

## Failure generates impulsivity only when outcomes cannot be controlled

Article (Accepted Version)

Dyson, Benjamin James, Sundvall, Jukka, Forder, Lewis and Douglas, Sophia (2018) Failure generates impulsivity only when outcomes cannot be controlled. *Journal of Experimental Psychology: Human Perception and Performance*, 44 (10). pp. 1483-1487. ISSN 0096-1523

This version is available from Sussex Research Online: <http://sro.sussex.ac.uk/id/eprint/75300/>

This document is made available in accordance with publisher policies and may differ from the published version or from the version of record. If you wish to cite this item you are advised to consult the publisher's version. Please see the URL above for details on accessing the published version.

### **Copyright and reuse:**

Sussex Research Online is a digital repository of the research output of the University.

Copyright and all moral rights to the version of the paper presented here belong to the individual author(s) and/or other copyright owners. To the extent reasonable and practicable, the material made available in SRO has been checked for eligibility before being made available.

Copies of full text items generally can be reproduced, displayed or performed and given to third parties in any format or medium for personal research or study, educational, or not-for-profit purposes without prior permission or charge, provided that the authors, title and full bibliographic details are credited, a hyperlink and/or URL is given for the original metadata page and the content is not changed in any way.

Failure-impulsivity during uncontrolled conditions

Running head: Failure-impulsivity during uncontrolled conditions

Failure generates impulsivity only when outcomes cannot be controlled

Benjamin James Dyson <sup>1,2</sup>

Jukka Sundvall <sup>1</sup>

Lewis Forder <sup>1</sup>

Sophia Douglas <sup>1</sup>

<sup>1</sup> University of Sussex, UK

<sup>2</sup> Ryerson University, Canada

Address : School of Psychology  
University of Sussex  
Falmer  
BN1 9QH  
UK

Telephone : +44 (0)1273 876661

Fax : +44 (0)1273 678058

E-mail : [b.j.dyson@sussex.ac.uk](mailto:b.j.dyson@sussex.ac.uk)

## Failure-impulsivity during uncontrolled conditions

### *Abstract*

Verbruggen, Chambers, Lawrence & McLaren (2017) recently challenged the view that individuals act with greater caution following the experience of a negative outcome by showing that a gambled loss resulted in faster reaction time on the next trial. Over three experiments, we replicate and establish the boundary conditions of this effect in the context of a simple game (Rock, Paper, Scissors). Choice responding against unexploitable opponents replicated the link between failure and faster responding. However, individuals with high win-rates against exploitable opponents initiated slower rather than faster responding following loss. The data suggest that the link between failure and impulsivity is limited to contexts where participants cannot exert control over outcomes.

### *Keywords*

Sequential effects

Impulsive action

Competitive exploitation

Gambling

Rock, Paper, Scissors

## Failure-impulsivity during uncontrolled conditions

### *Public Significance Statement*

This study challenges the view that a gambled loss will always lead to subsequently impulsive behaviour. We show that individual success within these context determines whether future performance will be faster or slower following failure. In particular, impulsive behaviour following failure is more likely when an individual cannot control the outcome of their environment either as a result of interacting with an unexploitable opponent, or, interacting with an exploitable opponent whom they fail to exploit. When individuals demonstrate domination against an exploitable opponent, loss trials led to less impulsive rather than more impulsive reactions.

## Failure-impulsivity during uncontrolled conditions

According to the traditional view of post-error slowing (e.g., Notebaert, Houtman, Van Opstal, Gevers, Fias & Verguts, 2009) and conflict adaptation (e.g., Botvinick, Braver, Barch, Carter & Cohen, 2001), people are more likely to proceed with caution following failure. In contrast, Verbruggen, Chambers, Lawrence & McLaren (2017) recently reported a series of experiments in which the experience of negative outcomes in a gambling context led to more impulsive (i.e., faster) reaction times (RT) relative to the experience of positive outcomes. Understanding individual impulses when engaging with purely-randomized gambling environments is clearly critical for addressing societal problems currently associated with fixed-odds betting terminal (FOBT) interactions.

