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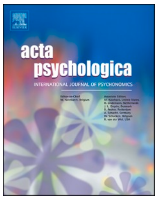

Cross-task congruency sequence effect without the contribution of multiple expectancy

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ABSTRACT

The confound-minimized cross-task design has been widely used to examine the characteristics of top-down cognitive control underlying the congruency sequence effect (CSE) without feature integration and contingency learning confounds. The present study reanalyzed our previous data obtained with the confound-minimized cross-task design, this time including the preceding congruency repetition type, to examine whether the cross-task CSE is confounded by feature integration from two-back (n-2) trials or multiple expectancies regarding the congruency and the congruency repetition type of the upcoming trial. As a result, the cross-task CSE interacted with the arbitrariness of S-R mapping or response mode regardless of the preceding congruency repetition type, indicating the contribution of top-down control triggered by conflict. Feature integration from n-2 trials, but not multiple expectancies, was found to have a lingering effect on the sequential modulation of the congruency effect between previous and current trials. However, because the influence of feature integration operated in opposite directions depending on the preceding congruency repetition type, the contribution of feature integration to the cross-task CSE can be minimized when the combined datasets of trials following a congruency repetition trial and those following a congruency alternation trial are analyzed. These findings are consistent with recent perspectives on cognitive control, which posit that top-down cognitive control and bottom-up feature integration operate independently to optimize task performance.

1. Introduction

The magnitude of the influence of a task-irrelevant distracting stimulus feature has been found to vary depending on the congruency of the preceding trial in conflicting tasks, such as Stroop, Simon, and flanker-compatibility tasks (e.g., Gratton, Coles, & Donchin, 1992). Specifically, a reduced congruency effect has been observed after incongruent trials as compared to after congruent trials. It has been widely accepted that this *congruency sequence effect* (CSE) occurs because of top-down cognitive control regulating the influence of task-irrelevant information after detecting conflict. For example, Botvinick, Braver, Barch, Carter, and Cohen's (2001) conflict monitoring theory suggests that cognitive control is up-regulated when a conflict monitoring system detects response conflict, leading to a smaller congruency effect after incongruent trials than after congruent ones.

Even though the CSE is well accounted for in terms of the top-down cognitive control accounts, it has been demonstrated that the sequential modulation can be obtained without the involvement of top-down cognitive control (Hommel, Proctor, & Vu, 2004; Mayr, Awh, & Laurey, 2003). According to Hommel et al.'s *feature integration theory*, the stimulus and response features of a given trial are automatically integrated into a transient event file, which is an episodic memory trace. If one or more features are repeatedly encountered on the following trial, the event file is retrieved. Responses are facilitated when either all features of the event file are repeated, or none are repeated. In contrast, partial repetition costs occur when some features are repeated, but the others are alternated. Especially, in 2-alternative forced choice tasks, all features are repeated, or no feature is repeated on incongruent trials after an incongruent trial (iI) and congruent trials after a congruent trial (cC), resulting in rapid responses. However, only some features are repeated, and the others are alternated on incongruent trials after a congruent trial (iC) and congruent trials after an incongruent trial (cI), resulting in slow responses. That is, the effects of the congruency sequence and the feature integration are completely confounded. Hommel et al. showed the sequential modulation without having conflict, and Mayr et al. found no sequential modulation when stimulus feature-repetition trials were excluded from analyses.

To examine the contribution of top-down cognitive control to the

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CSE without the contribution of bottom-up feature integration, many researchers increased the number of stimulus and response alternatives and analyzed a subset of data. For example, a significant CSE was obtained when analyzing complete alternation trials only (e.g., Kunde & Wühr, 2006; Ullsperger, Bylsma, & Botvinick, 2005) or when analyzing trial sequences with constant amounts of feature overlap (e.g., Wühr, 2005). However, increasing the number of stimulus and response alternatives to avoid the feature integration confound causes another type of confound, which is *contingency learning*. Because most researchers maintain the same number of congruent and incongruent trials while increasing the number of stimulus and response alternatives, the task-relevant stimulus feature is paired with its corresponding task-irrelevant stimulus feature more often than the other task-irrelevant stimulus features that do not correspond to it. Accordingly, this contingency between the task-relevant and its corresponding task-irrelevant stimulus features informs the correct response (Mordkoff, 2012). Most importantly, the benefits of high contingency trials over low contingency ones vary as a function of the contingency of the preceding trial (e.g., Schmidt, Crump, Cheesman, & Besner, 2007). Thus, this contingency learning confound is unavoidable when increasing the number of stimulus and response alternatives.

Kim and Cho (2014) found a significant CSE while minimizing the confounding effects of feature integration and contingency learning. In their experiment, participants were asked to perform two 2-alternative forced choice color flanker-compatibility tasks alternatively in a trial-by-trial manner.[1] Red and yellow circles were presented in one task and green and blue circles were in the other task as the target and flanker stimuli. Participants were asked to respond to one task with the index and middle fingers of their dominant hand and the other task with the ring and little fingers. Because the two tasks had different stimulus and response sets, no stimulus or response repetition occurred between two consecutive trials. Also, because each task was a 2-forced choice task, no contingency between the task-relevant and task-irrelevant stimulus dimensions existed. This method allowed to examine the cross-task CSE without the bottom-up repetition priming confounds between previous (n-1) and current trials (e.g., Kim & Cho, 2014; Schmidt & Weissman, 2014). This is consistent with the growing body of recent literature that has placed more emphasis on the need for adopting this confound-minimized cross-task design (for review, Braem et al., 2019; Schmidt, 2019). Using this design, CSEs were obtained between two prime-probe tasks (Schmidt & Weissman, 2014), two Stroop tasks (Aschenbrenner & Balota, 2017), two emotional facial Stroop tasks (Jeong & Cho, 2020), and two Simon tasks (Lim & Cho, 2020), indicating that the CSE can occur without feature integration or contingency learning.

However, Erb and Aschenbrenner (2019) suggested that the cross-task CSE found in this confound-minimized cross-task design contains lingering repetition-priming confounds from the 2-back (n-2) trial. According to their *multiple expectancy account*, which is based on Gratton et al.'s (1992) repetition expectancy account, the CSE occurs because of participants' expectations on the congruency of the upcoming trial based on n-1 trial congruency and preceding congruency repetition type (congruency repetition vs. congruency alternation between n-2 and n-1 trials). Participants expect that the congruency of a given trial (n) will match that of n-1 trial. At the same time, they expect that the congruency repetition type (repetition vs. alternation) between n-1 and n trials will match that between n-2 and n-1 trials. Thus, participants predict a certain type of congruency for the upcoming trial based on these multiple expectancies. Better performance is obtained when the congruency of the current trial matches with that predicted than when it does not. After congruency repetition trials, the expectations based on both congruency and congruency repetition type match with the current trial's congruency on cC and iI trials while neither does on iC and cI trials, resulting in the CSE. However, because the expectation based on the previous trial's congruency is opposite to that based on the congruency repetition type after congruency alternation trials, these two expectations cancel each other out, resulting in no CSE. Similarly, Jiménez and Méndez (2014) showed that the CSE was evident only after congruency repetition trials (ccC, ccI, iiC, & iiI), but not after congruency alternation trials (icC, icI, ciC, & ciI).

Erb and Aschenbrenner (2019) reanalyzed data from Schmidt and Weissman's (2014) two experiments and Aschenbrenner and Balota's (2017) six experiments, in which significant confound-minimized CSEs were obtained between two different tasks, in order to examine whether the findings of these experiments were consistent with their multiple expectancy account. In most of their experiments, the results were similar to those of Jiménez and Méndez's (2014) experiments. The CSE was significant after congruency repetition trials but not after congruency alternation trials in the RT data of seven of the eight experiments. This suggested that the confound-minimized CSE is modulated by participants' multiple expectancies about the congruency and congruency repetition types and that the conflict-based accounts should be modified to explain the contributions of multiple expectancy to the CSE.

In addition, to examine the contribution of bottom-up feature integration to the CSE in the confound-minimized cross-task design, Erb and Aschenbrenner (2019) analyzed the data after congruency repetition trials and found that the CSE was more evident when the response on n-2 trial was repeated on the current trial than when it was alternated. Based on these results, they concluded that the bottom-up feature integration from n-2 trial contributes to the CSE between current and previous trials, which was obtained with the confound-minimized cross-task design. However, in Erb and Aschenbrenner's analyses, as they mentioned, the trials on which the response on n-2 trial was repeated were either complete repetition or partial repetition, whereas the trials on which the response on n-2 trial was alternated involved complete alternation or partial repetition. According to Hommel et al. (2004), the sequential modulation of the congruency effect occurs because cC and iI trials involve complete repetition or complete alternation, resulting in faster responses, and iC and cI trials involve partial repetition, resulting in slow responses. Thus, it is critical to distinguish partial repetition trials from complete repetition or complete alternation trials to examine the effect of the bottom-up feature integration from n-2 trial.

To dissociate the effect of the bottom-up feature integration from n-2 trial on the current trial from that of the top-down control triggered by the preceding trial in the confound-minimized tasks, congruency effects should be separately analyzed depending on whether congruency is repeated between the n-2 and previous trials (see, Table 1). This is because those two effects operate in the same direction if the congruency of n-2 trial is repeated on the previous trial, whereas they operate in the opposite directions if the congruencies of n-2 and the previous trials are alternated. When the n-2 and previous-trial congruencies are identical, the feature integration effect engenders the sequential modulation of the typical CSE pattern. This is attributable to the fact that in the current trial, the stimulus and response features of n-2 trial are completely repeated or alternated on ccC and iiI trials, resulting in faster responses, while they are partially repeated on ccI and iiC trials, resulting in slower responses. On the other hand, when the congruency of n-2 trial is alternated on the previous trial, the repetition-priming effect generates the sequential modulation opposite to the typical pattern of the CSE. This reversal is because stimulus and response features are partially repeated on icC and ciI trials, whereas they are completely repeated or alternated on icI and ciC trials. Therefore, if the feature repetitions of n-2 trial still influence the current trial, the sequential modulation between

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[1] The boundary of task representation varies depending on other task properties, such as task-relevant stimulus dimension, response mode, S-R mapping rules, in a flexible manner (e.g., Lim & Cho, 2018; Schumacher & Hazeltine, 2016). However, in the present experiments, two different sets of stimuli were independently presented in turn and responded with different sets of responses. Thus, for convenience sake, we defined a task as a set of activities sharing task-relevant and task-irrelevant stimulus features and response alternatives in the present study.

Table 1
Illustration of the feature repetitions for congruency repetitions and congruency alternations in case the flanker-compatibility task consisting of letters T and L, and the flanker-compatibility task consisting of letters H and N are presented in turn.

		Congruency sequence															
		ccC				ccI				iiC				iiI			
Congruency repetition	n-2	TTT	LLL	LLL	TTT	TTT	LLL	LLL	TTT	TLT	LTL	LTL	TLT	TLT	LTL	LTL	TLT
	n-1	HHH or NNN	HHH or NNN	HHH or NNN	HHH or NNN	HHH or NNN	HHH or NNN	HHH or NNN	HHH or NNN	HNH or NHN	HNH or NHN	HNH or NHN	HNH or NHN	HNH or NHN	HNH or NHN	HNH or NHN	HNH or NHN
	n	TTT	TTT	LLL	LLL	TLT	TLT	LTL	LTL	TTT	TTT	LLL	LLL	TLT	TLT	LTL	LTL
	Repetition	CR	CA	CA	CR	PR	PR	PR	PR	PR	PR	PR	PR	CR	CA	CA	CR
		Congruency sequence															
		icC				icI				ciC				ciI			
Congruency alternation	n-2	TLT	LTL	LTL	TLT	TLT	LTL	LTL	TLT	TTT	LLL	LLL	TTT	TTT	LLL	LLL	TTT
	n-1	HHH or NNN	HHH or NNN	HHH or NNN	HHH or NNN	HHH or NNN	HHH or NNN	HHH or NNN	HHH or NNN	HHH or NNN	HHH or NNN	HHH or NNN	HHH or NNN	HHH or NNN	HHH or NNN	HHH or NNN	HHH or NNN
	n	TTT	TTT	LLL	LLL	TLT	TLT	LTL	LTL	TTT	TTT	LLL	LLL	TLT	TLT	LTL	LTL
	Repetition	PR	PR	PR	PR	CR	CA	CA	CR	CR	CA	CA	CR	PR	PR	PR	PR

CA denotes complete alternation, CR denotes complete repetition, and PR denotes partial repetition.

previous and current trials would be reduced following congruency alternation trials, as compared to following congruency repetition trials.

