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Additional considerations when measuring adaptive control in conflict tasks

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ABSTRACT

A recent review article by Braem et al. (2019, Trends in Cognitive Sciences) summarises some of the major challenges associated with investigating the dynamics of cognitive control in conflict tasks and recommends steps that researchers can take to minimise these challenges. This commentary highlights two further considerations for researchers studying the dynamics of cognitive control. First, researchers should consider analysing effects stemming from trial n - 2 to identify (a) how the congruency sequence effect emerges over a longer series of trials and (b) whether residual feature-integration effects remain in confound-minimised designs. Second, data from hand-tracking studies indicates that the dynamics observed in button-press measures of response time reflect the functioning of dissociable processes. Consequently, researchers should consider how the various manipulations used to investigate the dynamics of cognitive control might impact different processes underlying performance.

Conflict tasks such as the Eriksen flanker (Eriksen & Eriksen, 1974), Simon (1969), and Stroop (1935) tasks have played a major role in investigating how the cognitive and neural dynamics underlying cognitive control are modulated by the congruency sequence effect (CSE; also known as the Gratton effect) and proportion congruency effects (Egner, 2007, 2017; Schmidt, 2019). However, the interpretation of these dynamics is often complicated by the presence of feature-integration effects and contingency learning effects (Braem et al., 2019; Hommel, Proctor, & Vu, 2004; Schmidt & De Houwer, 2011). Braem et al. (2019) provide an excellent summary of how these effects can complicate the interpretation of performance on conflict tasks and what steps researchers can take to minimise the contribution of the effects. In this commentary, I highlight two further considerations for researchers interested in studying the dynamics of cognitive control with conflict tasks.

First, researchers using confound-minimised conflict tasks to investigate the CSE (see Braem et al., 2019, Fig. 1A) should consider evaluating the effects of trial n - 2 to identify (a) how the CSE emerges over a longer series of trials and (b) whether overlap between the stimulus and response features of trial n and trial n - 2 generates feature-integration effects. Erb and Aschenbrenner (2019) re-analysed data from a range of confound-minimised conflict tasks and found that the CSEs observed in the majority of the data sets were modulated by the congruency repetition type of trial n - 1 (see Fig. 1A and B). Of the seven analysed data sets to reveal a significant CSE, all seven showed a significant CSE on the subset of trials in which the congruency of trial n - 1 repeated the congruency of trial n - 2 (ccC, iiC, iiI, and ccI trials). However, only one of the data sets showed a significant CSE on the subset of trials in which the congruency of trial n - 1 differed from that of trial n - 2 (icC, ciC, ciI, and icI trials). These findings indicate that the CSE observed in the majority of confound-minimised tasks reflects a combination of effects stemming from trial n - 2 and trial n - 1.

To further evaluate the nature of these effects, Erb and Aschenbrenner (2019) conducted exploratory analyses to identify whether feature-integration effects stemming from the stimulus and response features of trial n - 2 contributed to the CSEs observed in trials preceded by a congruency repetition trial. Two of the data sets revealed significant three-way interactions among trial n congruency, trial n - 1 congruency, and trial n response repetition type, with larger CSEs observed in trials that repeated the response of trial n - 2 (see Fig. 1C and D). These results present preliminary evidence that feature-integration effects stemming from the stimulus and response elements of trial n - 2 can contribute to the CSEs observed in confound-minimised conflict tasks under certain conditions. As discussed in further detail by Erb and Aschenbrenner (2019), the presence of such effects can substantially complicate the interpretation of performance. Consequently, researchers should take steps to evaluate whether feature-integration effects stemming from trial n - 2 remain in confound-minimised designs by, for example, evaluating whether the CSE is larger on trials that repeat the response of trial n - 2.