Verbruggen et al. (2017) described their data in terms of the acceleration of ‘approach behavior’ since the central metric of interest was the speed with which participants *initiated* the next trial. This was distinct from a second, self-paced choice RT where participants decided whether or not to gamble again. Thus, the speeding associated with trial initiation might be quite different from the impulsivity associated with eventual choice RT. Indeed, their analysis of choice RT (Verbruggen et al., 2017, p. 157) was less clear in that responses following a gambled win were *slower* than a non-gamble baseline, despite the trial being initiated faster. In other words, participants might have been more impulsive in their approach behaviour but then were more cautious in deciding to gamble. To avoid the possibility that trial initiation and choice RT might conflict with one another, we focused on a simple Rock, Paper, Scissors (RPS) paradigm in which only one response was required per trial. Previous research using this paradigm (Forder & Dyson, 2016) also observed the finding of Verbruggen et al. (2017) in that choice RTs following negative outcomes (losses and

## Failure-impulsivity during uncontrolled conditions

draws) were faster than those following positive outcomes (wins), thereby supporting a more direct relationship between negative outcome and impulsivity.

One explanation for the observation of speeding following failure in gambling tasks but slowing following failure in cognitive tasks is the difference in responsibility one ultimately has in determining the outcome. Logically, if we operate in a purely random context then we are not culpable for our wins and losses. However, there are a number of gambling environments where outcomes are not only variable but also partly or wholly determined by skill (compare the continuum of roulette, blackjack, chess; Mauboussin, 2012). Over three experiments, we establish a replicable boundary condition that challenges the conclusion that “losses have a general effect on action” and that “in the context of potential rewards [losses] are emotional events that increase impulsivity” (Verbruggen et al., 2017, p. 147). To foreshadow our results, we found that a) negative outcomes do generate faster (i.e., more impulsive) subsequent decisions when outcomes were the result of chance play against *unexploitable* opponents but that b) negative outcomes did not lead to impulsivity when participants exhibited high win-rates against *exploitable* opponents. The data suggest that the degree of control one is able to exert over a variable outcome environment determines whether one becomes more or less impulsive after experiencing failure.

### Experiment 1

In Experiment 1, we attempted to replicate the findings of Forder & Dyson (2016) that negative outcomes yield faster decision-making than positive outcomes during RPS. For one condition, participants competed with a computerized opponent who behaved according to the mixed-equilibrium strategy (MES; Baek et al., 2013), with the randomized, equal (33%) selection of the three responses largely ensuring the

## Failure-impulsivity during uncontrolled conditions

lack of opponent exploitation <sup>1</sup>. This was contrasted with a second condition, where the computerized opponent was predictable on the majority of trials, and hence exploitable. We hypothesized that if impulsivity following loss was tied to a perceived inability to control outcomes, then this *failure-faster* link should be attenuated in the non-random (*exploitable*) condition relative to the random (*unexploitable*) condition.

### *Method*

50 individuals (33 female) from the University of Sussex community participated in the study; mean age was 22.72 years (SD = 5.71) and 42 were right-handed <sup>2</sup>. Studies were approved for testing by the Life Sciences and Psychology Research Ethics Committee (C-REC) at the University of Sussex (ER/SEDD20/1), and participants were entered into a prize draw to win £25. Static pictures of a white-gloved hand on the right (representing the participant) and a blue-gloved hand on the left (representing the opponent) depicting Rock, Paper and Scissors poses were displayed center screen at approximately  $6^\circ \times 6^\circ$ , with participants sat approximately 57 cm away from a 22" Diamond Plus CRT monitor (Mitsubishi, Tokyo, Japan). Stimulus presentation was controlled by Presentation 18.1 (build 03.31.15).

Participants completed 3 conditions consisting of 120 trials, in a semi-counterbalanced order. In the middle (*unexploitable*) condition, the computer opponent behaved according to MES (i.e., 40 Rock, 40 Paper, 40 Scissors responses in random order). Participants were explicitly informed that their opponent would play randomly in this condition. The *unexploitable* condition was always flanked by a first and third condition (*exploitable*; the order of these two conditions was counterbalanced across participants), in which the computer behaved in accordance with a strategy for 72 (60%) trials where it would select the response that would have

## Failure-impulsivity during uncontrolled conditions

beaten the player's previous response (e.g., player trial  $n$  = rock, computer trial  $n+1$  = paper), and MES for the remaining 48 (40%) trials. As a result of the behavioural isomorphism between differentially described strategies in Rock, Paper, Scissors (Dyson, in preparation), there was an additional language manipulation in the instructions between first and third conditions. For the first condition, participants were told "for most of the trials in the block, the computer's strategy will be based on your previous selection." For the third condition, participants were told "for most of the trials in the block, the computer's strategy will be based on its last selection and outcome." As a result of the equivalence in median RT (612 ms vs. 557 ms;  $t[39] = 0.62, p = .533$ ) and win-rate (44.21% vs. 44.58%;  $t[39] = 0.17, p = .863$ ) between first and third conditions of the final sample (see *Results*), data was collapsed across these two conditions.

