

Persistence of the PRP Effect: Evaluating the Response-Selection Bottleneck

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Background

If two responses must be executed in succession, each to a different stimulus, the second response is slowed relative to the case when only one stimulus is shown and only one response made. The slowing of second task reaction time (RT) is greater, the shorter the interval (SOA) between the stimulus presentations. This slowing of second task RT as a function of SOA is called the *psychological refractory period* (PRP) effect.

The most common account of the PRP effect is that there is a constraint, or bottleneck, in the information processing system that allows only one stimulus to be operated on at a time. Most researchers agree that the bottleneck is intermediate to processes of perception and response execution, at the level of response-selection (Pashler, 1994).

Introduction

If there is indeed a “hard-wired” bottleneck at the stage of response selection, then the bottleneck should persist regardless of the amount of practice on two tasks. Gottsdanker and Stelmach (1971) found evidence that suggested that the PRP effect could be greatly reduced. But, they concluded that the decrease in the PRP effect for the practiced SOA was due to a strategy specific to coordinating responses at that intervals, rather than to a more general improved ability to perform two tasks in rapid succession.

Since Gottsdanker and Stelmach used only one SOA, it could be argued that a more stringent test would be to give practice with a set of different SOAs. This would preclude a strategy based on the timing between the two responses, and thus may lead to one of two possible outcomes: Either no significant decrease in the PRP effect, due to the inability to employ such a strategy, or a general reduction in the effect due to bypassing the bottleneck limitation by a different strategy or restructuring of the task.

To preview, the results of the present experiments are consistent with Gottsdanker and Stelmach’s conclusion that the PRP effect is not eliminated with practice. The inclusion of stimulus-response (S-R) compatibility (correspondence of the spatial second-task stimuli and responses) as an experimental factor permits the further conclusion that the nature of the bottleneck does not change as a function of practice.

EXPERIMENT 1

Method

Fourteen right-handed college students with normal/corrected to normal vision and hearing participated in the experiment for course credit. Each person completed five 512-trial sessions over a period of five days.

Task 1 was tone discrimination task. A high (900 Hz) or low (300 Hz) tone was presented for 100 msec. Responses were made with left-hand keypresses (the A and Z keys on the computer keyboard; the high tone was assigned to the A key and the low tone to the Z key).

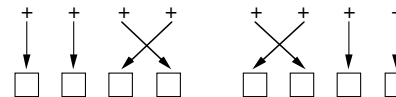
Task 2 was a visual discrimination task. A white “+” was shown at one of four possible spatial locations. The locations were marked by a row of four plus signs that remained in view 5 mm above the locations where the target stimulus would occur. The target plus sign appeared on the screen 50, 150, 350, or 650 msec after the onset of the tone.

Mean correct reaction time (RT) and proportion correct were analyzed for both Task 1 and Task 2. Effects of SOA (50, 150, 350, or 650 msec), practice (Sessions 1-5), and S-R compatibility (compatible vs. incompatible mappings) were interpreted.

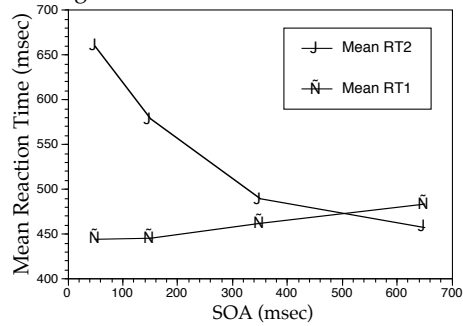
Responses to stimulus location were made by pressing either the M, <, >, or ? key on the computer keyboard using the index, middle, ring, and little fingers of the right hand, respectively.

Two of the stimuli were assigned directly to responses (compatible mapping) and two were assigned to “opposite” keys (incompatible mapping). As shown below, either the right two stimuli were compatibly assigned, or the left two were. Half of the subjects used each response set.

The Left-Right Assignments Used in Experiments 1 and 2

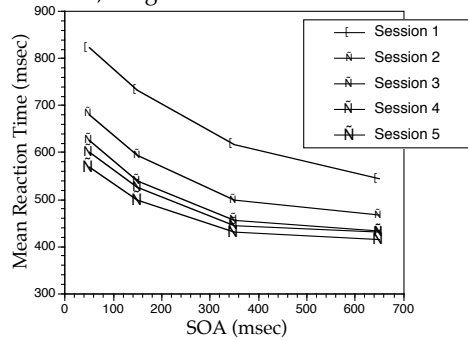


Overall, the typical PRP effect was observed. The slight *increase* in RT for Task 1 was not significant.