Second, researchers should consider the extent to which the

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behavioural dynamics observed in conflict tasks reflect the functioning of dissociable processes underlying cognitive control. Recent research has used techniques like reach tracking (Erb & Marcovitch, 2018a, 2018b; Erb, McBride, & Marcovitch, 2019; Erb, Moher, Sobel, & Song, 2016; Erb, Moher, Song, & Sobel, 2018; Erb, Touron, & Marcovitch, 2020 in press; Scorolli, Pellicano, Nicoletti, Rubichi, & Castiello, 2015), mouse tracking (Incera & McLennan, 2018; Scherbaum & Dshemuchadse, 2019; Scherbaum, Dshemuchadse, Fischer, & Goschke, 2010), and force-sensitive buttons (Weissman, 2019) to shed light on how the dynamics of cognitive control are reflected in participants' unfolding actions. For example, results from a reach-tracking study by Erb and Marcovitch (2018a) indicate that the CSE originally observed in response times in a confound-laden two-alternative forced-choice flanker task (Gratton, Coles, & Donchin, 1992) reflects the combination of two distinct patterns of effects (see Fig. 2A). Response initiation times (the time elapsed from stimulus onset to movement initiation) in the task revealed main effects of trial n congruency and trial n - 1 congruency on both response alternation trials and response repetition trials (Fig. 2B). In contrast, reach curvatures (a measure of the extent to which a movement trajectory deviated from a direct path to the selected target) revealed enhanced performance on iI trials compared to cI trials, but only on the subset of trials featuring a response repetition (Fig. 2C).

Erb and Marcovitch (2018a) interpreted the pattern of effects observed in initiation times to reflect the functioning a threshold adjustment process that inhibits motor output in response to signals of conflict, whereas the pattern of effects observed in reach curvatures was interpreted to reflect the functioning of a controlled selection process that directs top-down resources to support goal-driven stimulus-response translation. Results from reach-tracking versions of the Simon task (Erb & Marcovitch, 2018b) and the Stroop task (Erb et al., 2016, (Erb,