At the bottom of the screen, the cumulative scores for both computer and player were displayed, in addition to the trial count within that block. At each trial, the participant pressed one of three buttons corresponding to Rock, Paper or Scissors, prompted by the presentation of a fixation cross. Following response, the participant's selection was presented for 1000 ms. After the clearing of the picture (500 ms), feedback was provided for a further 1000 ms center screen as to whether the participant won, lost or drew the trial. Scores were then updated during a 500 ms period (+1 for win, -1 for lose, 0 for draw) and the next trial began with a fixation cross.

## *Results*

12 participants were rejected as a result of their average median RT being at least twice as large as the group average median RT (after Forder & Dyson, 2016)

## Failure-impulsivity during uncontrolled conditions

within any ANOVA cell, resulting in a final sample of 38 (see Supplementary Table A for all descriptive statistics without outlier removal). A two-way repeated-measures ANOVA on trial  $n+1$  median RTs using opponent (*unexploitable*, *exploitable*) and outcome at trial  $n$  (win, lose, draw; see Table 1) revealed a significant main effect of opponent [ $F(1,37) = 22.43$ ,  $MSE = 49996$ ,  $p < .001$ ,  $\eta_p^2 = .377$ ], a significant main effect of outcome [ $F(2,74) = 11.17$ ,  $MSE = 14370$ ,  $p < .001$ ,  $\eta_p^2 = .232$ ], and a non-significant interaction [ $F(2,74) = 0.68$ ,  $MSE = 12168$ ,  $p = .508$ ,  $\eta_p^2 = .018$ ]. Tukey's HSD test ( $p < .05$ ) revealed RTs against the unexploitable opponent to be faster than those against the exploitable opponent (370 ms vs. 510 ms). Independently of the nature of the opponent, both losses (435 ms) and draws (397 ms) yielded subsequently faster RTs than wins (488 ms).

## Discussion

Experiment 1 replicated the central result of Verbruggen et al. (2017) and Forder & Dyson (2016) that negative outcomes yielded more impulsive decision-making than positive outcomes (Supplementary Materials and Table 1 confirm the RT effect is carried by negative rather than positive outcomes by comparing game performance to a baseline where the participants merely observed the game). Negative outcomes yielded faster responding both when participants fruitlessly engaged with a random opponent (*unexploitable*), and also when they played against an opponent whose predominant strategy could be beaten (*exploitable*). While participants were more impulsive against an unexploitable relative to an exploitable opponent, the magnitude of the *failure-faster* effect was similar for both opponent types. One potential reason for this lack of distinction was that participants failed to successfully

## Failure-impulsivity during uncontrolled conditions

learn the correct strategy in the exploitable case, and so failed to control outcome to a meaningful degree. Indeed, this possibility may have been compounded by the use of two differentially described strategies that led participants to think that there were different rules to exploit. To increase the likelihood of strategy acquisition in Experiment 2, the frequency with which the opponent used their strategy was increased and the nature of the strategy was changed.

### Experiment 2

#### *Method*

40 individuals (31 female) from the University of Sussex community participated in the study; mean age was 21.13 years (SD = 4.37) and 39 were right-handed. The protocol for Experiment 2 was approved under ER/JS753/1, and participants received course credit or £10 for their participation. Experiment 2 involved a within-participants manipulation of both value (low, high) and opponency (*unexploitable*, *exploitable*) across four counterbalanced conditions (90 trials each). Value varied in terms of the points allocated for wins and losses (+1 / -1 in the low value condition, +3 / -3 in the high value condition, respectively) but was collapsed in the current analysis. In *unexploitable* conditions, the three responses of RPS were deployed randomly across 30 trials each (as per Experiment 1). In *exploitable* conditions, opponents used a strategy for 63 trials (now 70% rather than 60%) where it would select the response that would have been beaten by its own previous response (e.g., computer trial  $n$  = rock, computer trial  $n+1$  = scissors), and played MES for the remaining 27 (30%) trials. The reduction in random (MES) trials increased the predictability of the opponent and increased the chance of exploitation. On any given

## Failure-impulsivity during uncontrolled conditions

block, participants were not explicitly informed about the exploitable or unexploitable nature of their opponents.