Mean Correct RT as a Function of SOA in Experiment 1

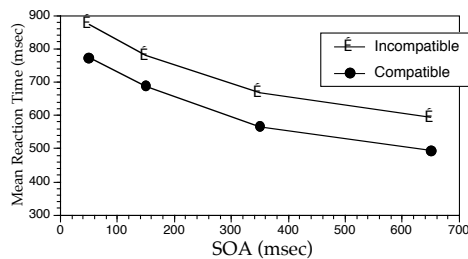
Mean RT decreased across sessions, and there was a practice by SOA interaction. However, a significant effect of SOA remained.



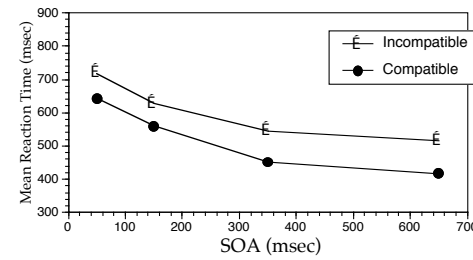
Effects of SOA and Session in Experiment 1

The main effect of compatibility was significant, reflecting faster reaction times for compatible responses. The compatibility effect was somewhat reduced with practice, as indicated by a significant Compatibility x Session interaction. If there is a bottleneck at response-selection, we would expect to see additive effects of SOA and compatibility (see Pashler, 1994). Indeed, there were no significant differences in the compatibility effect at different SOAs. Furthermore, there was no SOA x Compatibility x Session interaction.

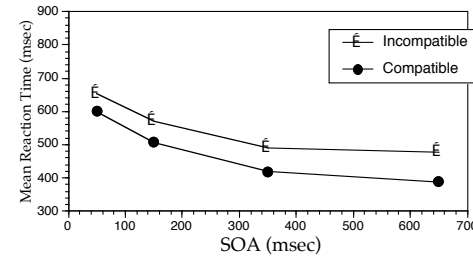
Session 1



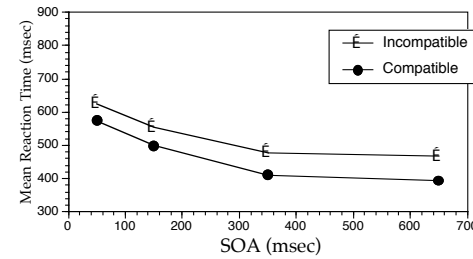
Session 2



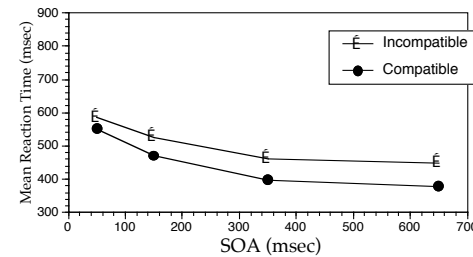
Session 3



Session 4



Session 5



EXPERIMENT 2

Purpose

The purpose of this experiment was to further probe the response-selection bottleneck by employing a transfer condition in which participants practiced with one S-R assignment for 1,600 trials, then switched to a new assignment. This transfer should certainly lead to longer RTs; the question was whether this general task disruption would also lead to an increase in the PRP effect.

Method

Thirty-six right-handed students were tested. Each person completed ten 320-trial sessions over a period of five days.

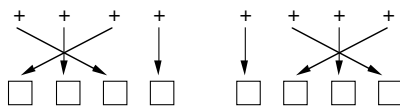
Task 1 was the same as in Experiment 1.

Task 2 was also the same. However, an additional SOA was used, such that the target plus sign appeared on the screen 50, 150, 350, 650, or 900 msec after the onset of the tone.

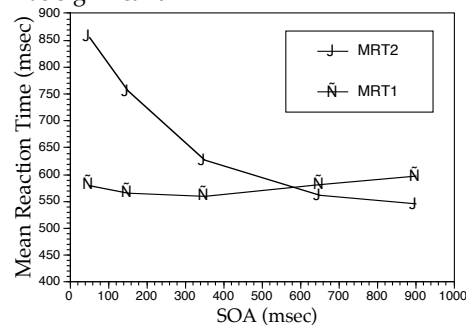
Separate analyses were performed for the practice and transfer sessions, and to compare Sessions 5 and 6.

In addition to the response assignments used in Experiment 1, assignments for which alternate locations were assigned either compatibly or incompatibly to the response keys were used.

