Supplementary materials

Summary of the pilot results

In a prior unpublished experiment, we aimed to disentangle the influence of Prospect versus Reception of reward, to determine their distinct effects on cognitive performance. Because this experiment initially had different experimental aims than those discussed in the main paper (see preregistration and results summary here: https://osf.io/cgx5b/), it was used as pilot data for the experiments presented in the paper. Participants (N=99) completed a Simon Task and had the opportunity to earn reward for fast and accurate performance on half of trials. Reward Prospect versus Reception was manipulated between subjects. In the Prospect group, a cue informed participants whether a given trial was reward-eligible, but participants received no local (trial-level) feedback about whether their performance was sufficient to receive the reward. In the Reception group, on the other hand, participants knew they could earn reward on some trials for fast and accurate performance, but they were not informed ahead of time which trials were reward-eligible. Rather, they received a cue as feedback following each trial (i.e., a post-cue) on which reward was earned for a sufficiently fast and accurate response. By manipulating the type of reward information participants received (i.e., Prospect versus Reception), we altered the reward schedule: In the Prospect group, participants had the option of selectively exerting effort only on these reward eligible trials. In contrast, participants in the Reception group knew with certainty on which trials they had just earned a reward but did not have advance information to allow them to selectively exert effort on a trial-by-trial basis.

As expected, and similar to the results of Yamaguchi and Nishimura (2018), participants in the Prospect group showed selective speeding of responses on reward-eligible trials compared to reward-ineligible trials. Participants in the Reception group performed faster overall, but showed no selective effect of the reward feedback information on the subsequent trial. This pattern of results largely reflects a rational response to the task: In the Prospect group, participants could conserve effort by exerting it only when necessary, whereas in the Reception group, participants could maximize reward only by exerting effort on every trial. Results in the Reception group also mirror findings from the literature on partial

reinforcement: When effort is rewarded only on a proportion of trials, extinction occurs more slowly following unrewarded trials (Spear, Hill, & O'Sullivan, 1965; Wagner, 1961; Wilton, 1972).

It was also possible to examine trial-by-trial changes in task engagement, by comparing unrewarded trials immediately following rewarded trials to those not immediately following rewarded trials. Interestingly, in the Prospect group, participants responded more slowly on trials with no reward prospect immediately following trials on which they earned a reward, compared to no-prospect trials not immediately following rewarded trials. The same post-reward slowing was not found in the Reward Reception group. This intriguing finding mirrored the post-reward disengagement and recovery effects observed by Goswami and Urminsky (2017) and motivated the current investigation.

Experiment 1 power analysis

For Experiment 1, the power analysis was based on the results of the initial pilot study (https://osf.io/cgx5b/). Our initial power analysis indicated that a minimum of 35 participants per group (Prospect, Reception, Control) was necessary to detect a medium-small effect (d = 0.3) with a power of 80% and an alpha of 0.05 (two-tailed).

Specifically, we used the G*Power program (Faul et al., 2007) to calculate the sample size for the repeated measures ANOVA within-between interaction, since this was the hypothesized interaction of interest for the pilot study. The power analysis used the following values: effect size was set to 0.15 (reflecting a small effect size), type I error rate was set to 0.05, power was set to 80%, number of groups was set to 3 (levels of the between-subjects factor, i.e., the number of reward groups: Prospect, Reception, Control), and number of measurements was set to 2 (number of repeated measures, i.e., the reward opportunity: yes vs no).

Unfortunately, after repeating the power analysis, we noticed that we made a mistake in the initial power analysis. According to the corrected power analysis the total sample size required for Experiment 1 should have been 111, equivalent to 37 participants per group. We

note that we collected 35 participants per group not 37 participants. A post hoc power analysis, based on our actual sample size of 105 (35 participants per group), indicates a power of 78% to detect the small effect. Although this shows that the study was slightly underpowered, we note that we had clear directional hypothesis which somewhat compensates for the loss in power (Lakens, 2022).

Experiment 1 supplementary materials

Table S1. Reaction Time as a function of Reward Opportunity, Group, Congruence and Previous Trial Congruence in Experiment 1.