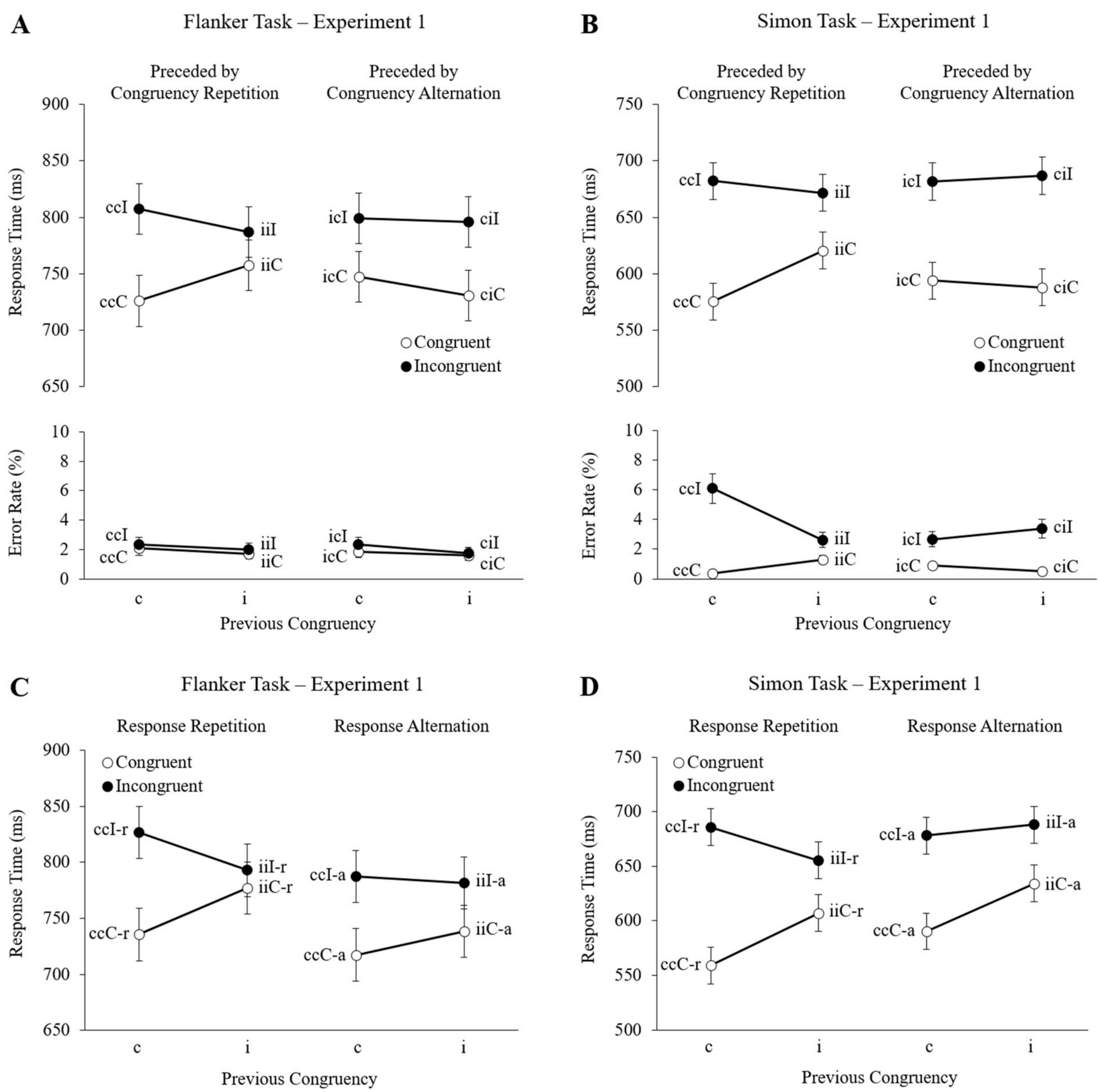

Fig. 1. Results from two data sets reanalysed by Erb and Aschenbrenner (2019). The (A) flanker task and (B) Simon task revealed a significant CSE in trials preceded by a congruency repetition trial (ccC, iiC, ccI, and iiI trials) but not trials preceded by a congruency alternation trial (icC, ciC, icI, and ciI trials). Subsequent exploratory analyses revealed significantly larger CSEs in response repetition trials (trials in which the response of trial n matched the response of trial n - 2) than in response alternation trials (trials in which the response of trial n did not match the response of trial n - 2) in the (C) flanker task and (D) the Simon task. Error bars display standard errors. This figure was adapted from Erb and Aschenbrenner (2019) and is presented with permission from the authors.