The Alternate-Location Response Sets

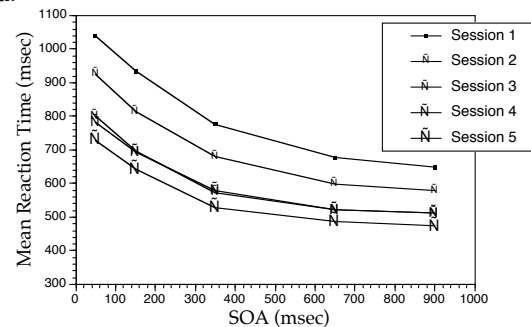


Again, the typical PRP effect was observed. This time, the increase in RT for Task 1 was significant.



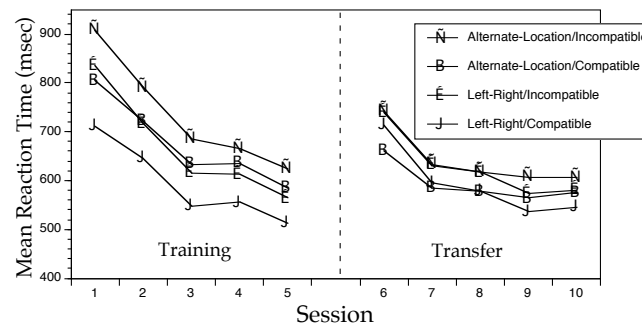
Effect of SOA in Experiment 2, Sessions 1-5

Mean RT decreased across the first five sessions, and there was a practice by SOA interaction. However, a significant effect of SOA remained.

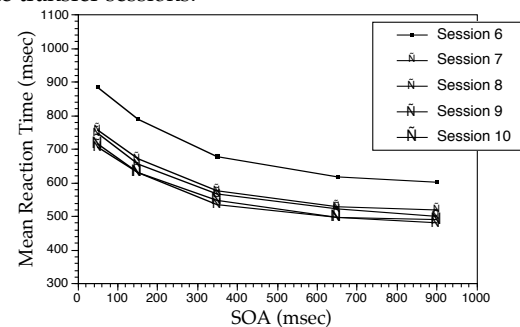


Effects of SOA and Session in Exp. 2: Sessions 1-5

Assignment, compatibility, and session interacted in the second five (transfer) sessions, but not in the initial five sessions.

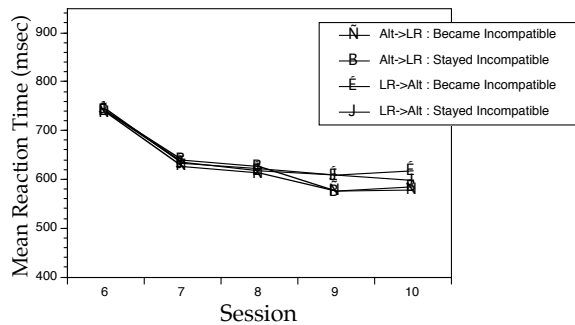
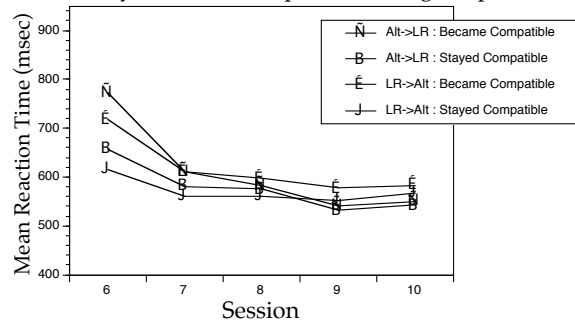


Mean RT decreased quickly across the transfer sessions. The effect of SOA was the same as in the last practice session and hardly changed across the transfer sessions.



Effects of SOA and Session in Exp. 2: Sessions 6-10

Some interesting transfer effects were observed, including a tendency for more transfer to occur to compatible responses *if* the response assigned to that key had been compatible during the practice sessions.



Transfer as a Function of Change in Assignment

Conclusions

- The PRP effect is quite robust with respect to practice. Although it is never possible to say that the effect will not change with further practice, there is no indication in our data that it will disappear.
- The nature of the mechanism that causes the PRP effect does not appear to change as a function of practice. If the bottleneck is at the stage of response selection, then factors affecting response selection should be additive with SOA effects. Compatibility did not interact with SOA overall, and there was no SOA x Compatibility x Session interaction. Thus, the data are consistent with the hypothesis that the bottleneck is (*and remains*) at the stage of response selection.
- Transfer from one assignment to another greatly affects RTs. However, the lack of a change in the SOA effect at transfer suggests a dissociation between factors affecting an individual task and factors affecting the scheduling of tasks.

References

- Gottsdanker, R., & Stelmach, G. E. (1971). The persistence of psychological refractoriness. *Journal of Motor Behavior*, 3, 301-312.
- Pashler, H. (1994). Dual-task interference in simple tasks. *Psychological Bulletin*, 116, 220-244.