The goal of the present study was to examine whether the cross-task CSEs obtained between previous and current trials in the confound-minimized cross-task design are due to the top-down cognitive control, multiple expectancies, or lingering repetition-priming of n-2 trial by reanalyzing data from two of our previous studies (Lim & Cho, 2018, 2020). In Lim and Cho (2018), participants were asked to perform two letter flanker-compatibility tasks alternatively in a trial-by-trial manner with different response sets for different tasks. In Experiment 1, for one group of participants, the stimulus sets and stimulus-response mappings (S-R mappings) of the two tasks were non-arbitrary (e.g., letter A, B, C, and D) as they shared a common S-R mapping rule (i.e., alphabetical order). For another group, however, the alphabet letters were selected in a random order as target stimuli (e.g., letter T, L, H, and N), resulting in arbitrary sets of stimulus and S-R mappings. The cross-task CSE was obtained when the stimulus sets and S-R mappings of the two tasks were non-arbitrary but not when they were arbitrary (see Table 2). In Experiment 2, the arbitrariness of the stimulus set and response mode were manipulated. One group of participants was asked to respond with one of their index fingers for one task and one of their middle fingers for the other task (same response mode), whereas the other group were to respond with their left hand for one task and the right hand for the other task (different response modes). The stimulus sets of the two tasks were arbitrary for half of each group and non-arbitrary for the other half, even though the S-R mappings were always arbitrary. Regardless of the arbitrariness of the stimulus sets, the cross-task CSE was obtained when the two tasks were performed with the same response mode, but not when they were performed with different response modes. Lim and Cho concluded that the scope of the cognitive control triggered by conflict is determined by the arbitrariness of S-R mappings and response mode.

In Lim and Cho's (2020) study, participants were asked to perform horizontal and vertical color Simon tasks alternatively in a trial-by-trial manner in Experiment 1 and horizontal and vertical arrow flanker-compatibility tasks in Experiment 3 by using aimed movements. One group of participants were asked to perform the two tasks with different response modes and the other group were to perform them with the same response mode. In both experiments, significant cross-task CSEs were obtained when the two tasks were performed with the same response mode but not when they were performed with different modes (see, Table 2). The authors suggested that the specificity of cognitive control is determined by response mode as it affects how horizontal and vertical spatial dimensions are cognitively coded.

The data from these four experiments were useful to examine whether the cross-task CSE between previous and current trials is due to the contributions of multiple expectancies or lingering repetition-priming of n-2 trial, rather than the contribution of top-down cognitive control triggered by conflict, because the results of all four experiments showed that the cross-task CSE was evident in one condition and not in the other. It has been suggested that the cognitive control process operates in a domain-specific manner (e.g., Akçay & Hazeltine, 2008; Egner, Delano, & Hirsch, 2007; Lee & Cho, 2013; Notebaert & Verguts,

Table 2
Summary of results in Lim and Cho's (2018) and Lim and Cho's (2020) experiments.

Experiment	Condition	Cross-task CSE	Interaction of n0, n-1 and PCRT	CSE after congruency repetition	CSE after congruency alternation
Lim and Cho's (2018) Experiment 1	Non-arbitrary S-R mapping	+	X	+	X
	Arbitrary S-R mapping	X	Δ	X	X
Lim and Cho's (2018) Experiment 2	Same response mode	+	X	+	+
	Different response mode	X	Δ*	X	X
Lim and Cho's (2020) Experiment 1	Same response mode	+	O	+	X
	Different response mode	X	O	+	–
Lim and Cho's (2020) Experiment 3	Same response mode	+	O	+	X
	Different response mode	X	O	Δ	X

Interaction of n0, n-1, and PCRT denotes the 3-way interaction of current-trial congruency, previous-trial congruency, and preceding congruency repetition type. O denotes a significant effect, X denotes no CSE, Δ denotes a marginally significant CSE, + denotes a significant CSE and – denotes a significant reversed CSE.

* $p = .0676$.

2008). Thus, only when two tasks share a specific feature, such as type of conflict (Egner et al., 2007), task-relevant dimension (Notebaert & Verguts, 2008), task-irrelevant dimension (Weissman, 2020), task representation (Akçay & Hazeltine, 2008), or response mode (Lee & Cho, 2013), can the cross-task CSE occur between the two tasks. Specifically, those four experiments of Lim and Cho (2018, 2020) demonstrated that the cross-task CSE was dependent on the arbitrariness of S-R mappings and response mode. In contrast, according to the multiple expectancy account, the congruency of the current trial matches participants' expectations based on the previous trial's congruency and congruency repetition type (Erb & Aschenbrenner, 2019). Since these multiple expectancies are independent of any stimulus, response, or any other task features, the effect of multiple expectancies can occur regardless of whether two tasks share a domain. On the other hand, the effect of feature integration occurs only when two tasks share stimulus and response features. Thus, regardless of whether two tasks share a domain, the feature repetition between n-2 and current trials can have a lingering effect on the cross-task CSE between previous and current trials.

If multiple expectancies are a critical factor in determining the performance of conflict tasks, as Erb and Aschenbrenner (2019) suggested, the sequential modulation between previous and current trials would be evident after congruency repetition trials but not after congruency alternation trials. Moreover, this effect of congruency repetition type would be found regardless of the arbitrariness of S-R mapping or response mode. Similarly, if the lingering repetition-priming of n-2 trial engenders the sequential modulation between previous and current trials without the contribution of top-down control, the cross-task CSE should be obtained following the congruency repetition trials but not following congruency alternation trials. More specifically, after congruency alternation trials, the reversed cross-task CSE (i.e., the smaller congruency effect following congruent trials than following incongruent ones) would be obtained.

However, if the cross-task CSE is due to the top-down cognitive control triggered by conflict on the preceding trial, the CSE would be found only when the two tasks share a common task feature (i.e., non-arbitrary S-R mappings or the same response mode). In addition, if the conflict-driven cognitive control and the feature integration from n-2 operate independently, the pattern of the sequential modulation would vary depending on the task features and congruency repetition type. When the two tasks have non-arbitrary S-R mappings or same response mode, the cross-task CSE would be more evident after congruency repetition trials than after congruency alternation trials. This is because the top-down cognitive control and the bottom-up feature integration from n-2 trials generate the same pattern of sequential modulation after congruency repetition trials, whereas they generate the opposite pattern of sequential modulation and cancel out each other after congruency alternation trials. On the contrary, when the two tasks have arbitrary S-R mappings or different response modes, the top-down cognitive control triggered by conflict of one task would not regulate the conflict of the other task. Consequently, only the feature integration from n-2 trial contributes to the sequential modulation, and thus the typical pattern of the sequential modulation would be engendered after congruency repetition trials, but the opposite pattern of the sequential modulation would be obtained after congruency alternation trials.

2. Methods

2.1. Participants

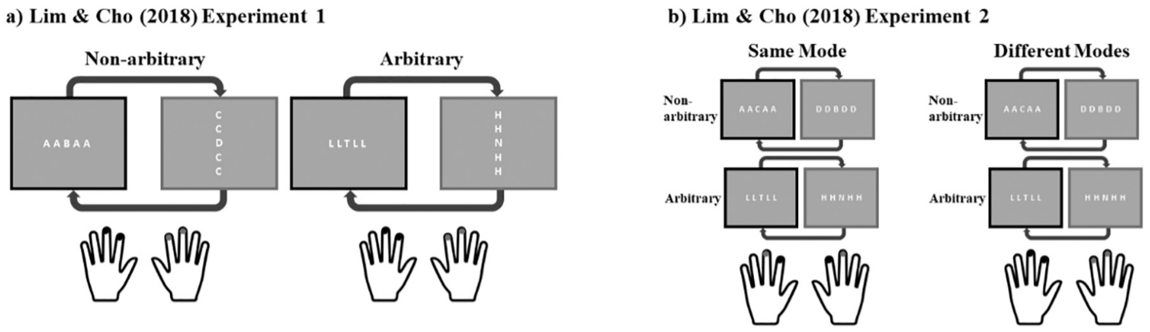
Thirty-two undergraduate students participated in Experiment 1 of Lim and Cho's study (2018). Sixteen participants were asked to perform two letter-flanker compatibility tasks with arbitrary S-R mappings, and the other participants were assigned tasks with non-arbitrary S-R mappings. In Experiment 2, 64 participants performed two letter-flanker compatibility tasks consisting of either non-arbitrary or arbitrary stimulus sets. Half the participants who completed each task (a non-arbitrary or arbitrary stimulus set, 16 participants) were to perform the two tasks with the same response mode while the other participants were to perform tasks with different response modes.

In Experiment 1 of Lim and Cho's (2020) study, 32 participating undergraduate students were to perform horizontal and vertical Simon tasks with aimed movements. Sixteen were to perform the two tasks with the same response mode, and another 16 participants were to perform the two tasks with different response modes. In Experiment 3, 32 participants performed horizontal and vertical arrow flanker-compatibility tasks. Similar to Experiment 1, half of the participants responded to with the same response mode, while the other half responded to with different response modes. The participants gave their informed consent and all experiments were approved by the Institutional Review Board at Korea University (KU-IRB-16-138-A-1).

2.2. Tasks

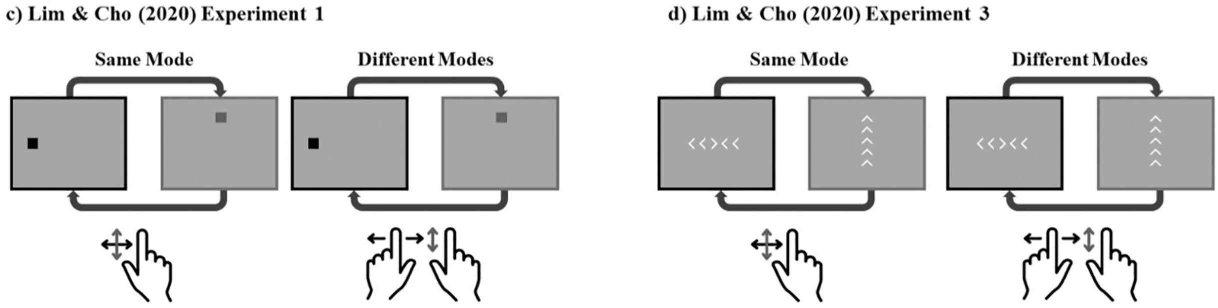
In Experiment 1 of Lim and Cho (2018), one group of participants were to perform two letter flanker-compatibility tasks consisting of a non-arbitrary stimulus set (A, B, C, and D) alternatively in a trial-by-trial manner and the other group were to perform tasks incorporating an arbitrary stimulus set (L, T, H, and N) in the same manner. Participants were asked to make a keypress response to the target flanked by two letters on each side. Participants were asked to perform one task with their left hand and the other with their right hand (see Fig. 1). The experiment consisted of 30 practice trials and eight experimental blocks of 82 trials. In Experiment 2, arbitrary stimulus sets were used for half the participants and non-arbitrary stimulus sets were used for the other half. For the non-arbitrary stimulus sets, a set of letters A, B, C, and D were used that presumably has a non-arbitrary relationship due to their alphabetical order. On the other hand, for the arbitrary stimulus sets, a set of letters T, L, H, and N were presented, which have no meaningful relationship with each other. Moreover, in Experiment 2, response mode was manipulated. Response mode is a representational group of related motor responses divided by salient features, such as anatomical distinction, relative location of responses, or task representation (Kim & Cho, 2014; Lim & Cho, 2018). Thus, one group of participants were to respond to the target of the former task with their index fingers and that of the latter task with their middle fingers (same response mode) of both hands, whereas the other group were to respond to the target of the former task with their left index and middle fingers and that of the latter task with their right index and middle finger (a different response mode). Other procedures were identical to those of Experiment 1.

