Experiment 1, we observed a main effect of keystroke type, $F(3, 153) = 15.67$ ($\varepsilon = .60$), $p < .001$, $\eta_p^2 = .24$, driven by slow responses when initiating the violation and by short inter-keystroke intervals while passing through the one-way (as compared to violation-unrelated responses). Additionally, keystrokes during the first violation trial were overall slower than those of the remaining trials, $F(1, 51) = 45.70$, $p < .001$, $\eta_p^2 = .47$, whereas the interaction of keystroke type and violation order did not interact for Experiment 2, $F(3, 153) = 0.98$ ($\varepsilon = .73$), $p = .384$, $\eta_p^2 = .02$. Separate pairwise comparisons indicated that the inter-keystroke interval when entering the one-way was significantly longer than violation-unrelated inter-keystroke intervals for the first violation ($\Delta = 56$ ms), $t(51) = 2.47$, $p = .017$, $d = 0.34$, as well as for the following violations ($\Delta = 56$ ms), $t(51) = 3.78$, $p < .001$, $d = 0.52$. Similarly, inter-keystroke intervals while passing the one-way were significantly shorter than unrelated ones for the first violation ($\Delta = -52$ ms), $t(51) = -3.02$, $p = .004$, $d = -0.42$, and also for the following violations ($\Delta = -43$ ms), $t(51) = -7.79$, $p < .001$, $d = -1.08$. The difference between unrelated inter-keystroke intervals and inter-keystroke intervals right before the violation did not approach significance for either comparison ($ps > .258$).

[5] We thank the action editor and an anonymous reviewer for stimulating this experiment.

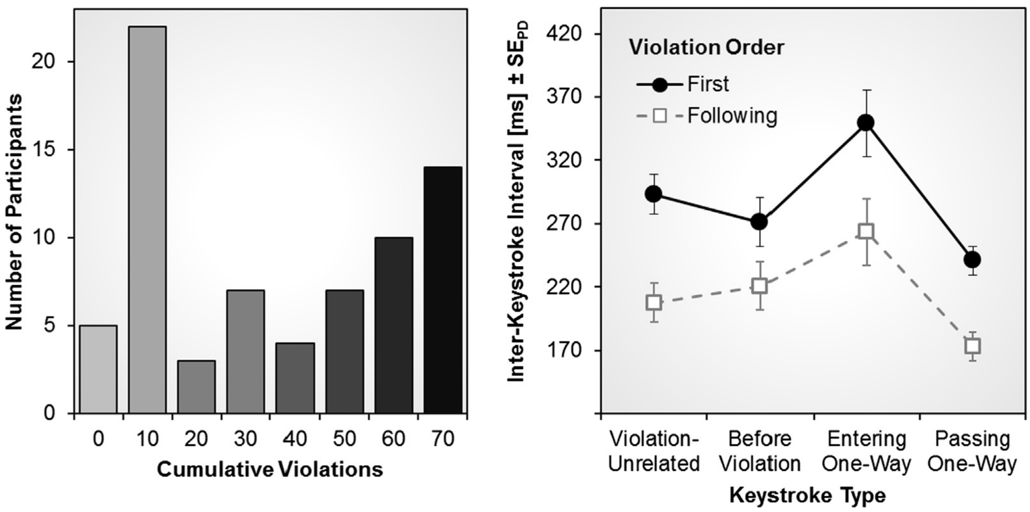

Fig. 3. Results of Experiment 2. Left panel: Histogram of the individual proneness to violate rules. Bins are labeled in terms of their upper boundary with a maximum of 70 violations being permitted by the experimental design. Right panel: Inter-keystroke intervals for the four different conditions during a violation trial of the pizza task (see also Fig. 2). Error-bars are standard errors of paired differences (SE_{PD}), computed separately for each keystroke type. For additional data and analyses, see Fig. S2 in the Supplementary Material.

