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The Effects of Response and Stimulus Repetition across Sequences of Trials in Go/No-go Tasks

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THE EFFECTS OF RESPONSE AND STIMULUS REPETITION ACROSS SEQUENCES OF TRIALS IN GO/NO-GO TASKS

by

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Abstract

Previous research has found inconsistent repetition effects from the immediately preceding trial in choice-RT tasks. The current study focused on the effects of response and stimulus repetitions, respectively, over a sequence of preceding trials in go/no-go tasks. In all of the three experiments, we found that additional go trials preceding the current trial sped up responding but caused false alarms and additional no-go trials slowed responding but reduced false alarms. We also found that repeatedly responding to the same stimulus sped up responding without increasing false alarm rates. Finally, increasing the speed stress did not alter this pattern.

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Introduction

When a trial involves a response or a stimulus that is the same as the previous one, there are usually benefits in performance, like faster reaction times, in this trial. This effect is called the repetition effect (Bertelson, 1961). This repetition effect is commonly observed in choice-RT tasks (e.g. Bertelson, 1965; Pashler & Baylis, 1991b) and it had been studied for over 50 years.

With multiple stimuli being mapped to each response, it is possible to separate stimulus repetition and response repetition to study the difference between them and which one of them may be a major account for the repetition effect overall. Bertelson (1965) used this method in a two-choice task and he found that it was mostly the response repetition that accounted for the repetition effect. However, the findings about the response repetition effect are pretty inconsistent, for example, Smith (1968) found under some conditions, participants were even slower when repeating a response than when making a different response, and he pointed out that Bertelson's method might help participants create superordinate categories of even and odd by assigning the digits 2 and 4 to one response and other two digits 5 and 7 to another response. Later findings by Marcel and Forrin (1974) supported Smith's criticism on Bertelson's method suggesting that even different stimuli from a same category could trigger the beneficial effect of repetition on reaction times.

Pashler and Baylis (1991) also demonstrated that stimulus repetition played a major role in the repetition effect and the effect of the response repetition only appeared "when the different stimuli mapped onto a given response differ only in as superficial an attribute as color".

Despite the inconsistency, and more importantly, those studies only considered the trial that was immediately preceding the current trial, which means they only studied the response repetition where the same response was required only in the current trial and the immediately preceding trial. In our experiments, we studied repetition effects beyond the immediately preceding trial and purposely prevented participants from creating superordinate categories.

However, there are many real-life situations where they do not require decisions of what to do, like a choice-RT task, but decisions of whether or not to do something, instead, like a go/no-go task. In addition, previous research has shown that choice-RT task and go/no-go task are qualitatively different (Ulrich, Mattes & Miller, 1999; Danek & Mordkoff, 2011). Therefore, both tasks should be studied, but a majority of previous work on repetition effects has used choice-RT tasks. Thus, our research concerned the repetition effects over a sequence of preceding trials with response and stimulus repetitions being studied separately in go/no-go tasks.

General Methods

In all of the reported experiments, participants were instructed to respond to target colors with their dominant hand and not to respond to non-target colors. Participants were asked to be as fast as possible while making few errors.

Subjects

Each experiment had its own set of twenty-four undergraduate students from the University of Iowa who participated for course credit. All had full color vision.

Task and Equipment

Six colors (red, orange, yellow, green, blue, and purple) with approximately equal luminance were used as stimuli, and they were presented on a black background by a computer running E-Prime with a 17” monitor. Responses were made using the rightmost (leftmost) key on a customized response button box for right-handed (left-handed) participants. Colors were divided into two groups: red, yellow, blue and orange, green, purple to create target colors and non-target colors. Thus, no adjacent colors were used in the same group in order to prevent participants from creating superordinate categories. The color-response mappings were counterbalanced across participants.

Procedure

Each participant started with a general instruction showing their target colors and non-target colors, followed by four blocks of practice. In the first practice block, participants were given feedback no matter whether their responses were correct. In the second and the third practice blocks, participants were only given a brief error message when they made an error. In the fourth practice block, participants were told that they would receive feedback even when they made correct responses but not fast enough. Participants would receive this feedback if their reaction time of the current go trial were slower than the 75 percentile of the reaction times of the correctly responded trials of the previous 2 blocks. The remaining blocks had the same feedback system as the fourth practice block. There was a summary of performance about the average reaction time and accuracy of the current block at the end of each block. Each block contained 24 trials.

