



# Influence of Cognitive Resource Allocation on the Attraction Effect in Multi-Alternative Decision Making: An Experimental Study Using a Dual-Task Paradigm

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## Introduction

- Studies of the attraction effect usually utilize a three-alternative (target, competitor, and decoy) decision-making task in which each alternative has two attributes (Tsuzuki & Busemeyer, 2012; Tsuzuki & Guo, 2004).
- When the decoy attributes are slightly inferior to those of the target, the choice probability of the target increases compared to that of the competitor.
- The attraction effect in multi-alternative decision making reflects the context-dependent violation of axioms that are considered fundamental to rational choice.
- This effect is believed to depend on relatively effortless and intuitive processing (System 1 of the dual-process theory) rather than on effortful and elaborative processing (System 2).
- In our previous study (Tsuzuki, Takeda, & Chiba, 2016) that investigated the relationship between cognitive resources and the attraction effect in detail, we used a task-irrelevant probe technique (Takeda & Kimura, 2014) and measured the electroencephalographic (EEG) responses to the probes.
- We found that the mean N1 amplitudes of the event-related potentials (ERPs) elicited by the auditory probes were significantly larger when participants chose the target than when they chose the competitor.
- In this study, to confirm the a priori assumption of the previous experiment, we performed an additional experiment without measuring ERPs to examine the competition between a visual three-alternative decision-making task and an auditory oddball task (i.e., the detection of a target).
- We examined whether or not the choice proportion of the target (i.e., the strength of the attraction effect) was influenced by performing an auditory oddball task.
- Because the auditory oddball task should consume the cognitive resources, it was predicted that the attraction effect would increase when the participants performed the visual decision-making task concurrently with the auditory oddball task compared with when the participants performed only the visual decision-making task and ignored the auditory stimuli.

## Method

### Participants

- Thirty-three young adults with normal vision and normal hearing participated in this study (mean age = 21.79 years, standard deviation [SD] = 1.45).

### Apparatus and stimuli

- The visual stimuli were presented on a 20-inch LCD monitor (Dell, 2007FPb) and the auditory stimuli were presented binaurally via headphones (Sennheiser, HD265). The stimuli were controlled by a computer operating Mac OSX, MATLAB (MathWorks), and the Psychophysics Toolbox (Brainard, 1997).
- The three-alternative decision-making task was identical to that in the previous EEG study, except that only half of the 48 items was used (i.e., each participant performed 24 trials).
- Each choice set contained a decoy and two core alternatives based on a single type of consumer product or service, and each had two attributes (e.g., quality, functional capability, design, or price). Across the 24 choice sets, the average choice proportions for the target versus the competitor were not significantly different.
- The 24 trials were divided into three conditions (eight trials for each); that is, a task-relevant oddball condition (A), a task-irrelevant oddball condition (B1), and a task-irrelevant standard condition (B2).
- In the task-irrelevant standard condition (B2), 1000-Hz pure tones (75 dB/SPL, with a duration of 50 ms including 10 ms rise and fall times) were presented with an inter-stimulus interval of 400–800 ms during the viewing of the alternatives.
- In the task-irrelevant oddball and task-relevant oddball conditions (B1 and A respectively), 500-Hz pure tones were presented with the probability of 5.70%, whereas the 1000-Hz pure tones were presented with the probability of 94.30%.

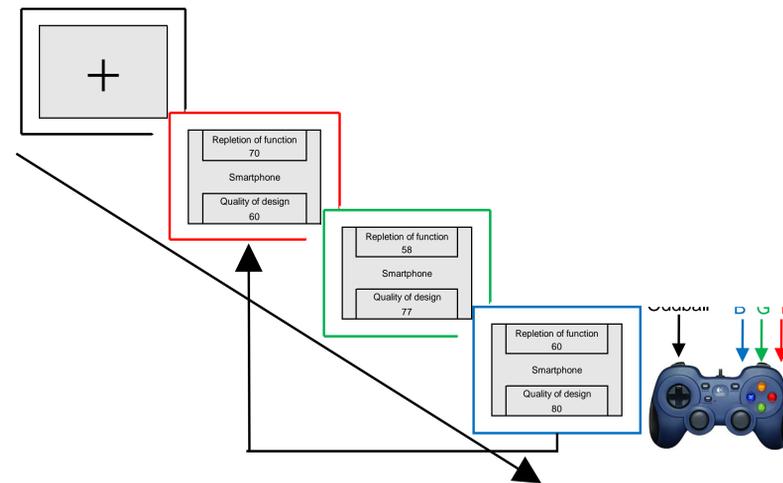


Figure 1 The time course of a single trial in the dual-task experiment.