3.2.2. Correlation of cognitive conflict and violation frequency

To test Hypothesis 2, i.e., to probe for the hypothesized negative correlation of cognitive conflict during deliberate rule violations and the individual's proneness to violate rules, we computed a conflict index as for Experiment 1. The conflict index was again correlated with the number of one-way violations across participants, $r = -0.40$, $t(50) = 3.16$, $p = .003$ (see Figure S2 in the Supplementary Material). Likewise, this correlation mainly derived from prolonged inter-keystroke intervals when entering the one-way road relative to baseline, $r = -0.37$, $t(46) = 2.78$, $p = .007$, and not from the shorter inter-keystroke intervals when passing through the one-way road, $r = 0.15$, $t(46) = 1.08$, $p = .284$.

3.3. Discussion

In Experiment 2, participants were able to earn extra money ("tips") when they delivered a pizza quickly. This additional monetary incentive was introduced to further motivate participants to use forbidden shortcuts by entering a one-way road in the wrong direction on top of the benefit of faster task completion.

Importantly, we still observed cognitive conflict in terms of longer inter-keystroke intervals when participants just entered the one-way road (Hypothesis 1). The results further replicated the negative correlation of the strength of this conflict and the frequency of rule violations (Hypothesis 2), corroborating the results obtained in Experiment 1.

Two observations depart from the previous results, however. First, we did no longer observe an interaction of keystroke type and violation order. For Experiment 1, this interaction had derived from especially large costs when entering a forbidden one-way road for the first time, an effect that is likely due to the uncertainty associated with this response. It seems tempting to attribute this different pattern of results to the stronger motivational pull offered by the additional monetary incentive (Shalvi et al., 2012) which seems to render participants more resilient to uncertainty while it does not overcome the associated cognitive costs.[6] The second observation pertains to the slightly altered shape of the distribution of violation choices across participants: Whereas a sizeable proportion of the participants in Experiment 1 had not committed a single violation throughout the entire session, most participants of Experiment 2 opted to violate the rules at least in a small fraction of the trials. Note, however, that the mean number of violation choices did not differ between experiments as suggested by a post hoc comparison of both data sets with an average of 33.8 violations per participant in Experiment 1 versus 31.4 violations in Experiment 2, $t(142) = 0.56$, $p = .575$, $d_z = 0.09$. On the one hand, this result may be taken to suggest that the size of the monetary incentives might not have been attractive enough for our participants to instigate violation behavior after receiving tips for fast deliveries. Whether or not decisions for dishonesty depend on the amount of possible payoffs is still under debate at present with several studies showing an impact of payoff magnitude (Gneezy, Rockenbach, & Serra-Garcia, 2013; Hilbig, & Thielmann, 2017) while other studies yielded evidence for the contrary (Fischbacher & Föllmi-Heusi, 2013; Harkrider et al., 2013). The question of whether or not higher payoff magnitudes would alter the cognitive effects of rule-violation behavior thus calls for additional empirical clarification. If one assumes that higher payoffs would not qualitatively alter this pattern, the differing distributions of violation frequencies resonate with the idea that monetary incentives may reduce the impact of uncertainty, thus promoting the chance of observing at least one violation response, while not negating other consequences

[6] The first violation condition necessarily comes with rather noisy data especially for the keystrokes before and when entering the one-way, because each participant contributed exactly a single inter-keystroke interval here.

of rule violation behavior such as cognitive conflict.

4. General discussion

The current study set out to bridge cognitive approaches to rule-violation behavior with motivational approaches as they have been put forward in applied psychology and behavioral economics. We studied rule-violation behavior in a task that allowed for shortcutting through one-way roads while participants were to deliver a virtual pizza as quickly as possible. Cognitive conflict during rule-violation behavior was assessed by analyzing the effects of rule violations on continuous task performance while decision biases toward rule-breaking were assessed in terms of the overall frequency of overt rule violations. From a motivational perspective, Experiment 1 focused on optimizing violations, i.e., participants were able to expedite task completion when using one-way roads in the forbidden direction. Experiment 2 built on this setup but introduced additional monetary incentives by offering tips for quick deliveries. We hypothesized that cognitive conflict would emerge also for unsolicited rule violations as operationalized in both experiments (Hypothesis 1) and we further expected the strength of this conflict to go along with fewer instances of rule-violation behavior (Hypothesis 2). The results supported both hypotheses and we will discuss these findings in the following.