In Experiment 1 of Lim and Cho (2020), a red or yellow square was presented to the left or right side of fixation for the horizontal Simon task, while a green or blue square was presented above or below fixation for the vertical Simon task. Sixteen participants were asked to respond to the horizontal Simon task with the left hand and to the vertical Simon task with the right hand, while the other 16 participants were asked to respond to both tasks with the right hand. All participants performed the tasks by making aimed-movement responses. On each trial, when a fixation point was presented, they were asked to keep pressing a home key placed at the center of the response keys with their index finger until a target appeared and to lift the finger to press a directional key depending on the color of the target. Left or right aimed-movement was made for the horizontal task, and upward or downward aimed-movement for the vertical one. Initiation time (IT) and movement time (MT) were separately measured. IT was defined as the time elapsed between the target onset and home key release, and MT was defined as the time elapsed between the moments when participants released the home key and when they pressed the direction key. The experiment consisted of 34 practice trials and 8 main blocks of 82 trials. The procedures of Experiment 3 were identical to those of Experiment 1 with the following exceptions. For the horizontal arrow flanker-compatibility task, a left- or right-pointing arrowhead was presented at the center of the display as a target. On each side of the target, two left- or right-



a) Lim & Cho (2018) Experiment 1

b) Lim & Cho (2018) Experiment 2



c) Lim & Cho (2020) Experiment 1

d) Lim & Cho (2020) Experiment 3

Fig. 1. Examples of stimulus and response sets in (a) Lim and Cho's (2018) Experiment 1 and (b) Experiment 2, and (c) Lim and Cho's (2020) Experiment 1 and (d) Experiment 4.

pointing arrowheads were presented as flankers. For the vertical arrow flanker compatibility task, an upward- or downward- pointing arrowhead was presented at the center of the display as a target. Two upward- or downward-pointing arrowheads were presented above and below the target. One group of participants were asked to respond to the direction of the target arrowhead in both tasks with the right hand. The other group of participants were asked to perform the horizontal arrow flanker-compatibility task with their left hand and the vertical arrow flanker-compatibility task with their right hand.

2.3. Analyses

For all experiments, the first and second trials of each block were removed from analyses. For the data of Lim and Cho's (2018) Experiments 1 and 2, trials with RTs shorter than 150 ms or longer than 2.5 standard deviations from the individual's mean RT for each sequence type (cC, cI, iC, and iI) were excluded from the analyses as outliers. For the data of Lim and Cho's (2020) Experiments 1 and 3, outliers were defined as the trials in which either MT or IT was more than 3 standard deviations away from its conditional mean for each individual participant. RT (or MT) outliers and the trials following RT (or MT) outlier or incorrect responses were excluded from the analyses (approximately 8.72% and 9.5% of the total trials in Experiments 1 and 2 of Lim & Cho, 2018, respectively and approximately 8.63% and 6.04% of the total trials in Experiments 1 and 3 of Lim & Cho, 2020, respectively). For each experiment, mean correct RTs or movement times (MTs) were calculated for each participant as a function of previous-trial congruency (n-1 congruent vs. n-1 incongruent), current-trial congruency (congruent vs. incongruent), and preceding congruency repetition type (congruency repetition vs. congruency alternation between n-2 and n-1 trials). A repeated measures analysis of variance (ANOVA) was conducted on the mean correct RT for Lim and Cho's (2018) experiments or on the mean correct MT for Lim and Cho's (2020) experiments, with those variables as within-subject factors and S-R mapping (arbitrary vs. non-arbitrary; Lim & Cho, 2018, Experiment 1) or response mode (same vs. different modes; the other experiments) as a between-subject factor. The percentage error (PE) data were not included in these analyses because the overall PE was relatively low, and thus did not involve significant results regarding the focus of the current study.

3. Results

3.1. Lim and Cho's (2018) Experiment 1

The main effect of S-R mapping was significant, $F(1,30) = 9.51$, $p = .004$, $MSE = 28{,}997$, $\eta^2_p = 24$. The mean RT was shorter when the S-R mappings were non-arbitrary ($M = 489$ ms) than when they were arbitrary ($M = 554$ ms). The main effect of current trial congruency was significant, $F(1, 30) = 79.78$, $p < .001$, $MSE = 577$, $\eta^2_p = 0.73$, indicating a 27-ms congruence effect. Even though the interaction of current trial congruency and previous-trial congruency was not significant, $F(1, 30) = 1$, $p = .325$, the three-way interaction of preceding congruency repetition type, previous-trial congruency, and current-trial congruency was significant, $F(1, 30) = 5.89$, $p = .022$, $MSE = 120$, $\eta^2_p = 0.16$. The cross-task CSE was evident after congruency repetition trials, $F(1, 15) = 8.65$, $p = .006$, $MSE = 95$, $\eta^2_p = 0.37$, but not after congruency alternation trials, $F(1, 15) < 1$, $p = .548$. The congruency effect was smaller after incongruent trials (24 ms), $F(1, 30) = 71.03$, $p < .001$, $MSE = 130$, $\eta^2_p = 0.7$, than after congruent trials (34 ms), $F(1, 30) = 87.47$, $p < .001$, $MSE = 213$, $\eta^2_p = 74$, when the congruency of the preceding trial was repeated, whereas the congruency effect after congruent trials (23 ms), $F(1, 30) = 16.52$, $p < .001$, $MSE = 511$, $\eta^2_p = 0.36$, was similar to the effect after incongruent trials (26 ms), $F(1, 30) = 40.29$, $p < .001$, $MSE = 271$, $\eta^2_p = 0.57$, when the congruency of the preceding trial was alternated. The four-way interaction of S-R mapping, preceding congruency repetition, previous-trial congruency, and current-trial congruency was not significant, $F(1, 30) = 1.13$, $p = .297$, $MSE = 120$. Also, the three-way interaction of S-R mapping, previous-trial congruency, and current-trial congruency was significant, $F(1, 30) = 5.70$, $p = .024$, $MSE = 193$, $\eta^2_p = 0.16$. For further examination of this three-way interaction, separate analyses for each S-R mapping were conducted as a function of previous-trial congruency, current-trial congruency and preceding congruency repetition type as within-subject variables (see Fig. 2).

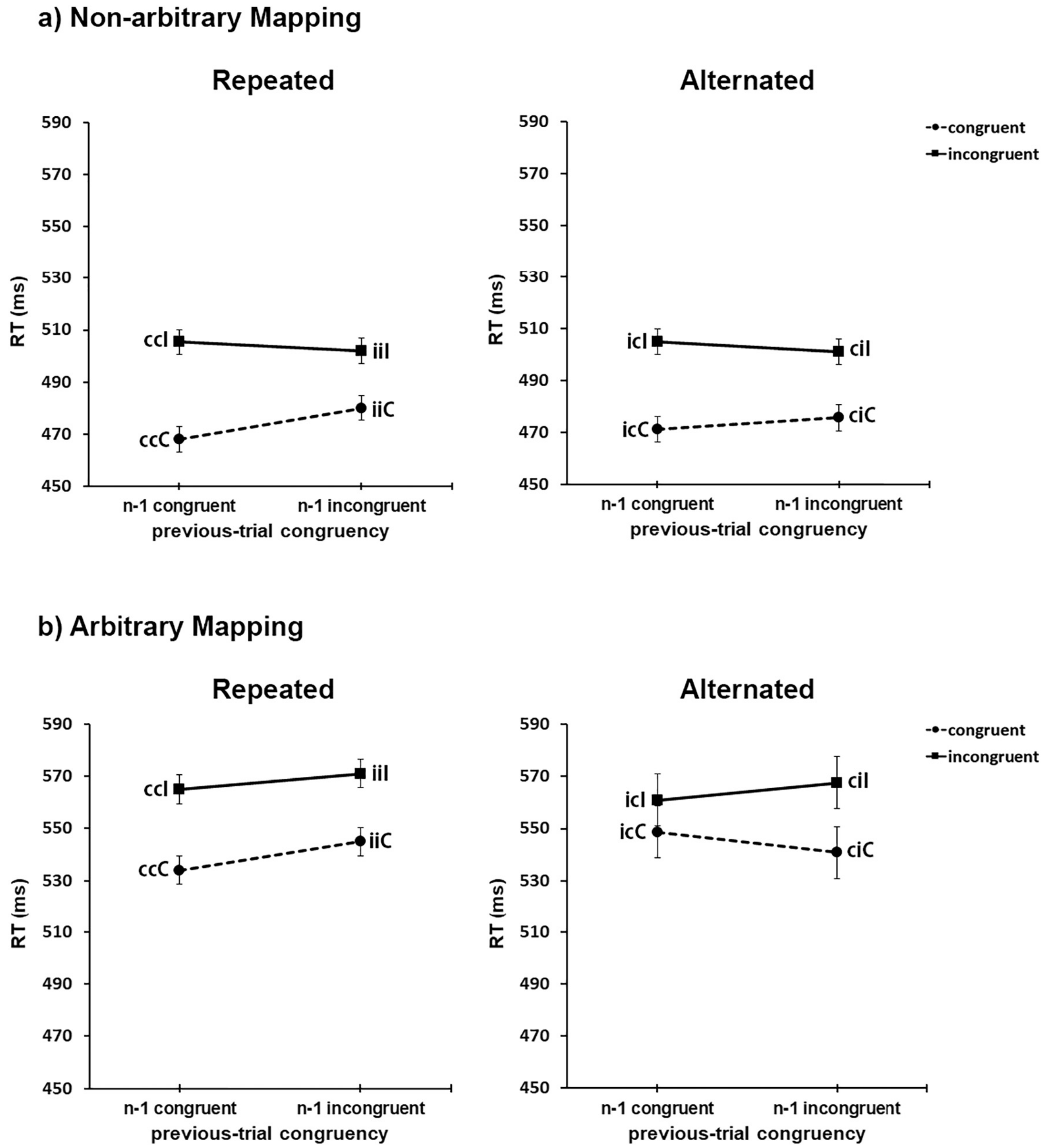


Fig. 2. Results of Lim and Cho's (2018) Experiment 1. a) The mean RT as a function of previous-trial congruency and current trial congruency on trials preceded by congruency repetition (left panel) and congruency alternation trials (right panel) for non-arbitrary S-R mappings. b) The mean RT as a function of previous-trial congruency and current trial congruency on trials preceded by congruency repetition (left panel) and congruency alternation trials (right panel) for arbitrary S-R mappings. The error bars indicate the 95% confidence interval around the mean (Loftus & Masson, 1994).

When the non-arbitrary S-R mappings were employed, the main effect of current-trial congruency was significant, $F(1, 15) = 65.36$, $p < .001$, $MSE = 429$, $\eta^2_p = 0.81$, indicating a significant 28-ms congruency effect. Also, the interaction of current-trial congruency and previous-trial congruency was significant, $F(1, 15) = 10$, $p = .007$, $MSE = 111$, $\eta^2_p = 0.4$. The congruency effect was smaller after incongruent trials (22 ms), $F(1, 15) = 68.25$, $p < .001$, $MSE = 132$, $\eta^2_p = 0.82$, than after congruent trials (34 ms), $F(1, 15) = 49.41$, $p < .001$, $MSE = 408$, $\eta^2_p = 0.77$. This cross-task CSE was not modulated by preceding congruency repetition type, $F(1, 15) = 2.01$, $p = .177$, $MSE = 56$, $\eta^2_p = 0.12$, even though the sequential modulation between previous and current trials was evident after congruency repetition trials, $F(1, 15) = 11.81$, $p = .004$, $MSE = 81$, $\eta^2_p = 0.44$, but not after congruency alternation trials, $F(1, 15) = 3.02$, $p = .103$, $MSE = 85$, $\eta^2_p = 0.17$.