Each trial began with a small gray plus sign (a visual angle of 0.19 degrees based on a typical viewing distance of 60 cm) in the first two practice blocks or a small gray square (a visual angle of 0.26 degrees) in the remaining blocks (to match unreported experiments) at the center of the screen for a variable SOA interval (500ms, 700ms, 1000ms, 1400ms), and it turned into a colored circle (a visual angle of 2.39 degrees) until a response was made or 1000ms passed. The intertrial interval was 1500ms.

Analysis

The practice blocks and the first two blocks after the practice were not kept for analysis. The first two trials of each block were not kept for analysis. Only trials after a correctly responded trial were kept for analysis. Only trials with a correct response were included for analysis of reaction time. The analysis of response repetitions only included trials with a previous trial that had a different stimulus. The analysis of stimulus repetition only included trials with a previous trial requiring the same response. The variable SOA interval was intended to reduce participants' rhythms in responses and it was not included in the analysis. Sphericity problem was evaluated by Mauchly's test. When it revealed a violation of sphericity, the degrees of freedom were adjusted using the Huynh-Feldt method. The error bars were calculated using the Cousineau/Morey method.

Experiment 1

Since previous research has found inconsistent results regarding the response repetition effects from the immediately preceding trial on the performance of the current trial, we intended to explore the effect of the sequence of trials before the immediately preceding trial on the performance of the current trial. For example, the immediately preceding trial could either be a go trial or a no-go trial, but the trial before the immediately preceding trial could also either be a go trial or a no-go trial. We extended the sequence of trials before the immediately preceding trial until we hit an alternation.

For instance, if the immediately preceding trial (P1) was a go trial, and the trial before the immediately preceding trial (P2) was a no-go trial, this condition was labeled as “GN”. If the immediately preceding trial (P1) was a go trial, and the trial before the immediately preceding trial (P2) was also a go trial following a no-go trial (P3), which meant there were two go trials in a row preceding the current trial, this condition was labeled as “GGN”. If there were at least three go trials in a row (at least P1, P2, and P3 were all go trials) preceding the current trial, this condition was labeled as “GGG”. Since there were few trials for analysis if we split the data as a function of P4, condition “GGG” thus included conditions like “GGGN” and “GGGG”. In the graphs, all trials in which the immediately preceding trial was a no-go trial are on the left part and all trials in which the immediately preceding trial was a go trial are on the right part, and we focused on analysis of the effects within each part instead of the effects between these two parts. Because an extended sequence of go trials was expected to produce a benefit in RT, while an extended sequence of no-go trials was expected to produce a cost in RT, the length of the sequence for the no-go trials was coded backwards, such that equivalent effects would produce additivity.

Methods

The experimental design was identical to the design described in General Methods, except that at the end of the experiment, participants completed the BIA/BAS scales.

Results and Discussion

The left panel of Figure 1 presents the mean reaction times of the current correctly responded trials as a function of sequence of preceding trials. Participants were faster when the current trial was immediately preceded by a go trial, $F(1, 23) = 16.85$, $p < .001$, p = .423. Participants were faster when the current trial was preceded by two or three go trials in a row than when it was preceded by one go trial, and they were slower when the current trial was preceded by two or three no-go trials in a row than when it was preceded by one no-go trial, $F(2, 46) = 13.77$, $p < .001$, p = .374. The number of go trials in a row preceding the current trial had a linear effect on the mean RT of the current trial, and the number of no-go trials in a row preceding the current trial had the identical linear effect on the mean RT of the current trial, $F(1, 23) = 29.29$, $p < .001$, p = .560. The linear trends for go trials and no-go trials across the number of repetitions were the same, $F(2, 46) = 1.60$, $p = .212$, p = .065.