### *Results*

5 participants were rejected as per Experiment 1, yielding a final sample of 35. Data revealed a non-significant main effect of opponent [ $F(1,34) = 0.67$ ,  $MSE = 158720$ ,  $p = .420$ ,  $\eta_p^2 = .019$ ], a significant main effect of outcome [ $F(2,68) = 4.97$ ,  $MSE = 77705$ ,  $p = .010$ ,  $\eta_p^2 = .128$ ] and a significant two-way interaction [ $F(2,68) = 6.26$ ,  $MSE = 59400$ ,  $p = .003$ ,  $\eta_p^2 = .156$ ]. Tukey's HSD test ( $p < .05$ ) revealed no significant differences in RT against an unexploitable opponent, although the pattern of data was similar to Experiment 1, with lose and draw trials yielding faster subsequent responses than win trials. Against an exploitable opponent however, lose trials (739 ms) were now statistically slower than draw trials (508 ms) and statistically equivalent but numerically slower than win trials (582 ms). Loss trials against exploitable opponents were also significantly slower than loss trials against unexploitable opponent (535 ms).

### *Discussion*

Experiment 2 provides a unique case (*contra* Verbruggen et al., 2017, and, Forder & Dyson, 2016) where choice RTs following negative outcomes (specifically, loss) against an exploitable opponent were no longer faster than positive outcomes. In Experiment 3, we investigated the robustness of this interaction by using a different expression of strategy.

## Experiment 3

### *Method*

## Failure-impulsivity during uncontrolled conditions

40 individuals (28 female) from the University of Sussex community participated in the study; mean age was 22.95 years ( $SD = 5.53$ ) and 36 were right-handed. The protocol was approved under ER/JS753/5. Experiment 3 again involved a within-participants manipulation of both value (low, high) and opponency (*unexploitable, exploitable*) across four counterbalanced conditions (90 trials each). This time, the low value conditions were associated with points only (+1 / -1), whereas the high value conditions were associated with points and converted to money at the end of the experiment at the rate of 10p per point (e.g., Losecaat Vermer & Sanfey, 2015). As such, participants received no less than £10 for the study but as in Experiment 2, performance was collapsed across value for the current analysis. Unexploitable and exploitable opponents were identical to Experiment 2, apart from in the exploitable condition the opponent now selected the response that would have beaten by its own previous response (e.g., computer trial  $n = \text{rock}$ , computer trial  $n+1 = \text{paper}$ ) for 70% of trials.

### *Results*

10 participants were rejected as per previous experiments, yielding a final sample of 30. Data revealed a significant main effect of opponent [ $F(1,29) = 5.59$ ,  $MSE = 71493$ ,  $p = .025$ ,  $\eta_p^2 = .162$ ], a non-significant main effect of outcome [ $F(2,58) = 2.40$ ,  $MSE = 80532$ ,  $p = .099$ ,  $\eta_p^2 = .076$ ] and a significant two-way interaction [ $F(2,58) = 5.11$ ,  $MSE = 43722$ ,  $p = .009$ ,  $\eta_p^2 = .150$ ]. Tukey's HSD test ( $p < .05$ ) revealed draw trials (513 ms) to be significantly faster than win trials (682 ms) during the unexploitable condition. No significant differences between outcomes were revealed during the exploitable condition, and loss trials against exploitable opponents (777 ms) were significantly slower than loss trials against unexploitable opponent

## Failure-impulsivity during uncontrolled conditions

(572 ms). This replicated the slowing of choice RT following negative outcome in Experiment 2 when the opponent was exploitable rather than unexploitable.