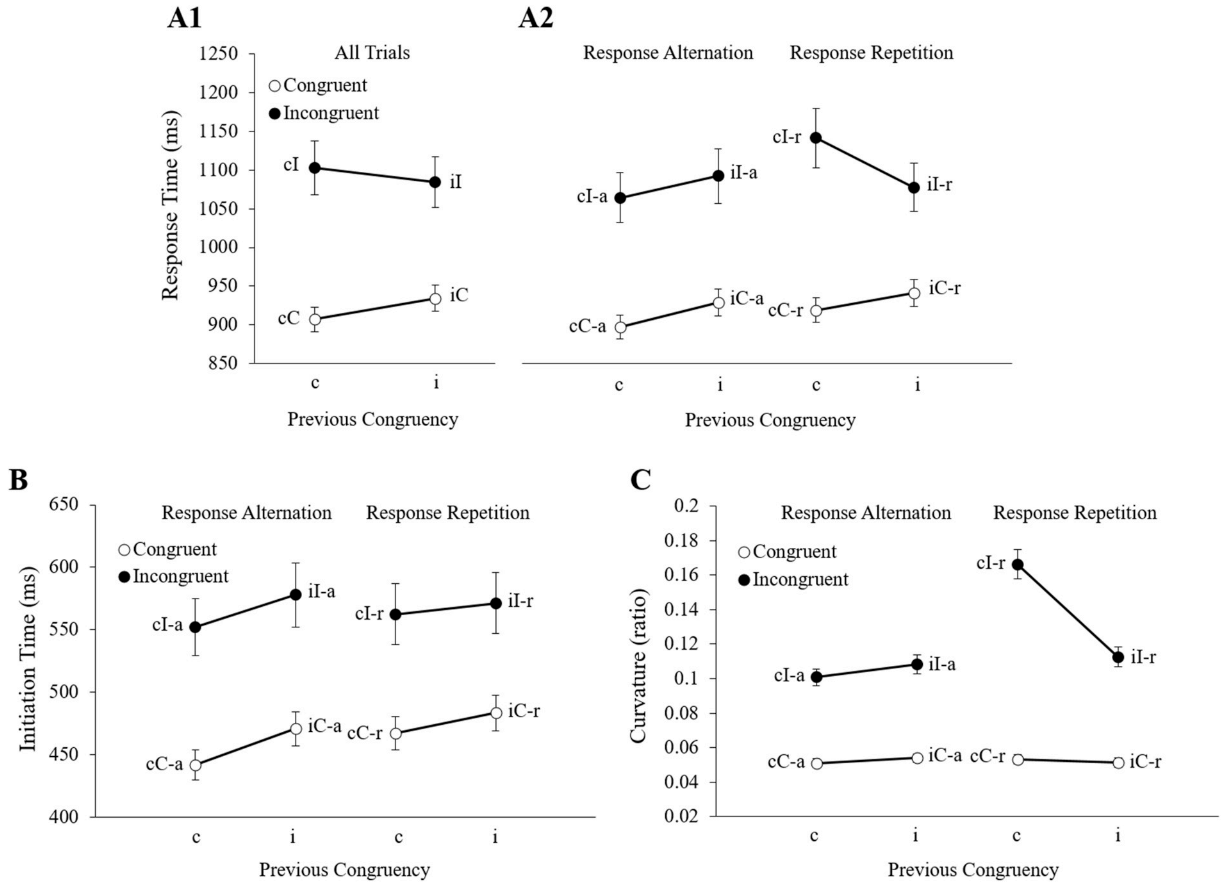

Fig. 2. Results from a reach-tracking version of a two-alternative forced-choice flanker task that featured 135 participants, with equal numbers of 6- to 8-year-olds, 10- to 12-year-olds, and adults. (A1) Response times replicated the results originally reported by Gratton et al. (1992). (A2) Response times also replicated the results of Mayr, Awh, and Laurey (2003) when response repetition type (alternation vs. repetition) was evaluated. (B) Initiation times revealed main effects of current congruency and previous congruency. (C) Reach curvatures revealed a significant interaction among trial n congruency, trial n - 1 congruency, and response repetition type. Notably, the pattern of effects observed in response times reflected a combination of the patterns of effects observed in initiation times and curvatures. Error bars display standard errors. This figure was adapted from Erb and Marcovitch (2018a) and is presented with permission from the authors.

McBride, & Marcovitch, 2019; Erb, Touron, & Marcovitch, 2020)) further support the notion that the threshold adjustment process and controlled selection process are differentially impacted by aspects of the preceding trials, with the controlled selection process particularly sensitive to feature-integration effects. Consequently, researchers investigating the dynamics of cognitive control should consider the extent to which the CSEs and proportion congruency effects observed across different conflict tasks might reflect the functioning of these processes.

Although measuring and interpreting the dynamics of cognitive control continues to present challenges, significant progress has been made during the past two decades. Braem et al. (2019) provide a much needed consensus view for researchers who are not "in the weeds" of the field. Hopefully, the additional considerations outlined above prove useful for researchers without requiring too long of an excursion into complexities of the field.

References

Braem, S., Bugg, J. M., Schmidt, J. R., Crump, M. J., Weissman, D. H., Notebaert, W., et al. (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.

Egner, T. (2007). Congruency sequence effects and cognitive control. *Cognitive, Affective, & Behavioral Neuroscience, 7*(4), 380–390. https://doi.org/10.3758/CABN.7.4.380.