When the arbitrary S-R mappings were used, the main effect of current-trial congruency was significant, $F(1, 15) = 25.49$, $p > .001$, $MSE = 724$, $\eta^2_p = 0.63$. The interaction of current-trial congruency and previous-trial congruency was not significant, $F(1, 15) < 1$, $p = .425$, $MSE = 275$, $\eta^2_p = 0.04$. The three-way interaction of current-trial congruency, previous-trial congruency, and preceding congruency repetition type was marginally significant, $F(1, 15) = 3.96$, $p = .065$, $MSE = 184$, $\eta^2_p = 0.21$. Even though the sequential modulation between previous and current trials was not significant either after congruency repetition or congruency alternation trials, the magnitude of the congruency effect was numerically larger after incongruent trials (28 ms) than after congruent trials (13 ms) when the congruency of the preceding trial did not match the congruency of n-2 trial, $F(1, 15) = 2.35$, $p = .146$, $MSE = 351$, $\eta^2_p = 0.14$. However, it was similar after congruent trials (36 ms) and incongruent trials (31 ms) when the congruency of the preceding trial matched the congruency of n-2 trial, $F(1, 15) < 1$, $p =$

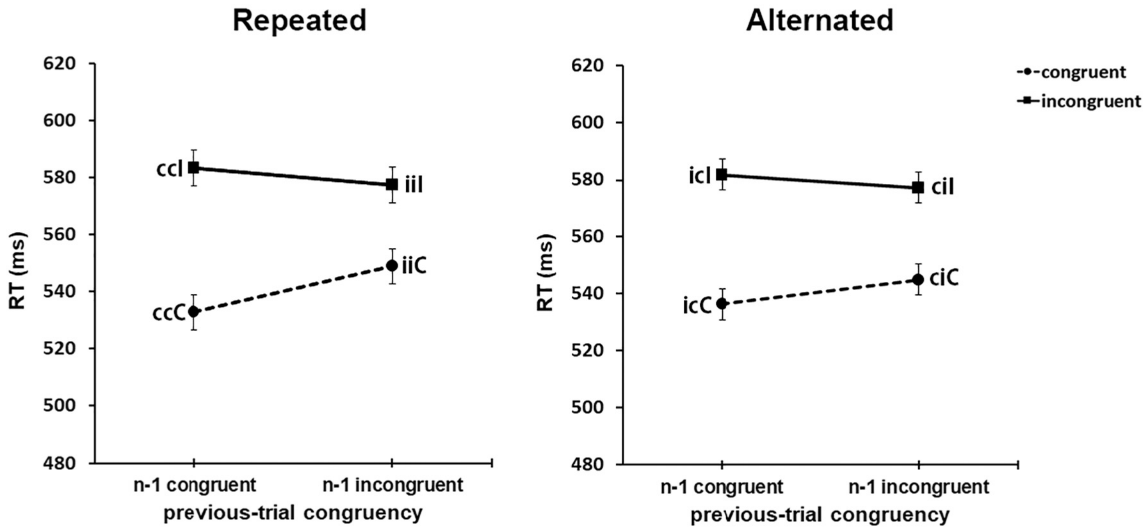
.377, $MSE = 108$, $\eta^2_p = 0.05$.

No other main or interaction term was significant, $Fs < 2.85$, $ps > 0.102$, except the interaction of previous-trial congruency and preceding congruency repetition type, $F(1, 30) = 5.67$, $p = .024$, $MSE = 120$, $\eta^2_p = 0.16$. Previous-trial congruency was significant after congruency alternation trials, $F(1, 15) = 6.36$, $p = .017$, $MSE = 208$, $\eta^2_p = 0.3$, but not after congruency repetition trials, $F(1, 15) < 1$, $p = .961$, $MSE = 137$. The mean RT was shorter after congruent trials (518 ms) than after incongruent trials (525 ms) when the congruency of the preceding trial was alternated.

3.2. *Lim and Cho's (2018) Experiment 2*

The main effect of current-trial congruency was significant, $F(1, 62) = 147.94$, $p < .001$, $MSE = 965$, $\eta^2_p = 0.7$, indicating a 34-ms congruency effect. The interaction of current trial and response mode was significant, $F(1, 62) = 4.78$, $p = .033$, $MSE = 965$, $\eta^2_p = 0.07$. The congruency effect was larger when the two tasks were performed with the same response mode (39 ms), $F(1,31) = 94.77$, $p < .001$, $MSE = 1048$, $\eta^2_p = 0.75$, than when they were performed with different response modes (28 ms), $F(1, 31) = 54.48$, $p < .001$, $MSE = 881$, $\eta^2_p = 0.64$. The interaction of current-trial congruency and previous-trial congruency was significant, $F(1, 62) = 8.88$, $p = .004$, $MSE = 319$, $\eta^2_p = 0.13$. The congruency effect was 39 ms after congruent trials, $F(1, 62) = 156.24$, $p < .001$, $MSE = 594$, $\eta^2_p = 0.72$, which was reduced to 29 ms after incongruent trials, $F(1, 62) = 76.44$, $p = .004$, $MSE = 689$, $\eta^2_p = 0.55$. The three-way interaction of current-trial congruency, previous-trial congruency, and preceding congruency repetition type was

a) Same Mode



b) Different Mode

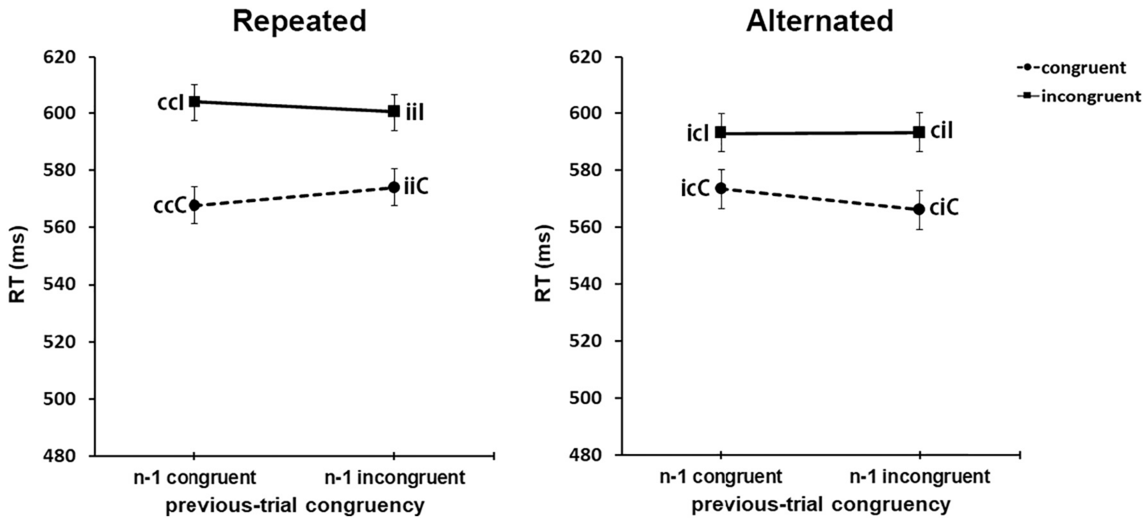


Fig. 3. Results of Lim and Cho's (2018) Experiment 2. a) The mean RT as a function of previous-trial congruency and current trial congruency on trials preceded by congruency repetition (left panel) and congruency alternation trials (right panel) when the two tasks were performed with the same response mode. b) The mean RT as a function of previous-trial congruency and current trial congruency on trials preceded by congruency repetition (left panel) and congruency alternation trials (right panel) when the two tasks were performed with different response modes. The error bars indicate the 95% confidence interval around the mean (Loftus & Masson, 1994).

significant, $F(1, 62) = 4.94$, $p = .03$ $MSE = 279$, $\eta^2_p = 0.07$. The interaction of current-trial congruency and previous-trial congruency was significant after congruent repetition trials, $F(1, 62) = 13.19$, $p < .001$, $MSE = 310$, $\eta^2_p = 0.18$, but not after congruency alternation trials, $F(1, 62) < 1$, $p = .505$, $MSE = 289$. The magnitude of the congruency effect was larger after congruent trials (44 ms), $F(1, 62) = 149.02$, $p < .001$, $MSE = 406$, $\eta^2_p = 0.71$, than after incongruent trials (28 ms), $F(1, 62) = 48.59$, $p < .001$, $MSE = 498$, $\eta^2_p = 0.44$, on trials preceded by a congruency repetition trial, but it was similar after congruent trials (33 ms), $F(1, 62) = 80.15$, $p < .001$, $MSE = 427$, $\eta^2_p = 0.56$, and incongruent trials (30 ms), $F(1, 62) = 61.86$, $p < .001$, $MSE = 461$, $\eta^2_p = 0.5$, on trials preceded by a congruency alternation trial. The interaction of current-trial congruency, previous-trial congruency, and response mode was significant, $F(1, 62) = 6.71$, $p = .012$, $MSE = 319$, $\eta^2_p = 0.1$. For further examination of the modulation of the CSE by response mode, separate analyses for each response mode were conducted as a function of previous-trial congruency, current-trial congruency and preceding congruency repetition type as within-subject variables (see Fig. 3).

When the two tasks were performed with the same response mode, the main effect of current-trial congruency was significant, $F(1, 31) = 94.77$, $p < .001$, $MSE = 1048$, $\eta^2_p = 0.75$, indicating a 39-ms flanker-compatibility effect. The interaction of current-trial congruency and previous-trial congruency was also significant, $F(1, 31) = 19.42$, $p < .001$, $MSE = 255$, $\eta^2_p = 0.39$. The magnitude of the flanker-compatibility effect was greater after congruent trials (49 ms), $F(1, 31) = 153.33$, $p < .001$, $MSE = 485$, $\eta^2_p = 0.83$, than after incongruent trials (30 ms), $F(1, 31) = 36.62$, $p < .001$, $MSE = 185$, $\eta^2_p = 0.54$. However, this cross-task CSE was not modulated by preceding congruency repetition type, $F(1, 31) = 1.25$, $p = .271$, $MSE = 262$.

When the two tasks were performed with different response modes, the main effect of current-trial congruency was significant, $F(1, 31) = 54.48$, $p < .001$, $MSE = 881$, $\eta^2_p = 0.64$, indicating a 28-ms flanker-compatibility effect. No significant interaction of current-trial congruency and previous-trial congruency was obtained, $F(1, 31) < 1$, $p = .803$, $MSE = 383$. The three-way interaction of current-trial congruency, previous-trial congruency, and preceding congruency repetition type was marginally significant, $F(1, 31) = 3.98$, $p = .055$, $MSE = 297$, $\eta^2_p = 0.11$. The interaction of current-trial congruency and previous-trial congruency was not significant either after congruency repetition trials, $F(1, 31) = 2.37$, $p = .134$, $MSE = 326$, $\eta^2_p = 0.07$, or after congruency alternation trials, $F(1, 31) = 1.23$, $p = .277$, $MSE = 354$, $\eta^2_p = 0.04$. However, the magnitude of the flanker-compatibility effect was smaller after incongruent trials (27 ms), $F(1, 31) = 29.05$, $p < .001$, $MSE = 383$, $\eta^2_p = 0.48$, than after congruent trials (36 ms), $F(1, 31) = 45.14$, $p < .001$, $MSE = 464$, $\eta^2_p = 0.59$, when the congruency of the preceding trial was repeated, showing a tendency of the typical pattern of the CSE. On the other hand, it was larger after incongruent trials (27 ms), $F(1, 31) = 22.18$, $p < .001$, $MSE = 533$, $\eta^2_p = 0.42$, than after congruent trials (20 ms), $F(1, 31) = 13.31$, $p = .001$, $MSE = 473$, $\eta^2_p = 0.3$, when the congruency of the preceding trial was alternated, demonstrating a reversed pattern of the CSE.

No other main or interaction term was significant, $Fs < 2.87$, $ps > 0.955$.