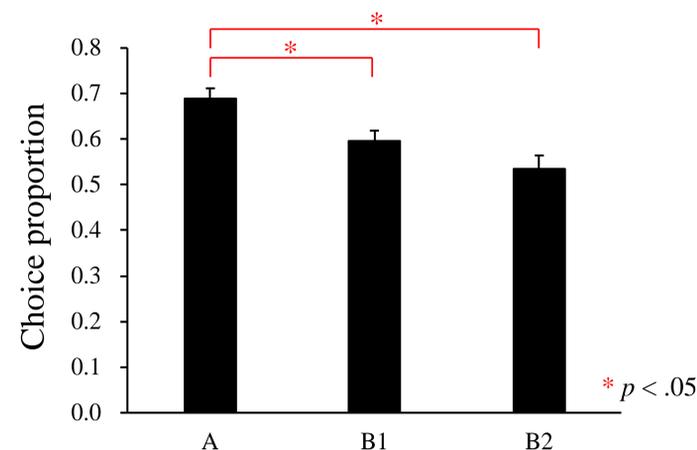


Figure 2 Mean choice proportions for the target in three conditions. Error bars indicate the standard error of the mean.

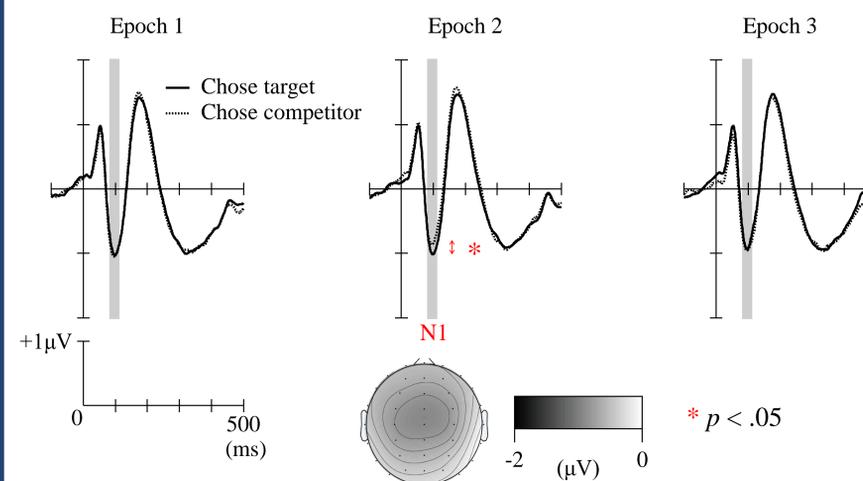


Figure 3 Tsuzuki et al. (2016): Grand-average ERP waves at FCz in the three epochs. Solid lines represent ERPs during trials in which participants chose the target and dashed lines represent ERPs during trials in which participants chose the competitor. Gray bars indicate the N1 range ( $92 \pm 12$  ms). Topographical maps represent mean amplitudes in the N1 range.

## Procedure

- Participants were asked to ignore the auditory stimuli in the task-irrelevant standard condition and task-irrelevant oddball condition (B2 and B1 respectively), whereas they were required to press a button as quickly as possible when the 500-Hz pure tone was presented in the task-relevant oddball condition (A). The three conditions were randomly switched every four trials.
- Figure 1 shows the time course of a single trial in the dual-task experiment.

## Results

- The average choice proportions (SD) of the target were 53.41% (0.17), 59.47% (0.14), and 68.94% (0.13) in the task-irrelevant standard condition, task-irrelevant oddball condition, and task-relevant oddball condition, respectively.
- A one-way analysis of variance revealed a significant main effect of the condition ( $F(2, 64) = 8.99, p < .001, \eta_p^2 = .22$ ).
- Post-hoc tests (with Bonferroni correction) demonstrated that the choice proportion of the target was significantly higher in the task-relevant oddball condition than in the task-irrelevant standard and task-irrelevant oddball conditions ( $ps < .011$ ).
- No significant difference was observed between the task-irrelevant standard and task-irrelevant oddball conditions ( $p = .44$ ).

## Discussion

- The attraction effect was significantly greater when the participants performed an auditory oddball task (i.e., detecting an auditory target) concurrently with a visual-choice task (A), than when they ignored the auditory stimuli (B1 and B2).
- These results successfully demonstrate that competition between visual and auditory processing (i.e., the consumption of cognitive resources by the processing of the auditory stimuli) can increase the choice proportion of the visual target.
- This finding supports the assumption, which is based on the dual-process theory, that intuitive comparisons among alternatives executed by System 1 are critical for the occurrence of the attraction effect, and it confirms the assumption of our previous experiment (i.e., that the competition between visual and auditory processing is mediated by the cognitive resources).

## References

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