Group	Reward	CC	IC	CI	II
Control	No Opportunity	444.64 (100.10)	461.27 (116.77)	476.61 (94.58)	470.93 (99.28)
	Opportunity	449.66 (99.26)	456.67 (100.21)	478.47 (93.02)	471.47 (92.22)
Prospect	No Opportunity	451.26 (98.20)	468.58 (104.99)	488.84 (97.73)	477.85 (94.06)
	Opportunity	423.08 (93.21)	432.50 (94.16)	464.00 (86.41)	453.53 (86.55)
Reception	No Opportunity	418.39 (93.94)	429.92 (107.97)	455.08 (94.70)	443.98 (93.16)
	Opportunity	416.96 (94.48)	427.98 (95.99)	451.86 (92.43)	443.55 (90.04)

Note. C/I abbreviations indicate trial sequence, i.e., CC = congruent-congruent; IC = incongruent, congruent; CI = congruent, incongruent; II = incongruent-incongruent

Table S2. Error Rate (%) as a function of Reward Opportunity, Group, Congruence and Previous Trial Congruence in Experiment 1.

Group	Reward	CC	IC	CI	II
Control	No Opportunity	0.54 (1.88)	1.55 (3.92)	4.30 (5.99)	1.72 (4.19)
	Opportunity	1.23 (3.45)	1.57 (4.51)	3.98 (6.47)	1.07 (3.12)
Prospect	No Opportunity	0.96 (3.20)	2.09 (4.75)	5.27 (7.19)	2.98 (5.95)
	Opportunity	0.98 (3.20)	2.01 (3.90)	4.36 (6.29)	2.22 (4.98)
Reception	No Opportunity	1.53 (3.68)	2.05 (4.43)	5.76 (6.76)	2.25 (5.14)
	Opportunity	1.42 (4.17)	2.87 (5.23)	4.62 (5.86)	2.34 (4.95)

Note. C/I abbreviations indicate trial sequence, i.e., CC = congruent-congruent; IC = incongruent, congruent; CI = congruent, incongruent; II = incongruent-incongruent

Table S3. Reaction Time as a function of Earned Reward, Group, Congruence and Previous Trial Congruence in Experiment 1.

Group	Reward	CC	IC	CI	II
Control	Not Earned	441.47 (97.73)	451.71 (97.87)	468.38 (82.27)	468.84 (87.38)
	Reward Earned	432.75 (86.67)	454.01 (103.11)	469.21 (89.14)	482.28 (99.86)
Prospect	Not Earned	414.42 (85.25)	443.41 (106.89)	457.60 (81.86)	453.73 (101.38)
	Reward Earned	435.67 (102.91)	442.60 (105.40)	470.92 (91.88)	457.73 (90.95)
Reception	Not Earned	407.99 (85.26)	424.87 (105.05)	444.86 (84.26)	440.34 (102.03)
	Reward Earned	412.47 (99.37)	422.63 (104.30)	452.33 (104.75)	442.57 (87.71)

Note. C/I abbreviations indicate trial sequence, i.e., CC = congruent-congruent; IC = incongruent, congruent; CI = congruent, incongruent; II = incongruent-incongruent

Table S4. Error Rate (%) as a function of Earned Reward, Group, Congruence and Previous Trial Congruence in Experiment 1.

Group	Reward	CC	IC	CI	II
Control	Not Earned	441.47 (97.73)	451.71 (97.87)	468.38 (82.27)	468.84 (87.38)
	Reward Earned	432.75 (86.67)	454.01 (103.11)	469.21 (89.14)	482.28 (99.86)
Prospect	Not Earned	414.42 (85.25)	443.41 (106.89)	457.60 (81.86)	453.73 (101.38)
	Reward Earned	435.67 (102.91)	442.60 (105.40)	470.92 (91.88)	457.73 (90.95)
Reception	Not Earned	407.99 (85.26)	424.87 (105.05)	444.86 (84.26)	440.34 (102.03)
	Reward Earned	412.47 (99.37)	422.63 (104.30)	452.33 (104.75)	442.57 (87.71)

Note. C/I abbreviations indicate trial sequence, i.e., CC = congruent-congruent; IC = incongruent, congruent; CI = congruent, incongruent; II = incongruent-incongruent