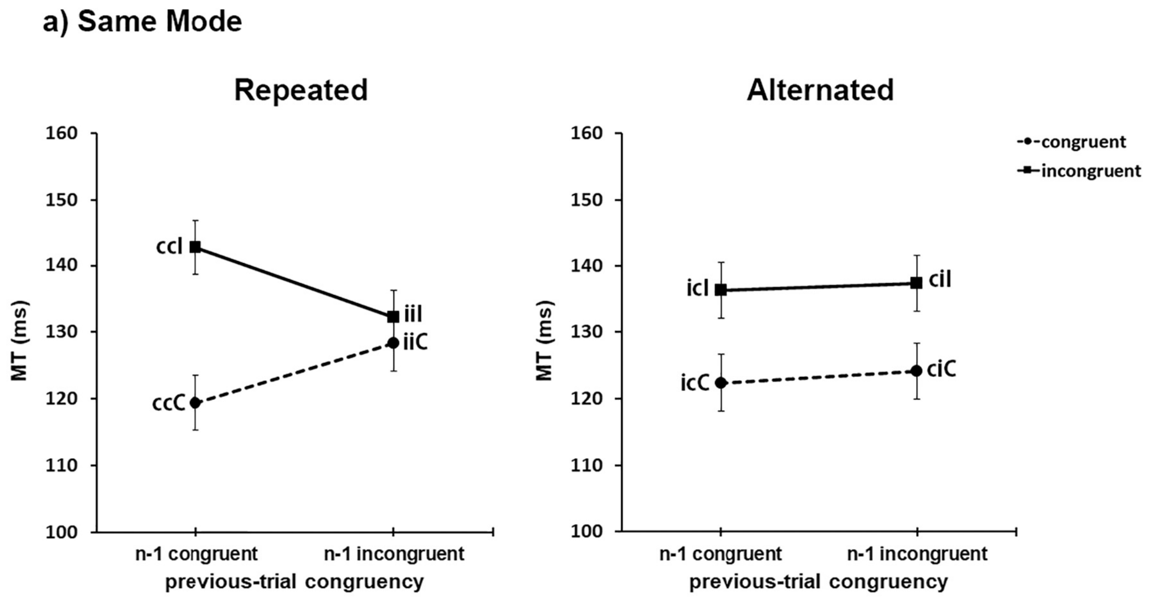
3.3. Lim and Cho's (2020) Experiment 1

In this and the following experiments, initiation time (IT), which is the temporal interval between the onset of the target stimulus and the moment when the home key was released, and MT, which is the temporal interval between the moment when the home key was released and the moment a directional key was pressed, were measured separately. However, in the present study, we analyzed only MT data because no cross-task CSE was obtained in the IT data.

The main effect of current-trial congruency was significant, $F(1, 30) = 33.55$, $p < .001$, $MSE = 206$, $\eta^2_p = 0.53$, indicating a significant 10 ms congruency effect. The congruency effect tended to be larger when the two tasks were performed with the same response mode (13 ms) than with different response modes (7 ms), but the interaction of current trial congruency with response mode was not significant, $F(1, 30) = 3.21$, $p = .083$, $MSE = 206$. The interaction of current-trial congruency and previous-trial congruency was significant, $F(1, 30) = 6.78$, $p = .014$, $MSE = 68$, $\eta^2_p = 0.18$. The magnitude of the congruency effect was smaller after incongruent trials (8 ms), $F(1, 30) = 16.19$, $p < .001$, $MSE = 117$, $\eta^2_p = 0.35$, than after congruent trials (13 ms), $F(1, 30) = 34.82$, $p < .001$, $MSE = 157$, $\eta^2_p = 0.54$. This sequential modulation interacted with preceding congruency repetition type, $F(1, 30) = 37.13$, $p < .001$, $MSE = 47$, $\eta^2_p = 0.55$. The typical pattern of the CSE was observed after congruency repetition trials, $F(1, 30) = 29.94$, $p < .001$, $MSE = 67$, $\eta^2_p = 0.5$, and the reversed pattern of the CSE was found after congruency alternation trials, $F(1, 30) = 4.22$, $p = .049$, $MSE = 49$, $\eta^2_p = 0.12$. The congruency effect was smaller after incongruent trials (2 ms), $F(1, 30) = 2.73$, $p < .109$, $MSE = 41$, than after congruent trials (18 ms), $F(1, 30) = 49.71$, $p < .001$, $MSE = 110$, $\eta^2_p = 0.62$, on trials preceded by a congruency repetition trial, whereas the congruency effect after congruent trials (7 ms), $F(1, 30) = 11.98$, $p = .002$, $MSE = 79$, $\eta^2_p = 0.29$, was smaller than the effect after incongruent trials (12 ms), $F(1, 30) = 21.34$, $p < .001$, $MSE = 121$, $\eta^2_p = 0.42$, on trials preceded by a congruency alternation trial. The four-way interaction of response mode, current-trial congruency, previous-trial congruency, and preceding congruency repetition type was not significant, $F(1, 30) < 1$, $p = .562$, $MSE = 47$. The three-way interaction of current-trial congruency, previous-trial congruency and response mode was significant, $F(1, 30) = 5.09$, $p = .032$, $MSE = 68$, $\eta^2_p = 0.15$. To examine these three-way interactions further, additional repeated ANOVAs for each response mode were conducted with previous-trial congruency, current-trial congruency and preceding congruency repetition type as within-subject variables (see Fig. 4).

When the horizontal and vertical Simon tasks were performed with the same response mode, the main effect of current-trial congruency was significant, $F(1, 15) = 20.79$, $p < .001$, $MSE = 285$, $\eta^2_p = 0.58$. The mean MT was greater on incongruent trials ($M = 137$) than congruent trials ($M = 124$). The interaction of current-trial congruency and previous-trial congruency was also significant, $F(1, 15) = 9.68$, $p = .007$, $MSE = 83$, $\eta^2_p = 0.4$. The Simon effect was greater after congruent trials (19 ms), $F(1, 15) = 33.47$, $p < .001$, $MSE = 166$, $\eta^2_p = 0.69$, than after incongruent trials (9 ms), $F(1, 15) = 5.82$, $p = .029$, $MSE = 202$, $\eta^2_p = 0.28$. Importantly, the three-way interaction of current-trial congruency, previous-trial congruency, and preceding congruency repetition type was significant, $F(1, 15) = 18.23$, $p < .001$, $MSE = 39$, $\eta^2_p = 0.55$. Separate analyses showed that the interaction of current-trial congruency and previous-trial congruency was significant after congruency repetition trials, $F(1, 15) = 25.39$, $p < .001$, $MSE = 60$, $\eta^2_p = 0.63$, but not after congruency alternation trials, $F(1, 15) < 1$, $p = .879$, $MSE = 63$, $\eta^2_p = 0.0016$. When the previous trial was a congruency repetition trial, the Simon effect was significantly evident after congruent trials (24 ms), $F(1, 15) = 36.97$, $p < .001$, $MSE = 118$, $\eta^2_p = 0.71$, but not after incongruent trials (4 ms), $F(1, 15) = 2.38$, $p = .144$, $MSE = 50$. When the previous trial was a congruency alternation trial, a 14-ms Simon effect was obtained after congruent trials $F(1, 15) = 23.65$, $p < .001$, $MSE = 65$, $\eta^2_p = 0.61$, and incongruent trials, $F(1, 15) = 6.92$, $p = .019$, $MSE = 204$, $\eta^2_p = 0.32$.

When the two tasks were performed with different response modes, the main effect of current-trial congruency was significant, $F(1, 15) = 12.97$, $p = .003$, $MSE = 127$, $\eta^2_p = 0.46$. The mean MT was greater on incongruent trials ($M = 135$ ms) than congruent trials ($M = 128$ ms). However, no significant cross-task CSE was obtained, $F(1, 15) < 1$, $p = .785$, $MSE = 53$, $\eta^2_p < 0.01$. Importantly, the three-way interaction of current-trial congruency, previous-trial congruency, and preceding congruency repetition type was significant, $F(1, 15) = 19.1$, $p = .001$, $MSE = 55$, $\eta^2_p = 0.56$. Separate analyses showed that the interaction of current-trial congruency and previous-trial congruency was significant after both congruency repetition trials, $F(1, 15) = 8$, $p = .013$, $MSE = 74$, $\eta^2_p = 0.35$, and congruency alternation trials, $F(1, 15) = 13.42$, $p = .002$,



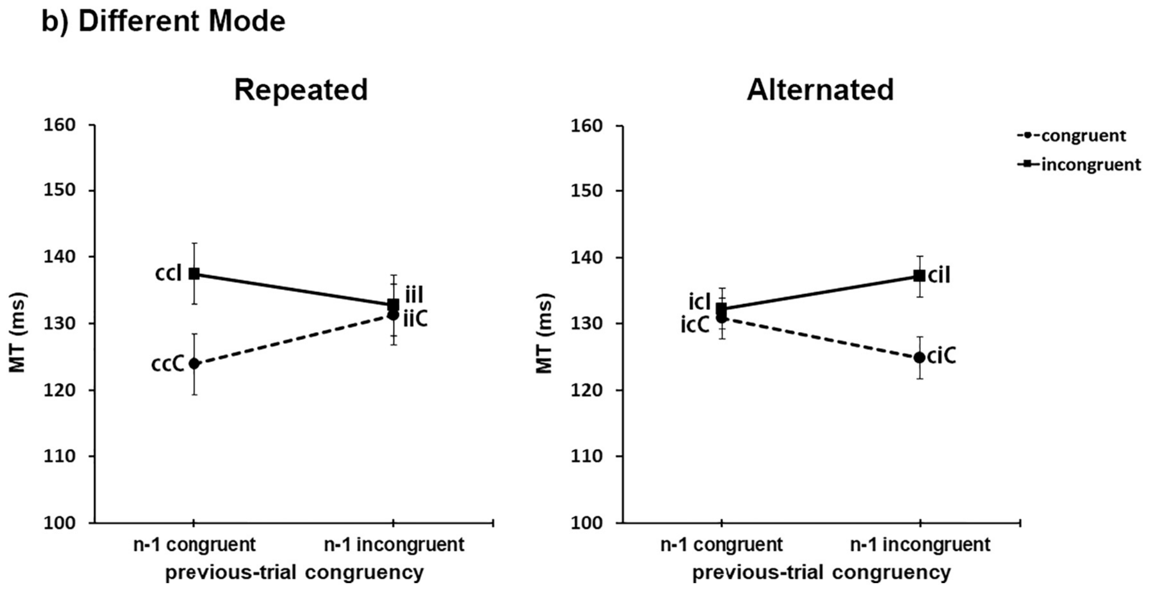


Fig. 4. Results of Lim and Cho's (2020) Experiment 1. a) The mean MT as a function of previous-trial congruency and current trial congruency on trials preceded by congruency repetition (left panel) and congruency alternation trials (right panel) when the two tasks were performed with the same response mode. b) The mean MT as a function of previous-trial congruency and current trial congruency on trials preceded by congruency repetition (left panel) and congruency alternation trials (right panel) when the two tasks were performed with different response modes. The error bars indicate the 95% confidence interval around the mean (Loftus & Masson, 1994).