4.1. Conflict and its underlying mechanisms

The analyses of inter-keystroke intervals while participants navigated through the city mazes indicated a systematic slow-down when participants just entered a one-way road in the forbidden direction. We propose that at least for repeated violations, this performance decrement indicates a tug-of-war between automatic tendencies to behave in a rule-based manner (i.e., to turn around and take an accepted route) and the deliberate action plan of moving into the one-way road.

Cognitive research on how rules are represented has indeed indicated that rules are retrieved automatically in the face of rule-related stimuli. This work typically used simple classification rules that prescribed the correct response for certain sets of target stimuli. Encountering any of the stimuli has been shown to retrieve the associated responses even for the very first instance of a stimulus-response episode (Cohen-Kdoshay & Meiran, 2007; Kunde, Kiesel, & Hoffmann, 2003; Wenke, Gaschler, & Nattkemper, 2007), suggesting that rule-based behavior is retrieved automatically even in cases when this behavior does not conform to the agent's current intentions (Dreisbach, 2012). Cognitive conflict during rule-violation behavior thus arises due to the concurrent activation of both, rule-based and rule-violating action tendencies.

The concurrent activation of two opposing action tendencies likely parallels findings on the cognitive psychology of lying, where research has highlighted an initial tendency toward truthful responding that needs to be overcome to successfully tell a lie (Debey, De Houwer, & Verschuere, 2014; Foerster, Wirth, Kunde, & Pfister, 2017; Spence et al., 2001; for a recent review, see Suchotzki, Verschuere, Van Bockstaele, Ben-Shakhar, & Crombez, 2017). Whether or not this analogy can be taken to suggest similar processing of lying on the one hand and non-deceptive rule violations on the other hand remains to be explored. For instance, motivational accounts have stressed that lying may become the default response given sufficient self-interest in the outcome of the lie (Verschuere & Shalvi, 2014; Bereby-Meyer & Shalvi, 2015). Along the same lines, it has been shown that frequent lying can facilitate dishonest responding to a degree that it appears to become the default response (Van Bockstaele et al., 2012; Verschuere, Spruyt, Meijer, & Otgaar, 2011; for the crucial role of lying recency in this context, see Foerster et al., 2018). Similar results were observed when participants received an explicit false alibi when lying about recently performed actions (Foerster, Wirth, Herbort, Kunde, & Pfister, 2017). By contrast, the violation of arbitrary stimulus-response mapping rules appears not to be malleable to a similar degree and may at times even yield increased cognitive conflict when violations are performed frequently (Wirth, Foerster, Herbort, Kunde, & Pfister, 2018). Similarly, lying typically involves an attempt to conceal the true answer in a communicative setting, which may impose additional processing demands as compared to instances of rule-breaking that do not hinge on communication and successful concealment. Possible commonalities and differences regarding the representation and processing of lying as compared to other types of rule- and norm-violation therefore wait for empirical clarification.

Further open questions relate to other potential contributions to the conflict effects observed in the present experiments. It is conceivable that the effects of rule violation on inter-keystroke intervals capture additional factors such as moral considerations relating to the participants' self-image (Mazar et al., 2008; Moore & Gino, 2015). Another process that might contribute to the prolonged inter-keystroke intervals when entering the one-way road is that participants tried to pre-plan the entire movement episode in advance. This assumption might also explain the systematic speed-up when passing through the one-way. Alternatively, or in addition, the speed-up when passing through the one-way might be attributed to negative affect that has been shown to accompany rule-violation behavior (Wirth, Foerster, Rendel, et al., 2018), as participants can be assumed to be motivated to avoid such negative affective states.