A three-way mixed-model ANOVA including Experiment (2, 3) as a between-participant factor, and, opponency (*unexploitable*, *exploitable*) and outcome (*win*, *lose*, *draw*) as within-participant factors failed to yield a significant main effect of Experiment [ $F(1,63) = 0.90$ ,  $MSE = 257298$ ,  $p = .347$ ,  $\eta_p^2 = .014$ ], nor, interactions with Experiment x opponency [ $F(1,63) = 0.50$ ,  $MSE = 118568$ ,  $p = .482$ ,  $\eta_p^2 = .482$ ], Experiment x outcome [ $F(2,126) = 0.13$ ,  $MSE = 79007$ ,  $p = .882$ ,  $\eta_p^2 = .002$ ], Experiment x opponency x outcome [ $F(2,126) = 0.41$ ,  $MSE = 52183$ ,  $p = .662$ ,  $\eta_p^2 = .006$ ]. The main effect of outcome [ $F(2,126) = 7.03$ ,  $MSE = 79907$ ,  $p = .001$ ,  $\eta_p^2 = .100$ ], and interaction between opponency x outcome [ $F(2,126) = 10.77$ ,  $MSE = 52183$ ,  $p < .001$ ,  $\eta_p^2 = .146$ ] confirmed three central significant findings (Tukey's HSD,  $p < .05$ ). First, against unexploitable opponents, RTs following wins (672 ms) were slower than those following losses (552 ms) or draws (504 ms). Second, against exploitable opponents, RTs following losses (756 ms) were slower than those following wins (611 ms) or draws (564 ms). Third, RTs following losses in unexploitable contexts (552 ms) were faster than RTs following losses in exploitable contexts (756 ms).

## Discussion

Experiment 3 replicated the findings of Experiment 2 where the experience of loss did not lead to more impulsive action on the subsequent trial when outcomes could be controlled as a result of playing against an exploitable opponent. One reason why this effect was not present at the group level in Experiment 1 was that the degree of exploitation was lower than in Experiments 2 and 3 (60% strategy and 40%

## Failure-impulsivity during uncontrolled conditions

random, compared to 70% strategy and 30% random). To test the idea that the degree to which participants were able to take control of the game outcome determined whether failure initiated impulsivity, individual win–lose rates were plotted against RT differences between lose and win trials during exploitation conditions in Experiment 1 ( $r = .647, p < .001$ ), Experiment 2 ( $r = .577, p < .001$ ) and Experiment 3 ( $r = .575, p = .001$ ; see Figure 1). It was apparent that for those individuals who established high win-loss ratios, a losing trial tended to slow rather than speed subsequent responding. Although the data are correlational rather than causal in nature, the suggestion here is that when participants develop a successful counter strategy against their opponent - allowing for a high degree of exploitation (wins) - loss trials slowed down rather than sped up subsequent decision-making.

### *General Discussion*

Across three experiments using the game space of RPS, we established an important boundary condition under which the experience of a negative outcome leads to subsequent impulsive behaviour (Verbruggen et al., 2017). Impulsive behaviour following failure is more likely when an individual cannot control the outcome of their environment either due to a) interacting with an unexploitable opponent, or, b) interacting with an exploitable opponent whom they fail to exploit. Across all three experiments, we saw that when participants were able to enact a high degree of opponent exploitation, loss trials led to less impulsive rather than more impulsive reactions.

The *failure-faster* link in random environments (e.g., unexploitable conditions) remains critical in understanding the emotional, cognitive and financial investments afforded by automated and random gambling systems such as FOBTs (Clarke, 2004).

## Failure-impulsivity during uncontrolled conditions

Nevertheless, gambling environments with variable outcome can also have a large skill-based component. The observation that participants can still act impulsively following negative outcomes as a result of low win-rate in exploitable conditions underscores how the quality of own our meta-cognition regarding performance, and the perceived degree of control we have over outcomes (e.g., Langer & Roth, 1975), might perpetuate the magnitude and frequency of loss (e.g., *tilting*, Laakasuo et al., 2015; *chasing behaviour*, Mitzenmacher & Upfal, 2005).

Most strikingly, the observation that participants act less impulsively following loss during successful exploitation represents an important constraint in the relationship between loss and impulsivity. One possibility is that this observation reflects expectancy violation. This would appear to be true in the case where a participant selects the putatively correct response on the basis of their opponent's common strategy, but their opponent happens to select from their (random) MES distribution on that trial. However, losses need not necessarily represent expectancy violation, such as cases where the player does not yet have a reliable understanding of their opponent's dominant strategy. The current data would also seem to suggest that it is only unambiguously negative outcomes (losses) rather than ambiguously negative outcomes (draws) that puncture the *failure-faster* link (see Gu, Feng, Broster, Yuan, Xu & Luo, 2017, for further discussion). Future research incorporating individual differences in empathy, locus of control, personal understanding of luck – skill balance, accuracy of meta-cognition regarding one's own performance, and the use of early neural responses to predict eventual behavioural outcomes will serve to further identify the conditions under which one becomes more or less impulsive as a function of outcome.

