Acta Psychologica 188 (2018) 177–187

Contents lists available at ScienceDirect

Acta Psychologica

journal homepage: www.elsevier.com/locate/actpsy

Can the post-error effect mask age-related differences in congruency conditions when education and overall accuracy are controlled for?

Arturo X. Pereiro[a,*], Byron F. Bustamante[b], María A. Cisneros[b], Onésimo Juncos-Rabadán[a]

[a] Department of Developmental Psychology, University of Santiago de Compostela, Spain
[b] Department of Psychology, Universidad Técnica Particular de Loja, Ecuador

ARTICLE INFO

Keywords:
Post-error effect
Monitoring
Aging
Sequential effect
Congruency

ABSTRACT

Objective: Age-related differences in stimulus–response congruency tasks have been attributed to older adults' greater difficulties in handling the irrelevant spatial-dimensional overlap between stimulus and response. However, performance on congruency tasks may also be influenced by the previous trial accuracy (i.e. post-error effect), which may affect young and older adults differently. The main objective of this study was to analyse age-related differences in the post-error effect as a function of congruency. In addition, we examined the meditational role of the Gratton effect on the age-related differences in the post-error slowing (PES) and post-error increased accuracy (PIA) as a function of congruency.

Method: The sample comprised 165 healthy adult participants with diverse educational attainment, divided into five age groups. Participants performed a spatial stimulus–response congruency task. Age-related differences in the post-error effect were analysed for each congruency condition taking into account educational attainment and overall accuracy. Statistical procedures were used to neutralize age-related processing speed effects on the PES.

Results: PES was observed across all age groups, except the Very old group (aged 85–98 years), and it was not related to congruency condition. PIA was observed across age groups in all congruency conditions and was slightly higher in incongruent trials. Evidence of simultaneous PES and PIA was found for young participants and older participants under 85 years. The Very old group did not need to significantly slow down their responses after errors to improve accuracy. No age- related difference was found in the influence of the Gratton effect on PES or PIA as a function of congruency.

Conclusions: PES and PIA were observed in young adults and older adults under 85 years old. Evidence of simultaneous PES and PIA in the young and older age group (except for the Very old) indicates that the post-error effect can be interpreted in terms of recruitment of additional resources to prevent subsequent errors. Slightly higher accuracy was observed in the incongruent condition in post-error trials relative to pre-error correct trials across age groups.

1. Introduction

The Simon paradigm (Simon & Rudell, 1967) provides specific measures of attentional control through stimulus–response congruency tasks that assess the effect of the irrelevant spatial-dimensional overlap between stimulus and response. The ‘Simon effect’ (Hedge & Marsh, 1975) is operationalized by subtracting performance indexes (i.e. reaction time, errors) measured in an incongruent condition (e.g. arrow pointing to the opposite side to where the stimulus is displayed) from those measured in a congruent condition (e.g. arrow pointing to the same side where the stimulus is displayed). In addition to the poorer performance (i.e. longer reaction time and more errors) in incongruent trials, the Simon effect can be increased by improved performance in the congruent condition associated with facilitation by matching the relevant and irrelevant dimensions of the stimuli (Umiltà, Rubichi, & Nicoletti, 1999). As a consequence, differences in reaction times (RT) and errors between incongruent and the congruent conditions may increase relative to the difference between incongruent and neutral conditions.