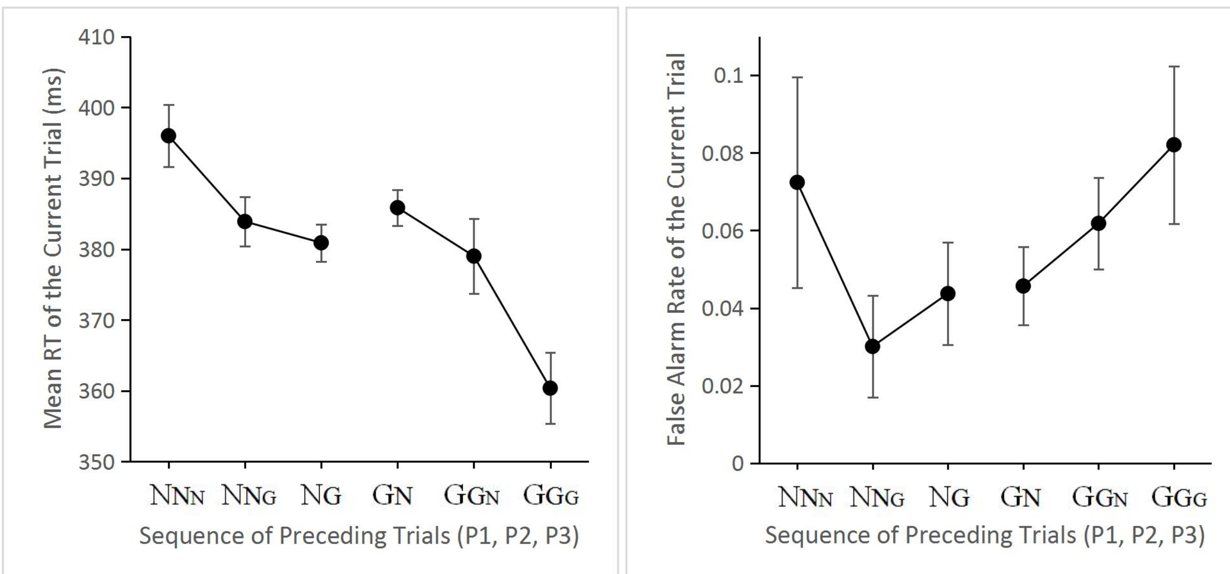

Figure 1. Mean correct response time and mean false-alarm rate from Experiment 1 as a function of the sequence of preceding trials. (Error-bars created using the Cousineau/Morey method.)

The right panel of Figure 1 presents the false alarm rates of the current trials as a function of sequence of preceding trials. Participants' false alarm rates were not affected by sequence of preceding trials, $F(1, 23) = 1.08$, $p = .310$, p = .045, nor by the number of repetitions of a certain response, $F(1.68, 38.62) = 1.08$, $p = .561$, p = .023.

The results showed that there was an overall beneficial effect of repeating the same response in this case, where participants were generally faster making a response preceded by a go trial. More importantly, each additional go trial before making a response sped up the responding at the same amount as each additional no-go trial slowed the responding.

Although, neither of sequence of preceding trials nor the number of repetitions of a certain response made a significant difference in false alarm rates, there appeared to be a trend for the false alarm rates that was opposite to the trend for the mean reaction time as showed in the figure 1b, which suggested a speed-accuracy trade-off, but one participant made a large number of false alarms in the "NNN" condition, which caused the result to be not significant. In addition, this trend was reliably showed in the subsequent experiments.

Experiment 2

Experiment 1 showed the effects of the number of repetitions of a certain response on mean reaction times and potentially on false alarm rates. However, response repetitions and stimulus repetitions were found to have different effects on performance, but with 3 target colors and 3 non-target colors, it led to few stimulus repetitions for analysis. Thus, we reduced the number of colors to 4 to make both making the same response without repeating a stimulus in a row and making responses to the same stimulus in a row possible.

Methods

This experiment only used 4 of the 6 colors that were used in Experiment 1 (orange, yellow, blue, and purple). Again, no adjacent colors were used in the same group when making target colors and non-target colors. We deleted the BIS/BAS scales and increased the number of blocks by 4.