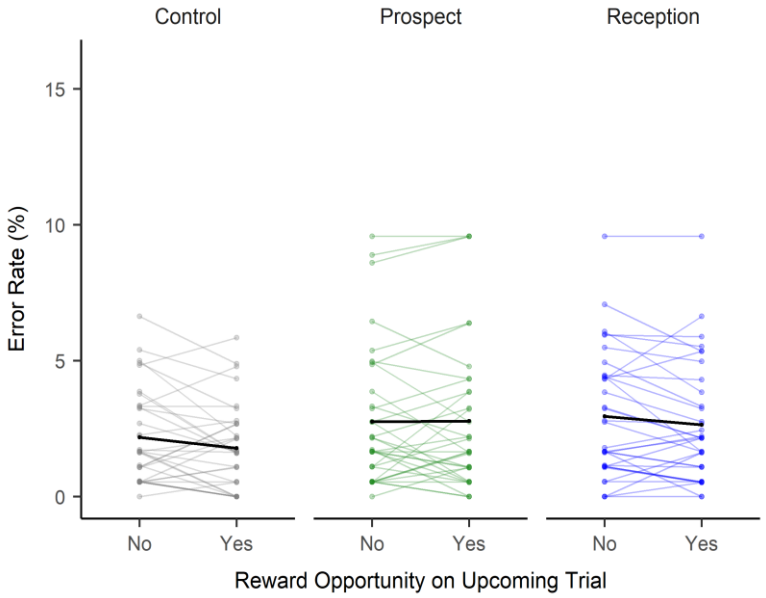

Figure S1. Mean error rates (%) for participants and groups as a function of Reward Opportunity in Experiment 1. There was a significant interaction between Reward Prospect group and Reward Opportunity; however, it appears to be driven by the Control group, rather than the Prospect group. Because participants in the Control group received no reward information, the effect is thus probably spurious.

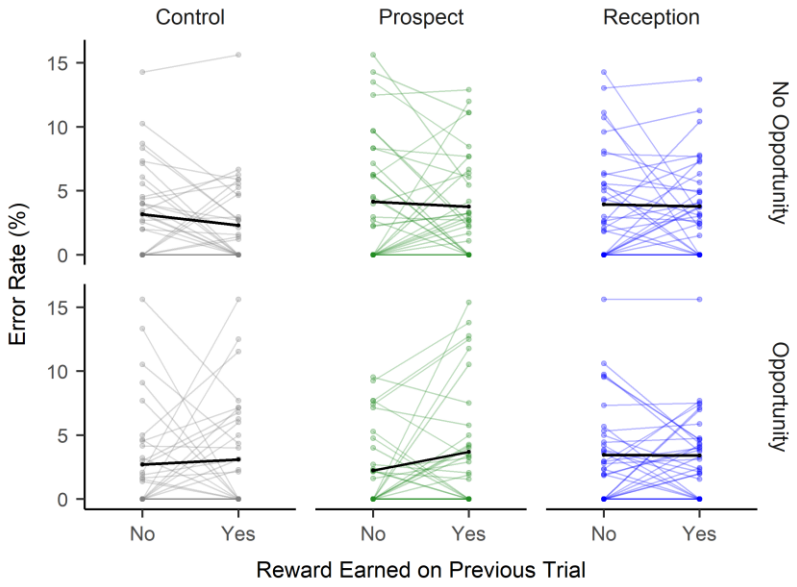

Figure S2. Mean error rates (%) for participants and groups as a function of Reward Earned and Reward Opportunity in Experiment 1. Note that only trials following correct and faster-than-reward-threshold trials were included in this analysis. There were no noteworthy effects of Group or Reward Earned.

Experiment 2 original study design

This experiment was initially intended to have a within-subjects design, with all participants receiving both Prospect and Reception conditions. More specifically, every participant completed a baseline block of 128 trials. Next, they completed two Prospect blocks and two Reception blocks. The order of the Prospect and Reception blocks was counterbalanced among the participants. Each block contained 128 trials.