Aging research has consistently reported higher costs in incongruent than in congruent trials (i.e. Simon effect) for older adults, and this is usually interpreted as an age-related deficit in attentional control

* Corresponding author at: Departamento de Psicoloxía Evolutiva e da Educación, Facultade de Psicoloxía, Universidade de Santiago de Compostela, Rúa Xosé María Suárez Núñez, s/n, Campus Vida, 15782 Santiago de Compostela, Spain.
E-mail address: arturoxose.pereiro@usc.es (A.X. Pereiro).

https://doi.org/10.1016/j.actpsy.2018.06.008
Received 4 July 2017; Received in revised form 20 June 2018; Accepted 21 June 2018

(Bialystok, Craik, Klein, & Viswanathan, 2004; Juncos, Pereiro, & Facal, 2008; Kubo-Kawai & Kawai, 2010; Proctor, Pick, Vu, & Anderson, 2005; Van der Lubbe & Verleger, 2002). However, age-related differences in stimulus–response congruency tasks may not only be a consequence of the degree of irrelevant spatial-dimensional overlap between stimulus and response respectively associated with incongruent and congruent trials (Notebaert & Verguts, 2011). Some sequential effects such as the 'post-error effect' (Rabbitt, 1966, 1979) may be responsible for a significant increase in reaction times (i.e. post-error slowing) or accuracy (i.e. post-error increased accuracy) when an error has been made in the previous trial, which could affect the performance of young and older adults differently (De Jong, Liang, & Lauber, 1994; Ridderinkhof, 2002). Nonetheless, the post-error slowing (PES) and post-error increased accuracy (PIA) may be differently emphasized or attenuated as a function of the 'Gratton effect' (Gratton, Coles, & Donchin, 1992), another sequential effect which may contribute to increasing the speed and response accuracy when an incongruent trial is preceded by another incongruent trial, relative to when the previous trial does not show irrelevant spatial-dimensional overlap between stimulus and response (i.e. neutral and congruent trials). The influence of the Gratton effect on the post-error effect may also differ as a function of age if it is greater in older adults, as some studies have suggested (Aschenbrenner & Balota, 2015; Puccioni & Vallessi, 2012). In addition, it has been pointed out that age-related differences in stimulus–response congruency tasks may also reflect greater global costs or unspecific difficulties in unambiguous set-selection of stimuli and responses according to the task goals, particularly when the response and set overlap (both hands were used to respond to both incongruent and congruent stimuli) (Mayr, 2001).

It has been postulated that the post-error effect depends on specific monitoring processes, which, after an error, initiate voluntary control processes to improve response accuracy, but which are time-consuming (Botvinick, Braver, Barch, Carter, & Cohen, 2001). Thus, the simultaneous PES and PIA could be interpreted in terms of recruitment of additional resources to prevent subsequent errors. However, increased post-error accuracy has not always been observed (Fiehler, Ullsperger, & Von Cramon, 2005; Hajcak & Simons, 2008; King, Korb, Von Cramon, & Ullsperger, 2010). In an attempt to explain this somewhat contradictory finding, Notebaert et al. (2009) postulated that the post-error slowing was a result of an orienting reaction to infrequent events (usually errors in the context of an experimental task) that had a negative impact on RTs but did not necessary increase the accuracy. Some studies have shown that error must be infrequent and therefore unexpected for the post-error effect to be observed (Braem, Coenen, Bombeke, Van Bochove, & Notebaert, 2015; Notebaert et al., 2009; Núñez, Kuhn, Fias, & Notebaert, 2010). Thus, because of the possible age-related differences, overall accuracy (e.g. total number of errors) should also be considered when studying the age differences in the post-error effect as a function of congruency. In fact, PES can even be reversed (i.e. increased RT in post-correct trials relative to post-error trials) when the number of errors is high and the expectation of success is low (Notebaert et al., 2009). On the other hand, Ruitenberg, Abrahamse, De Kleine, and Verwey (2014) supported the hypothesis that more infrequent errors facilitate the appearance of the PES in young adult and middle-aged participants but not in older adults.