Results and Discussion

Response Repetitions. The upper-left of Figure 2 presents the mean reaction times of the current correctly responded trials as a function of sequence of preceding trials. There was no effect of the immediately preceding trial type on the mean reaction times this time, $F(1, 23) = 3.72$, $p = .066$, p = .139. The other results of reaction times replicated Experiment 1 almost exactly. There was a significant effect of the number of response repetitions on reaction times, $F(2, 46) =$

24.05, p < .001, p = .511. Both the number of preceding go trials and the number of preceding no-go trials had linear effects on the mean reaction times, $F(1, 23) = 39.92$, p < .001, p = .634. The linear trends were the same, $F(1.70, 39.16) = .00$, p = .993, p < .000.

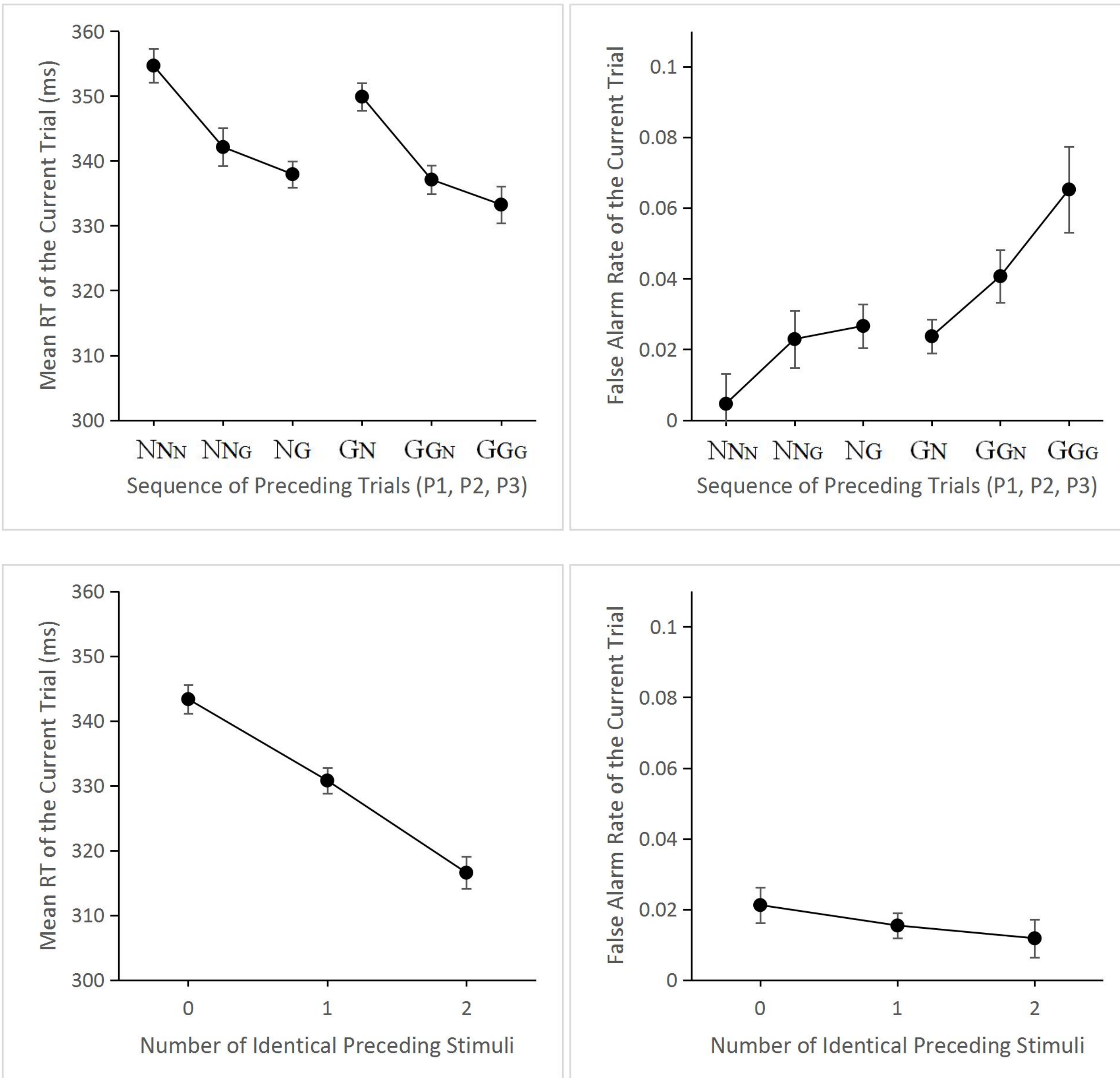

Figure 2. Mean correct response time and mean false-alarm rate from Experiment 2 as a function of repetition type and the sequence of preceding trials. (Error-bars created using the Cousineau/Morey method.)