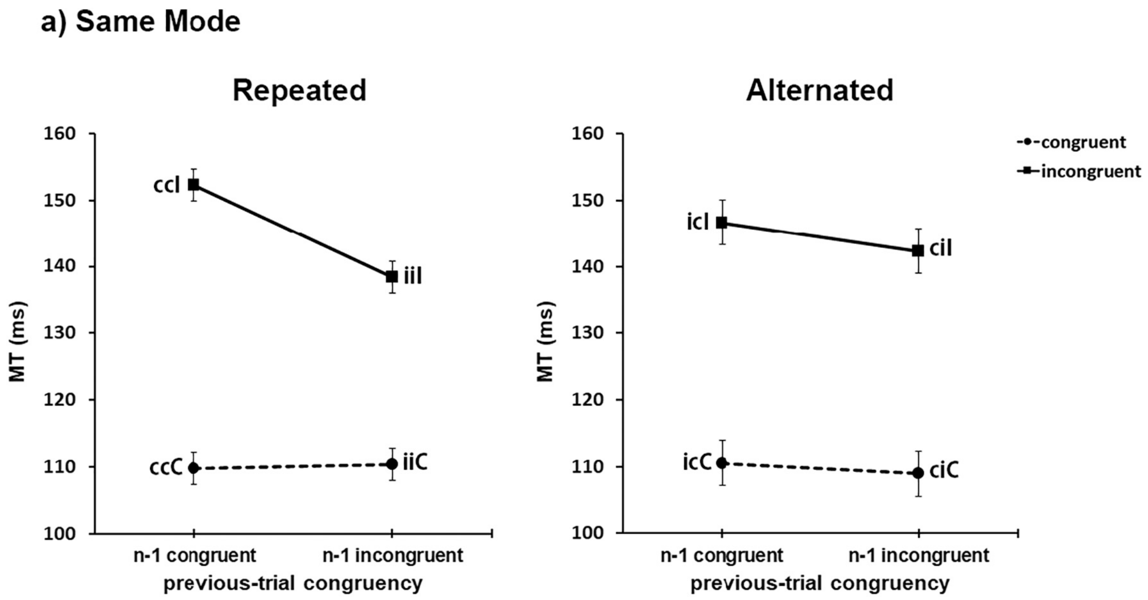
MSE = 34, η^2_p = 0.47. However, the pattern of this interaction was opposite each other. The magnitude of the Simon effect was smaller after incongruent trials (2 ms), *F*(1, 15) < 1, *p* = .486, *MSE* = 32, than congruent trials (14 ms), *F*(1, 15) = 14.54, *p* = .002, *MSE* = 102, η^2_p = 0.49, when the previous trial was a congruency repetition trial, whereas it was greater after incongruent trials (12 ms), *F*(1, 15) = 29.97, *p* < .001, *MSE* = 40, η^2_p = 0.67, than congruent trials (2 ms), *F*(1, 15) < 1, *p* = .669, *MSE* = 93, when it was a congruency alternation trial. No other term was significant, *F*s < 1, *p*s > 0.379.

No other main effect or interaction was significant, *F*s < 1.2 *p*s > 0.282.

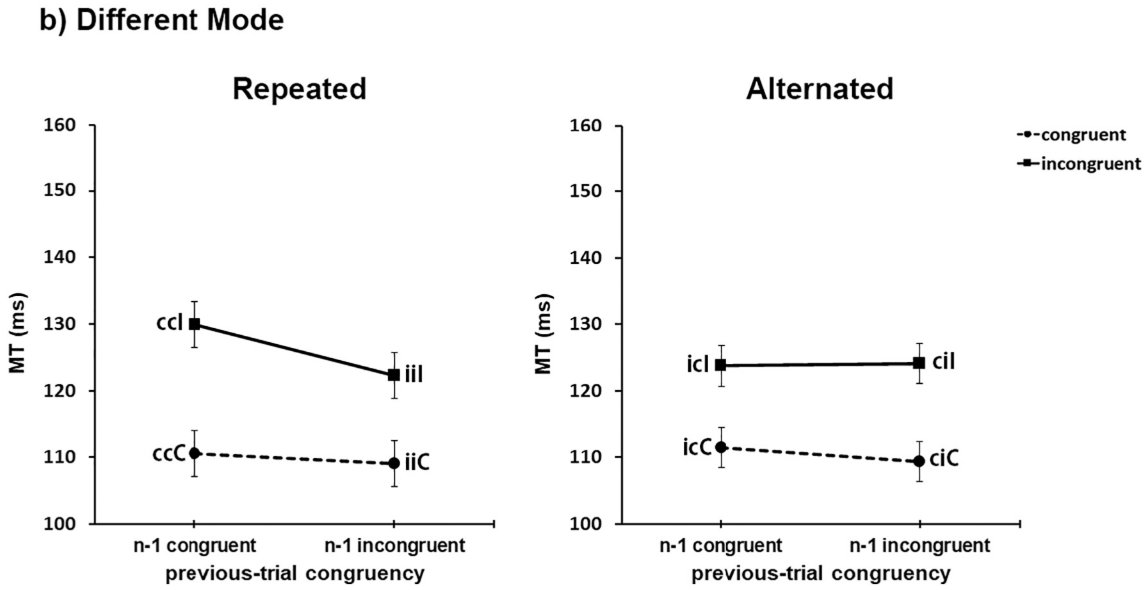
3.4. Lim and Cho's (2020) Experiment 3

The main effect of previous-trial congruency was significant, *F*(1, 30) = 26.14, *p* < .001, *MSE* = 25, η^2_p = 0.47. The mean MT was shorter after incongruent trials (*M* = 121 ms) than after congruent trials (*M* = 124 ms). The interaction of previous-trial congruency and preceding congruency repetition type was also significant, *F*(1, 30) = 13.43, *p* = .001, *MSE* = 17, η^2_p = 0.31. The mean MT was shorter after incongruent trials (*M* = 120 ms) than after congruent trials (*M* = 126 ms) when preceded by congruency repetition trials, *F*(1, 30) = 33.33, *p* < .001, *MSE* = 30, η^2_p = 0.53. Following congruency alternation trials, the mean MT was also shorter after incongruent trials (*M* = 123) than after congruent ones (M = 121 ms), *F*(1, 30) = 5.51, *p* = .026, *MSE* = 21, η^2_p = 0.16.

A 25-ms significant congruency effect was obtained, indicated by the main effect of current-trial congruency, $F(1, 30) = 60.32$, $p < .001$, $MSE = 660$, $\eta^2_p = 0.67$. Although the congruency effect tended to be larger after congruency repetition trials (26 ms) than after congruency alternation trials (24 ms), the interaction of current-trial congruency and preceding congruency repetition type was not significant, $F(1, 30) = 3.27$, $p = .081$, $MSE = 13$. The interaction of current-trial congruency and response mode was significant, $F(1, 30) = 9.82$, $p = .004$, $MSE = 660$, $\eta^2_p = 0.25$. The magnitude of the flanker-compatibility effect was larger when the two tasks were performed with the same response mode (35 ms), $F(1, 15) = 48.15$, $p < .0001$, $MSE = 814$, $\eta^2_p = 0.76$, than with different response modes (15 ms), $F(1, 15) = 14.01$, $p = .002$, $MSE = 505$, $\eta^2_p = 0.48$. The interaction of previous-trial congruency and current-trial congruency was significant, $F(1, 30) = 10.87$, $p = .003$, $MSE = 42$, $\eta^2_p = 0.27$. The congruency effect was larger after congruent trials (27 ms), $F(1, 30) = 57.63$, $p < .001$, $MSE = 423$, $\eta^2_p = 0.66$, than after incongruent trials (23 ms), $F(1, 30) = 57.02$, $p < .001$, $MSE = 278$, $\eta^2_p = 0.66$. The three-way interaction of current-trial congruency, previous-trial congruency and preceding congruency repetition type was significant, $F(1, 30) = 16.39$, $p < .001$, $MSE = 23$, $\eta^2_p = 0.35$. The interaction of current-trial congruency and previous-trial congruency was significant after congruence repetition trials, $F(1, 30) = 28.3$, $p < .001$, $MSE = 31$, $\eta^2_p = 0.49$, but not after congruency alternation trials, $F(1, 30) < 1$, $p = .92$, $MSE = 36$. The magnitude of the flanker-compatibility effect was smaller after incongruent trials (20 ms), $F(1, 30) = 55.65$, $p < .001$, $MSE = 121$, $\eta^2_p = 0.65$, than after congruent trials (31 ms), $F(1, 30) = 60.35$, $p < .001$, $MSE = 254$, $\eta^2_p = 0.67$, on trials preceded by a congruency repetition trial. However, the magnitude of



a) Same Mode



b) Different Mode

Fig. 5. Results of Lim and Cho's (2020) Experiment 3. a) The mean MT as a function of previous-trial congruency and current trial congruency on trials preceded by congruency repetition (left panel) and congruency alternation trials (right panel) when the two tasks were performed with the same response mode. b) The mean MT as a function of previous-trial congruency and current trial congruency on trials preceded by congruency repetition (left panel) and congruency alternation trials (right panel) when the two tasks were performed with different response modes. The error bars indicate the 95% confidence interval around the mean (Loftus & Masson, 1994).

the congruency effect after incongruent trials (24 ms), $F(1, 30) = 53.25$, $p < .001$, $MSE = 173$, $\eta^2_p = 0.64$, was similar to the effect after congruent trials (24 ms), $F(1, 30) = 49.06$, $p < .001$, $MSE = 191$, $\eta^2_p = 0.62$, on trials preceded by a congruency alternation trial. The three-way interaction of current-trial congruency, previous-trial congruency, and response mode was significant, $F(1, 30) = 4.29$, $p = .047$, $MSE = 42$, $\eta^2_p = 0.13$.

To examine the sequential modulation further, three-way repeated ANOVAs for each response mode were conducted on the MT data with previous-trial congruency, current-trial congruency and preceding congruency repetition type as within-subject variables (see Fig. 5). For the same response mode, the main effect of current-trial congruency was significant, $F(1, 15) = 48.15$, $p < .001$, $MSE = 814$, $\eta^2_p = 0.76$, as the mean MT was greater on incongruent trials ($M = 145$ ms) than congruent trials ($M = 110$ ms). The interaction of current-trial congruency and previous-trial congruency was significant, $F(1, 15) = 18.88$, $p < .001$, $MSE = 32$, $\eta^2_p = 0.56$. A smaller flanker-compatibility effect was obtained after incongruent trials (30 ms), $F(1, 15) = 39.45$, $p < .001$, $MSE = 192$, $\eta^2_p = 0.72$, than after congruent trials (40 ms), $F(1, 15) = 52.95$, $p < .001$, $MSE = 233$, $\eta^2_p = 0.78$. Importantly, the three-way interaction of current-trial congruency, previous-trial congruency, and preceding congruency repetition type was significant, $F(1, 15) = 9.7$, $p = .007$, $MSE = 28$, $\eta^2_p = 0.39$. The interaction of current-trial congruency and previous-trial congruency was evident after congruency repetition trials, $F(1, 15) = 42.82$, $p < .001$, $MSE = 20$, $\eta^2_p = 0.74$. The magnitude of the arrow flanker-compatibility effect was smaller after incongruent trials (28 ms), $F(1, 15) = 38.3$, $p < .001$, $MSE = 164$, $\eta^2_p = 0.72$, than after congruent trials (42 ms), $F(1, 15) = 63.15$, $p < .001$, $MSE = 229$, $\eta^2_p = 0.81$. However, this cross-task CSE was not significant after congruency alternation trials, $F(1, 15) < 1$, $p = .382$, $MSE = 40$, $\eta^2_p = 0.05$. The magnitude of the congruency effect was 33 ms after incongruent trials, $F(1, 15) = 36.42$, $p < .001$, $MSE = 244$, $\eta^2_p = 0.71$, and 37 ms after congruent trials, $F(1, 15) = 41.96$, $p < .001$, $MSE = 249$, $\eta^2_p = 0.74$.

For different response modes, the main effect of current-trial congruency was significant, $F(1, 15) = 14.01$, $p = .002$, $MSE = 505$, $\eta^2_p = 0.48$. The mean RT was shorter on congruent trials ($M = 110$ ms) than incongruent trials ($M = 125$ ms). The congruency effect was not modulated by previous-trial congruency, $F(1, 15) < 1$, $p = .448$, $MSE = 52$, $\eta^2_p = 0.04$. The three-way interaction of current-trial congruency, previous-trial congruency, and preceding congruency repetition type was significant, $F(1, 15) = 6.72$, $p = .02$, $MSE = 23$, $\eta^2_p = 0.31$. Separate analyses showed that the interaction of current-trial congruency and previous-trial congruency was marginally significant after congruent repetition trials, $F(1, 15) = 3.88$, $p = .068$, $MSE = 42$, $\eta^2_p = 0.21$ but not after congruent alternation trials, $F(1, 15) < 1$, $p = .411$, $MSE = 33$, $\eta^2_p = 0.05$. A smaller congruency effect was obtained after incongruent trials (13 ms), $F(1, 15) = 17.35$, $p = .001$, $MSE = 79$, $\eta^2_p = 0.54$, than after congruent trials (19 ms), $F(1, 15) = 10.8$, $p = .005$, $MSE = 280$, $\eta^2_p = 0.42$, on trials preceded by a congruency repetition trial, while a similar magnitude of the congruency effect was obtained after incongruent (15 ms), $F(1, 15) = 16.86$, $p = .001$, $MSE = 103$, $\eta^2_p = 0.53$, and congruent trials (13 ms), $F(1, 15) = 9.05$, $p = .009$, $MSE = 133$, $\eta^2_p = 0.38$, on trials preceded by a congruency alternation trial.