Experiment 2 power analysis

For Experiment 2, the power analysis was based on a specific effect in the mixed model analysis – the interaction between Group and Reward Earned. We used the simr package in R (Green & MacLeod, 2016) to estimate the sample size needed to replicate the interaction between Group and Reward Earned with adequate statistical power. Simulations were done on the data from Experiment 1, omitting the Control group and using only the first two blocks of trials, to match the conditions of this second experiment (B = -17.62).

Our initial power analysis indicated that 16 participants per group were needed to achieve a power of .80 with an alpha of .05. As a precaution, we recruited 40 participants (20 per group), ensuring more than adequate power even after pre-processing the data. Upon revisiting the power analysis, however, we observed that the initial model used in the power analysis was not the most accurate.

Specifically, we initially employed a model with only random intercepts for every participant. This differs from the main analysis where we used linear mixed modelling with the maximal possible random effects structure, as recommended by Barr and colleagues (Barr, 2013; Barr et al., 2013). In RT analyses, models included random intercepts and random slopes for all fixed within-subjects factors and their interactions. Thus, we repeated the power analysis with the maximal possible random effects structure. This analysis showed that to achieve 80%

power, 23 participants per group would be necessary. As we ultimately collected 20 participants for both groups, Experiment 2 was slightly underpowered. Based on the improved power analysis, for 20 participants per group, the expected power to detect a small effect is around 74%. Although this shows that the study was slightly underpowered, we note that we had clear directional hypothesis which somewhat compensates for the loss in power (Lakens, 2022).

Experiment 2 supplementary materials

Table S5. Reaction Time as a function of Reward Opportunity, Group, Congruence and Previous Trial Congruence in Experiment 2.

Group	Reward	CC	IC	CI	II
Prospect	No Opportunity	541.47 (130.51)	555.09 (113.99)	572.69 (105.70)	561.63 (115.36)
	Opportunity	528.11 (116.73)	540.12 (110.70)	561.79 (108.81)	542.32 (101.63)
Reception	No Opportunity	519.27 (139.60)	536.65 (149.59)	571.60 (164.10)	548.65 (143.37)
	Opportunity	519.77 (141.32)	540.72 (155.34)	564.50 (159.30)	556.16 (143.30)

Note. C/I abbreviations indicate trial sequence, i.e., CC = congruent-congruent; IC = incongruent, congruent; CI = congruent, incongruent; II = incongruent-incongruent

Table S6. Error Rate (%) as a function of Reward Opportunity, Group, Congruence and Previous Trial Congruence in Experiment 2.

Group	Reward	CC	IC	CI	II
Prospect	No Opportunity	0.57 (2.35)	2.66 (6.01)	4.08 (6.21)	2.47 (6.04)
	Opportunity	1.49 (4.21)	2.33 (5.44)	3.19 (5.42)	1.60 (4.29)
Reception	No Opportunity	1.22 (3.96)	2.47 (5.52)	7.93 (8.59)	3.72 (6.42)
	Opportunity	2.97 (6.44)	3.36 (6.02)	5.92 (7.70)	2.99 (6.10)

Note. C/I abbreviations indicate trial sequence, i.e., CC = congruent-congruent; IC = incongruent, congruent; CI = congruent, incongruent; II = incongruent-incongruent

Table S7. Reaction Time as a function of Earned Reward, Group, Congruence and Previous Trial Congruence in Experiment 2.

Group	Reward	CC	IC	CI	II
Prospect	Not Earned	513.91 (119.87)	545.81 (110.36)	568.12 (107.55)	539.99 (100.93)
	Reward Earned	534.88 (133.09)	539.03 (106.50)	562.47 (107.83)	565.75 (131.16)
Reception	Not Earned	498.63 (135.37)	518.46 (136.62)	541.31 (146.21)	528.73 (128.61)
	Reward Earned	503.83 (146.75)	516.69 (138.67)	547.98 (154.88)	534.72 (137.31)

Note. C/I abbreviations indicate trial sequence, i.e., CC = congruent-congruent; IC = incongruent, congruent; CI = congruent, incongruent; II = incongruent-incongruent

Table S8. Error Rate (%) as a function of Earned Reward, Group, Congruence and Previous Trial Congruence in Experiment 2.