The upper-right panel of Figure 2 presents the false alarm rates of the current trials as a function of sequence of preceding trials. Participants made more false alarms when the current trial was preceded by a go trial, $F(1, 23) = 8.90$, $p = .007$, p = .279. Participants made more false alarms when the current trial was preceded by two or three go trials in a row than when it was preceded by one go trial, and they made less false alarms when the current trial was preceded by two or three no-go trials in a row than when it was preceded by one no-go trial, $F(2, 46) = 7.73$, $p = .001$, p = .252. Both the number of preceding go trials and the number of preceding no-go trials had linear effects on the false alarm rates, $F(1, 23) = 11.00$, $p = .003$, p = .560. The linear trends were the same, $F(2, 46) = 1.43$, $p = .249$, p = .059.

Stimulus Repetitions. The lower-left panel of Figure 2 presents the mean reaction times of the current correctly responded trials as a function of the number of repetitions of a certain stimulus. Participants were faster after each additional stimulus repetition, $F(2, 46) = 35.66$, $p < .001$, p = .608. The number of repetitions of a certain stimulus had a linear effect on the mean reaction times of the current trial, $F(1, 23) = 58.81$, $p < .001$, p = .719.

The lower-right panel of Figure 2 presents the false alarm rates of the current trials as a function of the number of repetitions of a certain stimulus. Stimulus repetitions had no effect on the false alarm rates in this case, $F(2, 46) = 1.01$, $p = .373$, p = .042.

The behavior of subjects was relatively consistent since we replicated the effect of response repetitions on mean reaction times, where additional go trials preceding the current trial sped up responding the same amount as additional no-go trials slowed responding. In addition, we found a linear trend of response repetitions on false alarm rates that was opposite to the trend of response repetitions on reaction times as shown in the upper panels of figure 2, suggesting that the effect of response repetition would induce a speed-accuracy trade-off. The failure to replicate the overall beneficial effect of repeating the same response was expected because of the inconsistency of this effect across experiments according to the literature.

We also found a beneficial effect of repeating the same stimulus on mean reaction times that repeatedly responding to the same stimulus can make people faster, but we failed to find any effect on false alarm rate, suggesting that the effect of stimulus repetition would not induce a speed-accuracy trade-off. However, this failure to find any effect on false alarm rates was probably due to a floor effect, because participants rarely made mistakes in trials preceded by a no-go trial.

Experiment 3

Experiment 2 replicated the effect of response repetitions on mean reaction times and found the same but opposite pattern on false alarm rates, suggesting a speed-accuracy trade-off. This speed-accuracy trade-off was not observed in stimulus repetitions, since participants were faster after each additional stimulus repetition without making more false alarms. However, there was a possible floor effect of stimulus repetitions on false alarm rates, because the overall false alarm rates were relatively low. In order to get more false alarms, we increased the feedback duration of “Correct, but too slow.” to motivate participants to respond faster.

Methods

The experimental design was identical to the design of Experiment 2, except that the feedback duration of “Correct, but too slow.” was increased by 1000ms to 2500ms.

Results and Discussion

Response Repetitions. The upper-left panel of Figure 3 presents the mean reaction times of the current correctly responded trials as a function of sequence of preceding trials. There was no effect of the immediately preceding trial type on the mean reaction times, $F(1, 23) = .85$, $p = .366$, p = .036. Again, we replicated the effect of response repetitions on mean reaction times, $F(2, 46) = 17.01$, $p < .001$, p = .425. There was an interaction between sequence of preceding trials and response repetitions, $F(2, 46) = 3.85$, $p = .029$, p = .143. Additional go trials before making a response sped up the responding, $F(2, 46) = 17.15$, $p < .001$, p = .427. Additional no-go trials before making a response slowed the responding, $F(2, 46) = 5.97$, $p = .005$, p = .206. The interaction implies that the effect of additional go trials is larger than the effect of additional no-go trials. The number of preceding go trials had a linear effect on the mean reaction times, $F(1, 23) = 41.72$, $p < .001$, p = .645. The number of preceding no-go trials also had a linear effect on the mean reaction times, $F(1, 23) = 16.18$, $p = .001$, p = .413.