No other main or interaction term was significant, $Fs < 2.01$, $ps > 0.167$.

4. Discussion

Erb and Aschenbrenner (2019) proposed a possibility that the feature integration from n-2 trial and/or multiple expectancy influence the CSE obtained with the confound-minimized cross-task design. To examine this possibility, we reanalyzed the data of our previous experiments in which the cross-task CSE was evident in one condition (e.g., non-arbitrary S-R mapping or same response mode) and not in the other condition (e.g., arbitrary S-R mapping or different response modes). If the cross-task CSE between current and previous trials was due to multiple expectancies or a lingering effect of feature integration from n-2 trials, as Erb and Aschenbrenner suggested, the cross-task CSE should have been dependent on multiple expectancies or feature integration but not on the task feature (i.e., arbitrariness of S-R mapping and response mode) modulating the scope of top-down control triggered by conflict.

In all experiments, the sequential modulation significantly interacted with S-R mapping or response mode, as expected and planned. The cross-task CSE was obtained with non-arbitrary S-R mappings or the same response mode, but not with arbitrary S-R mappings or different response modes. Lim and Cho (2018, 2020) attributed these cross-task CSEs to local top-down control processes, whose scope is determined by response mode or the arbitrariness of S-R mapping. Importantly, the three-way interaction of current-trial congruency, previous-trial congruency, and preceding congruency repetition type was also significant regardless of S-R mappings or response mode in all experiments. The sequential modulation between previous and current trials was significant after congruency repetition trials in all experiments, while it was not after congruency alternation trials in all but Lim and Cho's (2020) Experiment 1, in which its magnitude was larger after incongruent trials (12 ms) than after congruent trials (7 ms) when preceded by a congruency alternation trial. These results are inconsistent with the idea that the CSE obtained with the confound-minimized cross-task design was due to multiple expectancies about the congruency and the congruency repetition type of the upcoming trial (Erb & Aschenbrenner, 2019).

To test whether multiple expectancy or feature integration contributed to the sequential modulation between previous and current trials, the effect of the previous congruency-repetition type was examined separately for the conditions in which the cross-task CSE was obtained and the conditions in which the cross-task CSE was absent. For the former conditions, the preceding congruency repetition type significantly modulated the cross-task CSE in Lim and Cho's (2020) two experiments but not in Lim and Cho's (2018) two experiments. The sequential modulation between previous and current trials was evident after congruency repetition trials in all experiments, which was not evident after congruency alternation trials in Lim and Cho's (2018) Experiment 1 and Lim and Cho's (2020) Experiments 1 and 3, as in the previous studies (Erb & Aschenbrenner, 2019).

However, for the conditions in which the conflict-driven CSE was not evident, the sequential modulation of previous and current trials interacted with preceding congruency repetition type. The congruency repetition type of the preceding trial significantly modulated the sequential modulation in Lim and Cho's (2020) two experiments and marginally modulated the sequential modulation in Lim and Cho's (2018) two experiments. Specifically, the typical pattern of the CSEs was found when preceded by congruency repetition trials, but the reverse pattern of CSEs was found when preceded by congruency alternation trials. For example, in Lim and Cho's (2020) Experiment 1, the magnitude of the congruency effect was significantly larger after congruent trials (14 ms) than after incongruent trials (2 ms) on trials preceded by a congruency repetition trial while it was significantly smaller after congruent trials (2 ms) than after incongruent trials (12 ms) on trials preceded by a congruency alternation trial.

These results are consistent with the prediction drawn from the feature integration theory (Hommel et al., 2004) but not with that drawn from the multiple expectancy account (Erb & Aschenbrenner, 2019). If the sequential modulation was attributed to multiple expectancies about the congruency and the congruency repetition type of the upcoming trial, the multiple expectancy account should have explained why the reversed CSE was obtained after congruency alternation trials when two tasks had different response modes or arbitrary S-R mappings. Also, the multiple expectancy account cannot explain why the cross-task CSE was evident with non-arbitrary S-R mappings or same response mode but not with arbitrary S-R mappings or different response modes, because those two task features determined the scope of control without influencing expectations of the congruency and preceding congruency repetition types.

One may argue that the CSE was more pronounced after congruency repetition trials because of a cumulative effect of several congruency repetition trials. However, when we excluded the trials preceded by more than two congruency repetitions (e.g., cccC or iiiI trials) and tested whether the CSE remained significant in congruency repetition condition for each experiment, the CSEs still reached or approached to significance when two tasks shared the same response mode or non-arbitrary S-R mappings in Lim and Cho's (2018) Experiment 1, $F(1, 15) = 16.32$, $p = .001$, $MSE = 48$, $\eta^2_p = 0.52$, Experiment 2, $F(1, 31) = 16.57$, $p < .001$, $MSE = 416$, $\eta^2_p = 0.35$, and Lim and Cho's (2020) Experiment 1, $F(1, 15) = 4.29$, $p = .056$, $MSE = 107$, $\eta^2_p = 0.22$, but not only in Lim and Cho's (2020) Experiment 3, $F(1, 15) = 0.78$, $p = .39$, $MSE = 62$, $\eta^2_p = 0.05$. It is possible that the absence of the CSE in the latter experiment might evidence the contribution of expectancy accumulated by several congruency repetitions. However, excluding repeated trials might have reduced the statistical power to observe the CSE (Schmidt & Weissman, 2014). Moreover, the significant CSEs found in the other experiments corroborate the evidence that the multiple expectancy is not the sole factor generating the sequential modulation of the congruency effect.

In a similar vein, Spinelli, Perry, and Lupker (2019) found a reversed pattern of the CSE when the expectancy generated by previous-trial congruency did not match with the general expectancy based on congruency proportion. Given that those two types of expectancies have independent influences on participants' expectations of the upcoming trial's congruency, the multiple expectancy account predicts the CSE only when previous-trial congruency matches the dominantly-presented congruency. Accordingly, it predicts no sequential modulation when comparing the congruency effect after congruent trials from a dominantly-incongruent list, where participants have a general expectation for incongruent trials, and the congruency effect after incongruent trials from a dominantly-congruent list, where congruent trials are expected to follow. However, when comparing those two congruency effects, Spinelli and his colleagues found a reversed CSE,[2] as a 263-ms congruency effect was evident after congruent trials from the dominantly-incongruent list, while a 313-ms congruency effect after incongruent trials from the dominantly-congruent list. It is difficult to reconcile this finding with the multiple expectancy account.

Our findings that the sequential modulation was not significant after congruency alternation trials suggest that the feature integration from n-2 trial had a lingering effect on this sequential modulation. However, the numerical pattern of the CSEs cannot be fully explained by the feature repetition account alone. According to the feature repetition account, the typical pattern of CSE should be observed after congruency repetition trials and the reversed pattern of CSE after congruency alternation trials, which is not consistent with the current findings. Rather, the results are consistent with the idea that top-down cognitive control and bottom-up feature integration operate independently to modulate the congruency effect (e.g. Weissman, Hawks, & Egner, 2016). In the conditions when the cross-task CSE was obtained, the effects of both top-down cognitive control and bottom-up feature integration occurred when preceded by a congruency repetition trial, resulting in larger CSEs, while these effects canceled each other out on trials preceded by a congruency alternation trial, resulting in a weaker CSE. On the contrary, in the condition when the conflict-driven CSE was absent, only bottom-up feature integration caused a typical pattern of the sequential modulation between previous and current trials after congruency repetition trials but evidenced a reversed pattern of the sequential modulation between them after congruency alternation trials.

Furthermore, it is important to note that the effect of n-2 trial's feature integration is minimized on the cross-task CSE when the datasets of congruency repetition and congruency alternation are analyzed together. This minimization is because partial repetitions occur in ccI and iiC sequence types when congruency is repeated, but they occur in icC and ciI sequence types when congruency is alternated. Thus, when the datasets are combined, partial repetitions from n-2 trials equally occur in cC, cI, iC, and iI sequence types, having no substantial and systematic influence on the cross-task CSE. Indeed, when we conducted additional analyses where preceding congruency repetition type factor was replaced with feature repetition type factor (partial repetition vs. complete repetition/alternation) in order to directly test whether the feature repetition from n-2 trials influenced the CSE, the interaction of previous-trial congruency and current-trial congruency was not modulated by feature repetition type in all experiments, $Fs < 2.79$, $ps > 0.1$. However, separate analyses depending on congruency repetition were of importance in that they dissociated the sequential modulation caused by previous trial's conflict from that caused by n-2 feature repetitions, especially when congruency alternated on the preceding trial. Furthermore, they showed that top-down sequential modulation did occur between previous and current trials, apart from the feature integration confounds from n-2 trial. Consistent with our previous findings, these additional analyses corroborate the evidence that the CSE obtained between previous and current trials in the confound-minimized cross-task design was indeed engendered by the top-down control mechanism, independently of feature integration.

4.1. No modulation of the cross-task CSE by lingering priming effects from response repetition

Response repetition is not directly related to feature integration because response repetition trials are either partial repetition or complete repetition trials while response alternation trials are either partial repetition or complete alternation trials. However, Erb and Aschenbrenner (2019) concluded that the cross-task CSE between previous and current trials obtained with the confound-minimized cross-task design is confounded with lingering repetition priming between n-2 and current trials based on the findings that in five out of eight experiments, no CSE was obtained on response alternation trials. Some other studies also showed that the CSE was obtained only on response repetition trials, but not on response alternation trials (e.g., Mayr et al., 2003; Nieuwenhuis et al., 2006).

However, Akçay and Hazeltine (2008) demonstrated significant sequential modulation of the congruency effect after eliminating response repetitions trials, and Notebaert and Verguts (2007) found a significant CSE after controlling the effects of bottom-up factors, including response repetition, by using multiple regression. Also, when additional ANOVAs were conducted on the RT data of Lim and Cho's (2018) Experiments 1 and 2 and the MT data of Lim and Cho's (2020) Experiments 1 and 3 with previous-trial congruency, current-trial congruency and response repetition (repetition vs. alternation) as within-subject variables and S-R mapping or response mode as a between-subject variable, neither the three-way interaction of previous-trial congruency, current-trial congruency, and response repetition, $Fs < 2.57$, $ps > 0.119$, nor the four-way interaction of previous-trial congruency, current-trial congruency, response repetition, and S-R mapping or response mode, $Fs < 1.2$, $ps > 0.283$, was significant in all experiments. These results indicate that lingering repetition priming does not necessarily modulate the cross-task CSE due to response repetition.

4.2. Contributions of multiple mechanisms to the sequential modulation of congruency effects

Since Gratton et al. (1992) first demonstrated that the congruency effect is modulated by the congruency of the preceding trial, many explanations have been given for the CSE. Different accounts suggest different levels of the boundary where the sequential modulation can

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[2] Even though the statistical result of this comparison was not reported in Spinelli et al. (2019), according to one of its authors, who reviewed this paper, the reversed CSE reached significance.

occur between two consecutive trials. For example, the feature integration theory posits that sequential modulation occurs between two trials sharing stimulus and response features. Top-down control explanations postulate that the CSE can occur between two tasks sharing some task features, such as task representation, (e.g., Akçay & Hazeltine, 2008) conflict type (e.g., Egner et al., 2007), stimulus dimensions (e.g., Verguts & Notebaert, 2008, 2009; Weissman, 2020), or response dimensions (e.g., Kim, Lee, & Cho, 2015). On the other hand, the multiple expectancy account suggests that the CSE occurs because the current congruency matches with participant's expectations based on the congruency and congruency repetition type of the preceding trial (Erb & Aschenbrenner, 2019) that are not specific to any task feature.