4.2. Conflict and choice

The distribution of rule violations across participants showed pronounced inter-individual differences with a clear bimodal shape: Participants either used very few forbidden shortcuts or they used many, whereas medium frequencies did not occur as often. This finding is in line with previous individual-differences approaches to cheating, which identified subgroups of mostly honest or "in-corruptible" participants that were distinct from other subgroups whose members were more prone to cheating if cheating behavior promised sufficient payoffs (Fischbacher & Föllmi-Heusi, 2013; Hilbig & Thielmann, 2017; Hilbig & Zettler, 2015).

Importantly, the frequency of rule-violation choices was correlated with cognitive conflict as measured via inter-keystroke intervals. This finding resonates with previous observations regarding rule-violation in simple classification tasks (Pfister et al., 2016a). Furthermore, such cognitive conflict has been shown to be absent for convicted criminals, i.e., individuals with a long history of repeated and severe rule-breaking (Jusyte et al., 2017).

In light of these findings, it seems worthwhile to consider the causal mechanisms underlying such correlations. That is: Do frequent violations reduce the associated conflict or, conversely, does anticipated conflict discourage rule-breaking? Regarding the first possibility, frequently committing rule violations has indeed been shown to reduce the cognitive costs associated with this behavior (given that a rule has been violated frequently and just recently), so that this mechanism likely accounts at least for a share of the observed correlation (Foerster et al., 2018; Verschuere et al., 2011; Wirth, Foerster, Herbort, et al., 2018). Regarding the second possibility, previous studies have argued that anticipating cognitive conflict may be a driving force behind decisions whether to violate a rule or not (Pfister et al., 2016a). Such an interpretation is tempting also for the present results, especially because it follows recent claims that human agents are highly sensitive to the cognitive effort that has to be invested in an upcoming task (Kool, McGuire, Rosen, & Botvinick, 2010). It thus seems likely that individuals who anticipated stronger cognitive costs are indeed deterred from committing a violation, suggesting that both proposed mechanisms work in concert.

The frequency of rule violations also correlated with the subjective feeling of guilt in the context of rule-violation behavior (at least for Experiment 1; see Supplementary Figure S1 and S2). This finding resonates with theories that propose rule-violation behavior to arise only if the potential gains outweigh negative side-effects related to the agent's self-perception (Hochman, Glöckner, Fiedler, & Ayal, 2016; Mazar et al., 2008; Shalvi, Handgraaf, & De Dreu, 2011). These theories postulate that most human agents intend to maintain a positive and moral self-image. Rule-violation behavior (especially lying and cheating) threatens this self-image and such threats are only condoned if the anticipated gains through a rule violation are sufficiently large. The present study calls for an extension of such psychological frameworks of rule-violation behavior by showing that rule violations do not only entail moral costs but that they also come with robust cognitive costs that emerge right before and while the agent deliberately violates a rule.

4.3. Conclusions

The present study shows that unsolicited, motivated rule violations yield cognitive conflict, as agents cannot suppress rule-based tendencies that are automatically activated upon encountering rule-related stimuli. These findings suggest that cognitive conflict is a robust and reliable downstream consequence of rule violation in many different contexts and they promote an agent-centered view on the cognitive, motivational, and affective processes that occur in the acting agent right at the moment a rule violation takes place.

Author note

Experiment 1 was reported in condensed form as part of the first author's PhD thesis (Pfister, 2013), and we are indebted to the dedicated students of the experimental lab course of the winter semester of 2012/13 who performed this experiment. The computer program for the employed pizza task was written during an unexpected overnight stay at Washington Dulles International Airport, due to an apparent lack of usable shortcuts when queueing for customs.

Data availability

The raw data and corresponding analysis scripts are openly available on the Open Science Framework, osf.io/v8usj.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.joep.2018.06.005.

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