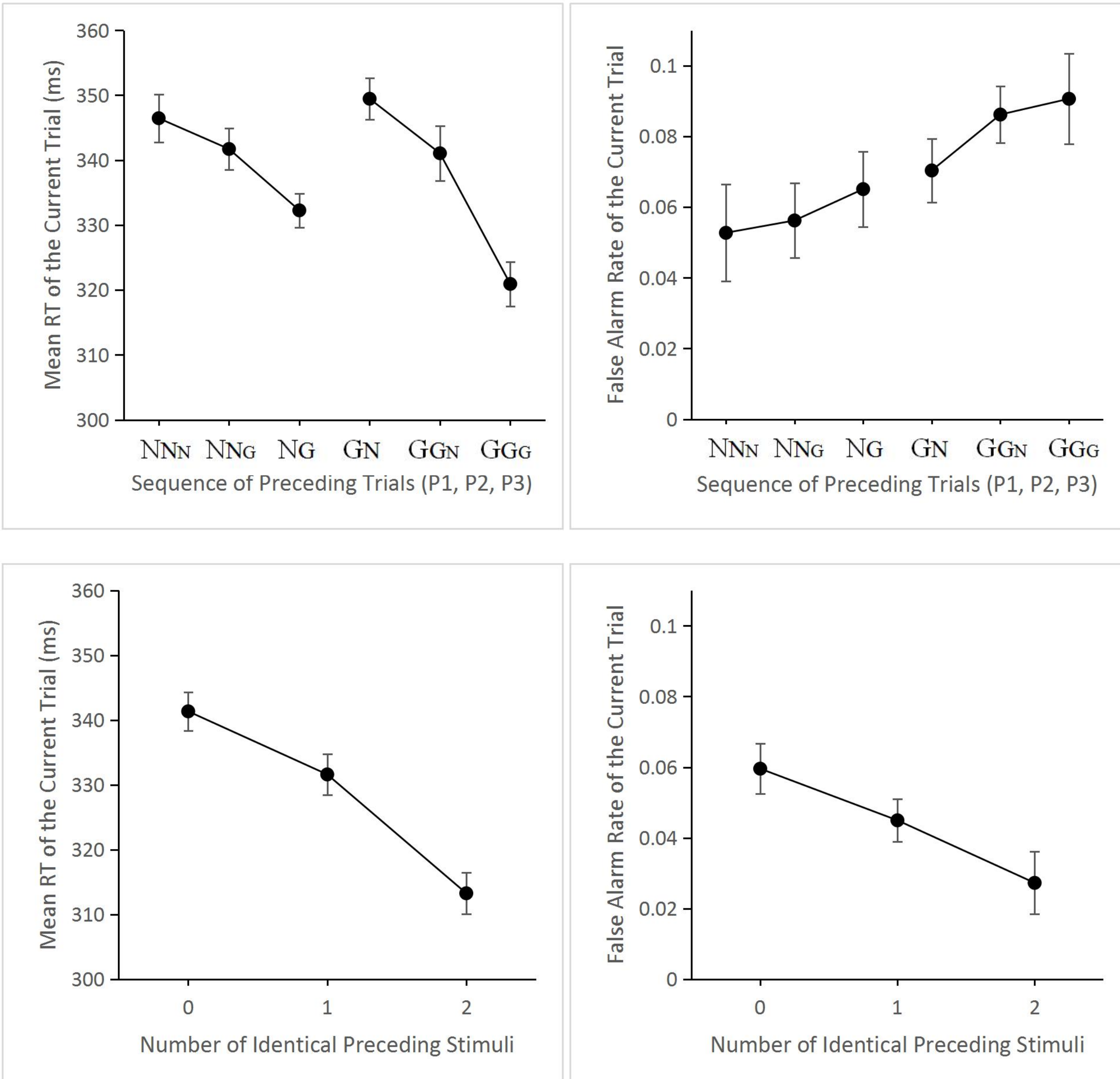

Figure 3. Mean correct response time and mean false-alarm rate from Experiment 3 as a function of repetition type and the sequence of preceding trials. (Error-bars created using the Cousineau/Morey method.)