However, although the boundary of cognitive control remains an open issue, most studies have shown that the CSE occurs between two tasks sharing a common task feature (e.g., Braem, Abrahamse, Duthoo, & Notebaert, 2014; Funes, Lupiáñez, & Humphreys, 2010; Notebaert & Verguts, 2008), rather than it occurring between two different congruencies. Moreover, Duthoo, Abrahamse, Braem, and Notebaert (2013) showed that expectancy plays a vital role in cognitive control only when it was explicitly manipulated. Jiménez and Méndez (2013, 2014) also demonstrated that the performance of confound-minimized tasks was independent of participants' explicit expectations regarding the congruency repetition type, even when ample time was available after a response for participants to utilize any strategy. Rather, the results suggested that the CSE is due to the integrated outcomes of multiple mechanisms exerting their functions based on experience.

Consistent with Jiménez and Méndez's (2013, 2014) view, the findings of the present study demonstrated the contributions of top-down control and bottom-up feature integration to the sequential modulation of the congruency effect between previous and current trials in the confound-minimized cross-task design. This is despite the fact that the impact of bottom-up feature integration was canceled out when the combined datasets of trials following a congruency repetition trial and those following a congruency alternation trial were analyzed. Recent perspectives on the CSE are based on the idea that the CSE is due to the integrated contributions of memory at multiple levels (e.g., Abrahamse, Braem, Notebaert, & Verguts, 2016; Egner, 2014; Weissman, Jiang, & Egner, 2014). Memory acquired by associative learning for bottom-up stimulus and response features at a concrete level elicits the sequential modulation of the congruency effect, as the bottom-up feature integration theory suggests. At the same time, memory acquired by associative learning for top-down cognitive control at an abstract level also causes the CSE (Spapé & Hommel, 2008). Furthermore, Weissman et al. (2014) have demonstrated that memories for concrete stimulus and response features and abstract control features operate together to generate the CSE. In line with these ideas, the findings of the present study imply that the top-down cognitive control triggered by the conflict of the preceding trial and bottom-up feature integration from n-2 trials contribute to the sequential modulation of the congruency effect independently.

4.3. Conclusion

The present study demonstrated that top-down cognitive control and bottom-up feature integration, but not multiple expectancies, are factors causing the sequential modulation of the congruency effect. However, because feature integration contributes to the CSE in opposite directions depending on preceding congruency repetition type, the cross-task CSE is independent of lingering repetition-priming confounds from n-2 trial. Consequently, the current findings imply that the confound-minimized cross-task design can still minimize the confound effects of feature integration and contingency learning.

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References

Abrahamse, E., Braem, S., Notebaert, W., & Verguts, T. (2016). Grounding cognitive control in associative learning. *Psychological Bulletin, 142*(7), 693–728. https://doi.org/10.1037/bul0000047

Akçay, Ç., & Hazeltine, E. (2008). Conflict adaptation depends on task structure. *Journal of Experimental Psychology: Human Perception and Performance, 34*(4), 958–973. https://doi.org/10.1037/0096-1523.34.4.958

Aschenbrenner, A. J., & Balota, D. A. (2017). Dynamic adjustments of attentional control in healthy aging. Psychology and Aging, 32(1), 1–15. doi:10.1037/pag0000148.

Botvinick, M. M., Braver, T. S., Barch, D. M., Carter, C. S., & Cohen, J. D. (2001). Conflict monitoring and cognitive control. *Psychological Review, 108*(3), 624–652. https://doi.org/10.1037/0033-295X.108.3.624

Braem, S., Abrahamse, E. L., Duthoo, W., & Notebaert, W. (2014). What determines the specificity of conflict adaptation? A review, critical analysis, and proposed synthesis. *Frontiers in Psychology, 5*, 1134. https://doi.org/10.3389/fpsyg.2014.01134

Braem, S., Bugg, J. M., Schmidt, J. R., Crump, M. J. C., Weissman, D. H., Notebaert, W., & Egner, T. (2019). Measuring adaptive control in conflict tasks. *Trends in Cognitive Sciences, 23*(9), 769–783. https://doi.org/10.1016/j.tics.2019.07.002

Duthoo, W., Abrahamse, E. L., Braem, S., & Notebaert, W. (2013). Going, going, gone? Proactive control prevents the congruency sequence effect from rapid decay. *Psychological Research, 78*, 483–493. https://doi.org/10.1007/s00426-013-0498-4

Egner, T. (2014). Creatures of habit (and control): A multi-level learning perspective on the modulation of congruency effects. *Frontiers in Psychology, 5*, 1247. https://doi.org/10.3389/fpsyg.2014.01247

Egner, T., Delano, M., & Hirsch, J. (2007). Separate conflict-specific cognitive control mechanisms in the human brain. *NeuroImage, 35*(2), 940–948. https://doi.org/10.1016/j.neuroimage.2006.11.061

Erb, C. D., & Aschenbrenner, A. J. (2019). Multiple expectancies underlie the congruency sequence effect in confound-minimized tasks. *Acta Psychologica, 198*, 102869. https://doi.org/10.1016/j.actpsy.2019.102869

Funes, M. J., Lupiáñez, J., & Humphreys, G. (2010). Analyzing the generality of conflict adaptation effects. *Journal of Experimental Psychology: Human Perception and Performance*, 36, 147-161. ttps://doi.org/10.1037/a0017598.

Gratton, G., Coles, M. G., & Donchin, E. (1992). Optimizing the use of information: Strategic control of activation of responses. *Journal of Experimental Psychology: General, 121*(4), 480–506. https://doi.org/10.1037/0096-3445.121.4.480.

Hommel, B., Proctor, R. W., & Vu, K. P. L. (2004). A feature-integration account of sequential effects in the Simon task. *Psychological Research, 68*(1), 1–17. https://doi.org/10.1007/s00426-003-0132-y

Jeong, H. J., & Cho, Y. S. (2020). The effects of induced and trait anxiety on the sequential modulation of emotional conflict. *Psychological Research Psychologische Forschung*. https://doi.org/10.1007/s00426-020-01289-1

Jiménez, L., & Méndez, A. (2013). It is not what you expect: Dissociating conflict adaptation from expectancies in a Stroop task. *Journal of Experimental Psychology: Human Perception and Performance, 39*, 271–284. https://doi.org/10.1037/a0027734

Jiménez, L., & Méndez, A. (2014). Even with time, conflict adaptation is not made of expectancies. *Frontiers in Psychology, 5*, 1042. https://doi.org/10.3389/fpsyg.2014.01042

Kim, S., & Cho, Y. S. (2014). Congruency sequence effect without feature integration and contingency learning. *Acta Psychologica, 149*, 60–68. https://doi.org/10.1016/j.actpsy.2014.03.004

Kim, S., Lee, S. H., & Cho, Y. S. (2015). Control processes through the suppression of the automatic response activation triggered by task-irrelevant information in the Simon-type tasks. *Acta Psychologica, 162*, 51–61. https://doi.org/10.1016/j.actpsy.2015.10.001

Kunde, W., & Wühr, P. (2006). Sequential modulations of correspondence effects across spatial dimensions and tasks. *Memory & Cognition, 34*(2), 356–367.

Lee, J., & Cho, Y. S. (2013). Congruency sequence effect in cross-task context: Evidence for dimension-specific modulation. *Acta Psychologica, 144*, 617–627. https://doi.org/10.1016/j.actpsy.2013.09.013

Lim, C. E., & Cho, Y. S. (2018). Determining the scope of control underlying the congruency sequence effect: Roles of stimulus-response mapping and response mode. *Acta Psychologica, 190*, 267–276. https://doi.org/10.1016/j.actpsy.2018.08.012

Lim, C. E., & Cho, Y. S. (2020). Response mode modulates the congruency sequence effect in spatial conflict tasks: Evidence from aimed-movement responses. *Psychological Research Psychologische Forschung*. https://doi.org/10.1007/s00426-020-01376-3

Loftus, G. R., & Masson, M. E. (1994). Using confidence intervals in within-subject designs. *Psychonomic Bulletin & Review, 1*(4), 476–490. https://doi.org/10.3758/BF03210951

Mayr, U., Awh, E., & Laurey, P. (2003). Conflict adaptation effects in the absence of executive control. *Nature Neuroscience, 6*(5), 450–452. https://doi.org/10.1038/nn1051

Mordkoff, J. T. (2012). Observation: Three reasons to avoid having half of the trials be congruent in a four-alternative forced-choice experiment on sequential modulation. *Psychonomic Bulletin & Review, 19*, 750–757. https://doi.org/10.3758/s13423-012-0257-3

Nieuwenhuis, S., Stins, J. F., Posthuma, D., Polderman, T. J. C., Boomsma, D. I., & De Geus, E. J. (2006). Accounting for sequential trial effects in the flanker task: Conflict adaptation or associative priming? *Memory & Cognition, 34*(6), 1260–1272. https://doi.org/10.3758/BF03193270

Notebaert, Wim, & Verguts, Tom (2007). Dissociating conflict adaptation from feature integration: A multiple regression approach. *Journal of Experimental Psychology:*

Human Perception and Performance, 33(5), 1256–1260. https://doi.org/10.1037/0096-1523.33.5.1256

Notebaert, Wim, & Verguts, Tom (2008). Cognitive control acts locally. *Cognition, 106*(2), 1071–1080. https://doi.org/10.1016/j.cognition.2007.04.011

Schmidt, J. R. (2019). Evidence against conflict monitoring and adaptation: An updated review. *Psychonomic Bulletin & Review, 26*, 753–771. https://doi.org/10.3758/s13423-018-1520-z

Schmidt, J. R., Crump, M. J. C., Cheesman, J., & Besner, D. (2007). Contingency learning without awareness: Evidence for implicit control. *Consciousness and Cognition, 16*, 421–435. https://doi.org/10.1016/j.concog.2006.06.010

Schmidt, J. R., & Weissman, D. H. (2014). Congruency sequence effects without feature integration or contingency learning confounds. *PLoS One, 9*(7), Article e102337. https://doi.org/10.1371/journal.pone.0102337

Schumacher, E. H., & Hazeltine, E. (2016). Hierarchical task representation: Task files and response selection. *Current Directions in Psychological Science, 25*(6), 449–454. https://doi.org/10.1177/0963721416665085

Spapé, M. M., & Hommel, B. (2008). He said, she said: Episodic retrieval induces conflict adaptation in an auditory Stroop task. *Psychonomic Bulletin & Review, 15*, 1117–1121. https://doi.org/10.3758/PBR.15.6.1117

Spinelli, G., Perry, J. R., & Lupker, S. J. (2019). Adaptation to conflict frequency without contingency and temporal learning: Evidence from the picture–word interference task. *Journal of Experimental Psychology: Human Perception and Performance, 45*(8), 995.

Ullsperger, M., Bylsma, L. M., & Botvinick, M. M. (2005). The conflict adaptation effect: It's not just priming. *Cognitive, Affective, & Behavioral Neuroscience, 5*, 467–472. https://doi.org/10.3758/CABN.5.4.467

Verguts, T., & Notebaert, W. (2008). Hebbian learning of cognitive control: Dealing with specific and nonspecific adaptation. *Psychological Review, 115*(2), 518–525. https://doi.org/10.1037/0033-295X.115.2.518

Verguts, T., & Notebaert, W. (2009). Adaptation by binding: A learning account of cognitive control. *Trends in Cognitive Sciences, 13*, 252–257. https://doi.org/10.1016/j.tics.2009.02.007

Weissman, D. H. (2020). Interacting congruency effects in the hybrid Stroop–Simon task prevent conclusions regarding the domain specificity or generality of the congruency sequence effect. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 46*(5), 945–967. https://doi.org/10.1037/xlm0000769

Weissman, D. H., Hawks, Z. W., & Egner, T. (2016). Different levels of learning interact to shape the congruency sequence effect. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 42*(4), 566–583. https://doi.org/10.1037/xlm0000182

Weissman, D. H., Jiang, J., & Egner, T. (2014). Determinants of congruency sequence effects without learning and memory confounds. *Journal of Experimental Psychology: Human Perception and Performance, 40*(5), 2022–2037. https://doi.org/10.1037/a0037454

Wühr, P. (2005). Evidence for gating of direct response activation in the Simon task. *Psychonomic Bulletin & Review, 12*, 282–288. https://doi.org/10.3758/BF03196373