## Failure-impulsivity during uncontrolled conditions

### *Acknowledgements*

The work was partly supported by a Research Development Fund from the University of Sussex under grant SA016-01 awarded to BJD. Correspondence should be addressed to: Ben Dyson, School of Psychology, Pevensey Building, University of Sussex, Falmer, BN1 9QH, UK. E-mail: [b.j.dyson@sussex.ac.uk](mailto:b.j.dyson@sussex.ac.uk).

## Failure-impulsivity during uncontrolled conditions

### *Footnotes*

1 As one reviewer pointed out, this particular implementation of the MES raises the possibility of exploitation if a high degree of item bias is exhibited in the earlier stages of the block (e.g., opponent overplay of Rock in the first half of the block dictates underplay of Rock in the second half of the block). It is possible to estimate the degree of exploitation under such circumstances by examining participant win-rate in the second half of the block, as a function of the absolute deviation from the rectangular 33.33% distribution for Rock, Paper, Scissors responses expressed by the opponent in the first half of the block: if the player is sensitive to their opponent's item bias, a larger deviation expressed by the opponent in the first half of the block should yield higher win-rate for the player in the second half of the block. We examined data from our Supplementary Experiment in which participants played 3 blocks of 75 trials against an MES opponent. Average absolute deviation from 33.33% for all three responses across the first 36 trials (range 1.86% - 7.41%) and participant win-rate across the last 36 trials (range 22.22% - 43.52%) was calculated within each block, and then averaged across block for each of the 36 participants. The non-significant, negative correlation between opponent random deviation and player win-rate ( $r = -.128$ ,  $p = .458$ ) did not support the idea that participants were using item bias to increase their success in the 'unexploitable' condition.

2 To estimate the effect size and, hence, minimal sample size required for the comparison of RT as a function of outcome in Rock, Paper, Scissors, data from Forder & Dyson (2016) was utilized, collapsing across an original manipulation of value. With win RT = 708 (sd = 312), lose RT = 555 (sd = 207) and  $r = 0.707$ , Cohen's  $d$  was estimated at 0.77. A sample size of at least 24 was estimated to observe this effect

## Failure-impulsivity during uncontrolled conditions

size (two-tailed) with  $\alpha = 0.01$  and a power of 0.95. Sample sizes were also additionally determined by the application of the same outlier removal procedure applied across all experiments, and, the studies being derived from an on-going stream of research into competitive decision making that included other considerations such as individual difference measures and electrophysiological recording.

## Failure-impulsivity during uncontrolled conditions

### *References*

- Baek, K. et al. (2013). Response randomization of one- and two-person Rock-Paper-Scissors games in individuals with schizophrenia. *Psychiatry Research*, *207*, 158-163.
- Botvinick, M. M., Braver, T. S., Barch, D. M., Carter, C. S. & Cohen J. D. (2001). Conflict monitoring and cognitive control. *Psychological Review*, *108*, 624–652.
- Clarke, D. (2004). Impulsiveness, locus of control, motivation and problem gambling. *Journal of Gambling Studies*, *20*, 319-345.
- Dyson, B. J. (in preparation). Behavioural isomorphism, cognitive economy and recursive thought in non-transitive game strategy.
- Forder, L. & Dyson, B. J. (2016). Behavioural and neural modulation of win-stay but not lose-shift strategies as a function of outcome value in Rock, Paper, Scissors. *Scientific Reports*, *6*: 33809.
- Gu, R., Feng, X., Broster, L. S., Yuan, L., Xu, P. & Luo, Y-J. (2017). Valence and magnitude ambiguity in feedback processing. *Brain and Behavior*, *7*: e00672.
- Laakasuo, M., Palomäki, J. & Salmela, J. M. (2015). Emotional and social factors influence poker decision making accuracy. *Journal of Gambling Studies*, *31*, 933–947.
- Langer, E. J. & Roth, J. (1975). Heads I win, tails it's chance: The illusion of control as a function of the sequence of outcomes in a purely chance task. *Journal of Personality and Social Psychology*, *32*, 951-955.
- Losecaat Vermeer, A. B. & Sanfey, A. G. (2015). The effect of positive and negative feedback on risk-taking across different contexts. *PLoS One*, *10*: e0139010.

## Failure-impulsivity during uncontrolled conditions

Mauboussin, M. J. (2012). *The success equation: Untangling skill and luck in business, sports, and investing*. Harvard Business Press.

Mitzenmacher, M. & Upfal, E. (2005). *Probability and computing: randomized algorithms and probabilistic analysis*. Cambridge: Cambridge University Press.