The upper-right panel of Figure 3 presents the false alarm rates of the current trials as a function of sequence of preceding trials. Participants made more false alarms when the current trial was preceded by a go trial, $F(1, 23) = 6.64$, $p = .017$, p = .224. The number of response repetitions did not have an effect on false alarm rates, $F(2, 46) = .99$, $p = .381$, p = .041. There was no interaction between sequence of preceding trials and the number of response repetitions, $F(2, 46) = .20$, $p = .820$, p = .009.

Stimulus Repetitions. The lower-left panel of Figure 3 presents the mean reaction times of the current correctly responded trials as a function of the number of repetitions of a certain stimulus. Participants were faster after each additional stimulus repetition, $F(2, 46) = 35.66$, $p < .001$, p = .479. The number of repetitions of a certain stimulus had a linear effect on the mean reaction times of the current trial, $F(1, 23) = 41.50$, $p < .001$, p = .643.

The lower-right panel of Figure 3 presents the false alarm rates of the current trials as a function of the number of repetitions of a certain stimulus. Participants made less false alarms after repeatedly seeing the same non-target stimulus, $F(2, 46) = 4.78$, $p < .013$, p = .172. The number of repetitions of a certain stimulus had a linear effect on the mean reaction times of the current trial, $F(1, 23) = 7.19$, $p < .013$, p = .238.

In Experiment 3, we again replicated the effect of response repetitions on mean reaction times, and even if the effect of response repetitions on false alarm rates was not significant, the trend was still the same as the one in Experiment 2 as shown in Figure 3b and Figure 2b, suggesting a speed-accuracy trade-off.

There was again a beneficial effect of repeating the same stimulus on mean reaction times. By increasing the feedback duration, we successfully made participants make more false alarms, and their false alarm rates decreased as the same stimulus repeated. Both response repetitions and stimulus repetition sped up responding, but stimulus repetition made participants faster without sacrificing the accuracy. On the contrary, participants made less false alarms when the same stimulus repeated before the current trial.

General Discussion

In summary, we found consistent but different patterns for response and stimulus repetitions in go/no-go tasks when we extend the analysis to the sequence of preceding trials. With regard to the response repetition effects, the more go trials there are in a row on preceding trials, the faster the response is on the current trial, but the more likely people are to make a false alarm on the current trial. The more no-go trials there are in a row on preceding trials, the slower the response is on the current trial, but the less likely people are to make a false alarm on the current trial. Regarding to the stimulus repetitions, repeating the same target stimulus makes people faster on the current trial, and repeating the same non-target stimulus makes people less likely to make false alarms. The results also show the inconsistency of the effect of response repetitions as the previous research did when we only consider the immediately preceding trial.

This difference between response repetitions and stimulus repetitions shows that response repetitions induce a speed-accuracy trade-off, while the stimulus repetitions do not.

However, there are some limitations of these experiments. First, we only studied the repetition effects beyond the immediately preceding trial in go/no-go tasks. Since choice-RT tasks and go/no-go tasks are qualitatively different, future research should look into the effect of repeating the same response and repeating the same stimulus for more than one trial in choice-RT tasks. Second, in go/no-go tasks, because participants rarely make miss errors, we cannot not get an error rate on go trials. Conversely, there were no reaction times on correct no-go trials. Thus, the speed-accuracy trade-off is between conditions. In contrast, one can observe a speed-accuracy trade-off within a single condition in choice-RT tasks. Third, when we controlled for the stimulus repetitions to study the effect of response repetitions, we only controlled for the stimulus repetitions at the immediately preceding trial (P1), because there were few or even no data if we control for the stimulus repetitions at P2 and P3. Thus, future studies may need longer sessions to acquire more data, so that it would be possible to control for stimulus repetitions in at least three preceding trials to study the response repetitions.

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