The post-error effect has been shown to be capable of reducing differences between incongruent and congruent trials (Forster & Cho, 2014; Notebaert & Verguts, 2011; Ridderinkhof, 2002; Van der Borght, Braem, & Notebaert, 2014). Thus, PES could reduce the difference between RTs in incongruent and congruent trials because attentional control improves after errors have occurred, leading to shorter RTs, mainly in incongruent trials (Ridderinkhof, 2002). Alternatively, different additive effects of PES as a function of congruency would be expected if RT slowing has a greater effect on congruent and neutral trials than on incongruent trials. It can be hypothesized that PES reduces the difference between RTs in incongruent and congruent trials because the error made in the previous trial mainly increases the RTs in congruent trials (priming condition and in the absence of irrelevant spatial-dimensional overlap); the error has less effect on RTs in incongruent trials as the RTs are already slowed down by the irrelevant spatial-dimensional overlap between stimulus and response. For the same reason, it could be hypothesized that PES should have less effect in neutral than congruent trials, and therefore some variation is expected in the differences between incongruent and neutral conditions depending on whether an error was made in the previous trial, although less than the variation between incongruent and congruent trials. As PES is expected to have a different effect on congruency conditions and age-related differences as a function of congruency condition have been consistently reported, exploration of the age-related differences in the influence of PES on the RTs as a function of stimuli congruency is appropriate.

In addition, changes in the trade-off between speed and accuracy may occur because PES would allow extra time to initiate active and effortful control processes or would improve attentional control enabling more efficient reduction or suppression of automatic and prepotent responses (Ridderinkhof, 2002). Both hypotheses predict an increase in accuracy after an error, particularly in the incongruent condition in which more errors are usually made, and to a lesser extent in neutral and congruent trials. The use of these control processes may improve performance in both young and older adults (De Jong et al., 1994; Van der Lubbe & Verleger, 2002). However, it may be less advantageous or even detrimental to older participants if monitoring processes in older adults for delayed responses impaired in a similar way to the conscious and intentional handling of the irrelevant spatial-dimensional overlap between stimulus and response, as some studies suggest (Collette, Schmidt, Scherrer, Adam, & Salmon, 2009; Juncos et al., 2008). Nonetheless, these difficulties may be greater in Very old people as a consequence of the influence of biological decline (de Frias, Lövdén, Lindenberger, & Nilsson, 2007) or they may be mitigated by the selective effect of survival and non-normal influences such as educational attainment (Baltes, 1987). Fulfilment of the latter hypothesis, however, may also be favoured when recruitment of the sample is incidental and bias occurs as a result of positive selection of participants (Minder, Muller, Gillmann, Beck, & Stuck, 2002).

The findings of aging research on the post-error effect are not conclusive. Most studies have shown that PES occurs in young and older adults (Czernochowski, 2014; Dutilh, Forstmann, Vandekerckhove, & Wagenmakers, 2013; Falkenstein, Hoormann, Christ, & Hohnsbein, 2000; Friedman, Nessler, Cycowicz, & Horton, 2009; Nessler, Friedman, Johnson, & Bersick, 2007; Ruitenberg et al., 2014). However, while some of these studies reported significantly greater PES in older participants (Dutilh et al., 2013; Falkenstein et al., 2000; Friedman et al., 2009; Ruitenberg et al., 2014), others only reported age-related differences based on marginal levels of significance and score trends (Czernochowski, 2014; Nessler et al., 2007). In an aging study considering post-error accuracy measures, Ruitenberg et al. (2014) observed a similar increase in post-error accuracy in young, middle-aged and older participants.

As far as we know, the available evidence on age-related behavioural differences in the post-error effect as a function of congruency has been reported by Nessler et al. (2007) and Friedman et al. (2009). These studies explored the relationships between the post-error effect (RTs, error rate) and the congruency condition as well as age-related differences. Nessler et al. (2007) reported a significant age-related interaction between accuracy in the previous trial (i.e. trial type factor) and congruency condition only for the error rates, showing (contrary to the expected improvement of accuracy after an error) significantly lower accuracy after errors than after correct responses in incongruent trials, exclusively in older participants. Friedman et al. (2009) provided some evidence supporting the previously described greater decrease in post-error accuracy in older adults for the incongruent condition, as indicated by additional analysis carried out after verification that the