Egner, T. (2017). Conflict adaptation: Past, present, and future of the congruency sequence effect as an index of cognitive control. In T. Egner (Ed.), *The wiley handbook of cognitive control* (pp. 64–78). Oxford: Wiley-Blackwell.

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.

Erb, C. D., & Marcovitch, S. (2018a). Deconstructing the Gratton effect: Targeting dissociable trial sequence effects in children, pre-adolescents, and adults. *Cognition, 179*, 150–162. https://doi.org/10.1016/j.cognition.2018.06.007.

Erb, C. D., & Marcovitch, S. (2018b). *Tracking the within-trial, cross-trial, and developmental dynamics of cognitive control: Evidence from the Simon task*. Child Development. https://doi.org/10.1111/cdev.13111.

Erb, C. D., McBride, A. G., & Marcovitch, S. (2019). Associative priming and conflict differentially affect two processes underlying cognitive control: Evidence from reaching behavior. *Psychonomic Bulletin & Review, 26*(4), 1400–1410.

Erb, C. D., Moher, J., Sobel, D. M., & Song, J.-H. (2016). Reach tracking reveals dissociable processes underlying cognitive control. *Cognition, 152*, 114–126. https://doi.org/10.1016/j.cognition.2016.03.015.

Erb, C. D., Moher, J., Song, J. H., & Sobel, D. M. (2018). Reach tracking reveals dissociable processes underlying inhibitory control in 5- to 10-year-olds and adults. *Developmental Science, 21*(2), e12523. https://doi.org/10.1111/desc.12523.

Erb, C. D., Touron, D. R., & Marcovitch. (2020). Tracking the dynamics of global and competitive inhibition in early and late adulthood: Evidence from the flanker task. *Psychology and Aging* (in press).

Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception & Psychophysics, 16*(1), 143–149. https://doi.org/10.3758/BF03203267.

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.

Incera, S., & McLennan, C. T. (2018). Bilingualism and age are continuous variables that influence executive function. *Aging, Neuropsychology, and Cognition, 25*(3), 443–463. https://doi.org/10.1080/13825585.2017.1319902.

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.

Scherbaum, S., & Dshemuchadse, M. (2019). Psychometrics of the continuous mind: Measuring cognitive sub-processes via mouse tracking. *Memory & Cognition*, 1–19. https://doi.org/10.3758/s13421-019-00981-x.

Scherbaum, S., Dshemuchadse, M., Fischer, R., & Goschke, T. (2010). How decisions evolve: The temporal dynamics of action selection. *Cognition, 115*(3), 407–416. https://doi.org/10.1016/j.cognition.2010.02.004.

Schmidt, J. R. (2019). Evidence against conflict monitoring and adaptation: An updated review. *Psychonomic Bulletin & Review, 26*(3), 753–771. https://doi.org/10.3758/s13423-018-1520-z.

Schmidt, J. R., & De Houwer, J. (2011). Now you see it, now you don't: Controlling for contingencies and stimulus repetitions eliminates the Gratton effect. *Acta Psychologica, 138*(1), 176–186. https://doi.org/10.1016/j.actpsy.2011.06.002.

Scorolli, C., Pellicano, A., Nicoletti, R., Rubichi, S., & Castiello, U. (2015). The Simon effect in action: Planning and/or on-line control effects? *Cognitive Science, 39*(5), 972–991. https://doi.org/10.1111/cogs.12188.

Simon, J. R. (1969). Reactions toward the source of stimulation. *Journal of Experimental Psychology, 81*(1), 174. https://doi.org/10.1037/h0027448.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18*(6), 643–662. https://doi.org/10.1037/h0054651.

Weissman, D. H. (2019). Let your fingers do the walking: Finger force distinguishes competing accounts of the congruency sequence effect. *Psychonomic Bulletin & Review, 26*, 1619–1626. https://doi.org/10.3758/s13423-019-01626-5.