Notebaert, W., Houtman, F., Van Opstal, F., Gevers, W., Fias, W. & Verguts, T. (2009). Post-error slowing: An orienting account. *Cognition*, *111*, 275-279.

Verbruggen, F., Chambers, C. D. , Lawrence, N. S. & McLaren, I. P. L. (2017). Winning and losing: Effects on impulsive action. *Journal of Experimental Psychology: Human Perception and Performance*, *43*, 147-168.

Failure-impulsivity during uncontrolled conditions

Table 1. Descriptive statistics for Experiments 1 – 3 and Supplemental Experiment, with outlier removal

	<i>n</i>	Unexploitable Opponent			Exploitable Opponent		
		<i>After Win</i>	<i>After Lose</i>	<i>After Draw</i>	<i>After Win</i>	<i>After Lose</i>	<i>After Draw</i>
Experiment 1	38	407 (28)	367 (25)	336 (16)	570 (50)	504 (39)	457 (29)
Experiment 2	35	664 (57)	535 (37)	496 (45)	582 (41)	739 (98)	508 (43)
Experiment 3	30	682 (55)	572 (46)	513 (34)	645 (53)	777 (83)	629 (58)
		Unexploitable Opponent ( <i>Play</i> )			Unexploitable Opponent ( <i>Observe</i> )		
		<i>After Win</i>	<i>After Lose</i>	<i>After Draw</i>	<i>After Win</i>	<i>After Lose</i>	<i>After Draw</i>
Supplemental Experiment	31	564 (39)	484 (27)	493 (34)	539 (35)	534 (31)	527 (34)

Note : Standard error in parenthesis.

Failure-impulsivity during uncontrolled conditions

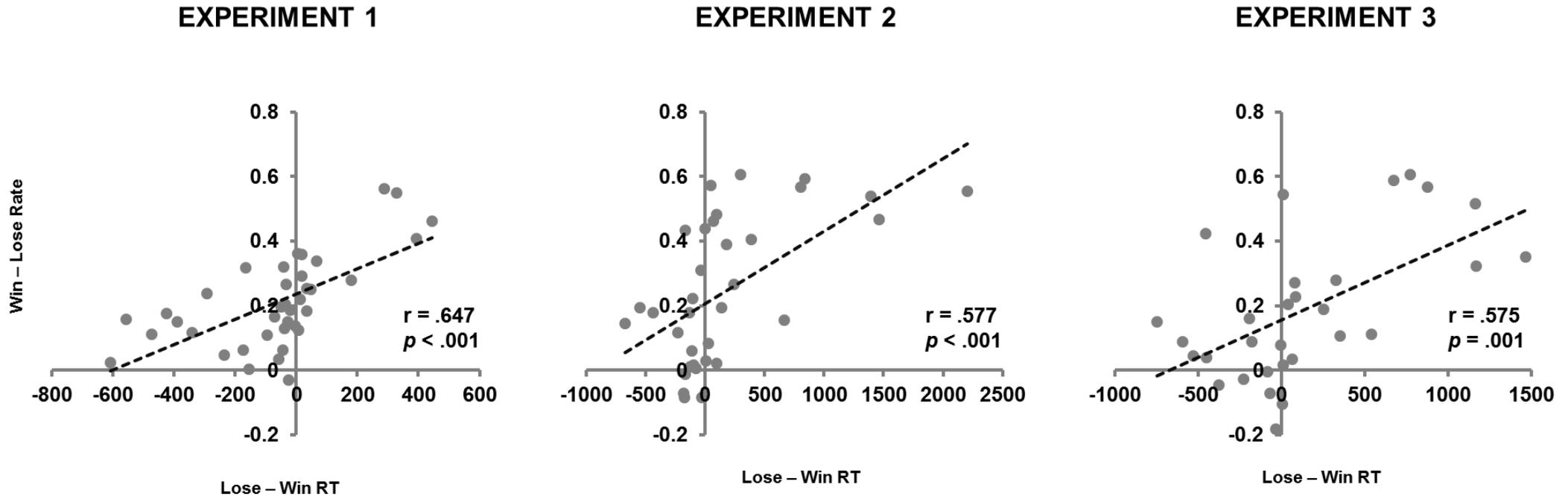


Figure 1. Scatterplots comparing individual win - lose rates against RT difference between lose - win for across Experiments 1-3.