Group	Reward	CC	IC	CI	II
Prospect	Not Earned	513.91 (119.87)	545.81 (110.36)	568.12 (107.55)	539.99 (100.93)
	Reward Earned	534.88 (133.09)	539.03 (106.50)	562.47 (107.83)	565.75 (131.16)
Reception	Not Earned	498.63 (135.37)	518.46 (136.62)	541.31 (146.21)	528.73 (128.61)
	Reward Earned	503.83 (146.75)	516.69 (138.67)	547.98 (154.88)	534.72 (137.31)

Note. C/I abbreviations indicate trial sequence, i.e., CC = congruent-congruent; IC = incongruent, congruent; CI = congruent, incongruent; II = incongruent-incongruent

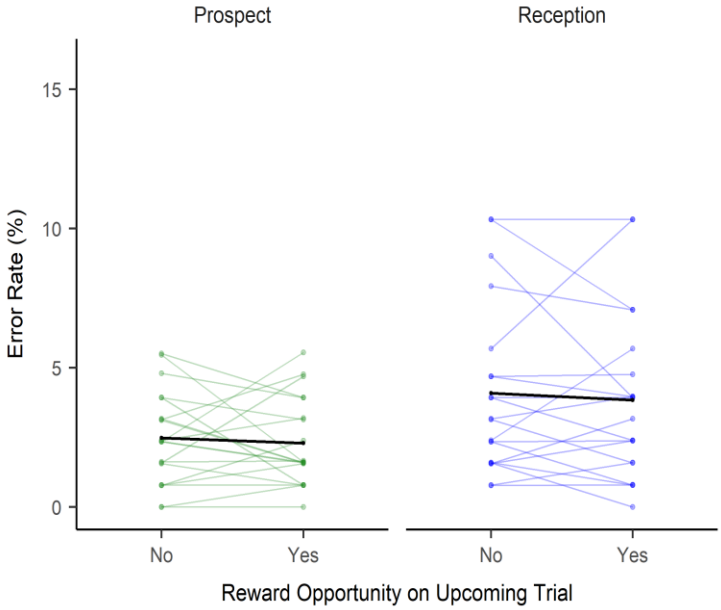

Figure S3. Mean error rates (%) for participants and groups as a function of Reward Opportunity in Experiment 2. At the trend level, participants in the Reception condition made more errors than those in the Prospect condition.

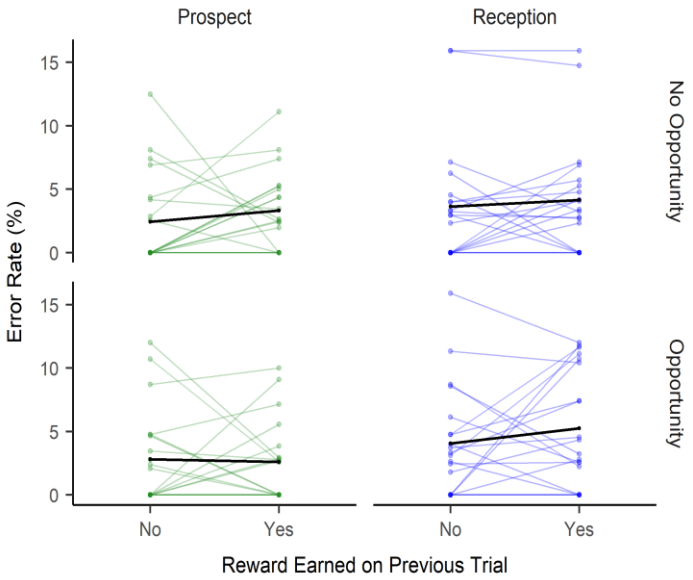

Figure S4. Mean error rates (%) for participants and groups as a function of Reward Earned and Reward Opportunity in Experiment 2. Note that only trials following correct and faster-than-reward-threshold trials were included in this analysis. There were no noteworthy effects of Group or Reward Earned.

References

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191. https://doi.org/10.3758/BF03193146

Green, P., & MacLeod, C. J. (2016). SIMR: An R package for power analysis of generalized linear mixed models by simulation. *Methods in Ecology and Evolution*, *7*(4), 493–498. https://doi.org/10.1111/2041-210X.12504

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