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Research report

Control adjustments in speaking: Electrophysiology of the Gratton effect in picture naming

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ABSTRACT

Accumulating evidence suggests that spoken word production requires different amounts of top-down control depending on the prevailing circumstances. For example, during Stroop-like tasks, the interference in response time (RT) is typically larger following congruent trials than following incongruent trials. This effect is called the Gratton effect, and has been taken to reflect top-down control adjustments based on the previous trial type. Such control adjustments have been studied extensively in Stroop and Eriksen flanker tasks (mostly using manual responses), but not in the picture–word interference (PWI) task, which is a workhorse of language production research. In one of the few studies of the Gratton effect in PWI, Van Maanen and Van Rijn (2010) examined the effect in picture naming RTs during dual-task performance. Based on PWI effect differences between dual-task conditions, they argued that the functional locus of the PWI effect differs between post-congruent trials (i.e., locus in perceptual and conceptual encoding) and post-incongruent trials (i.e., locus in word planning). However, the dual-task procedure may have contaminated the results. We therefore performed an electroencephalography (EEG) study on the Gratton effect in a regular PWI task. We observed a PWI effect in the RTs, in

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the N400 component of the event-related brain potentials, and in the midfrontal theta power, regardless of the previous trial type. Moreover, the RTs, N400, and theta power reflected the Gratton effect. These results provide evidence that the PWI effect arises at the word planning stage following both congruent and incongruent trials, while the amount of top-down control changes depending on the previous trial type.

1. Introduction

Goal-oriented behavior relies on a flexible system of top-down control that allows for modification of processing strategies based on an analysis of costs and benefits of different processing types in order to improve performance on a task (e.g., Gratton, Coles, & Donchin, 1992). For example, in an experiment with congruent and incongruent stimuli (like in the color-word Stroop task with congruent and incongruent color-word combinations, such as the word *red* in green ink), a participant can adjust the extent to which distractor information is processed depending on the expected trial type (e.g., Lamers & Roelofs, 2011). In particular, participants may choose between a narrow or a wide strategy in stimulus processing depending on whether a more or less thorough analysis is expected to optimize performance. In an experiment, the participant may rely on the previous trial type to form an expectation about the next trial type (Gratton et al., 1992), expecting trial-type repetition (e.g., Egner, 2007). Alternatively, a participant's expectations can be determined by cues that designate the probability of the next trial type (e.g., Aarts & Roelofs, 2011; Aarts, Roelofs, & Van Turennout, 2008; Gratton et al., 1992) or by means of global probability of stimuli of different types (e.g., Carter et al., 2000).

Control adjustments have been intensively studied using Stroop-like tasks. In a seminal study, Gratton et al. (1992) observed that in such tasks, the difference in response time (RT) between incongruent and congruent trials is typically larger following congruent trials than following incongruent trials, referred to as the *Gratton effect* in later research. The Gratton effect has been examined using Stroop and Eriksen flanker tasks (mostly employing manual responses), but not in the picture–word interference (PWI) task (e.g., Glaser & Düngelhoff, 1984), which has been much used in language production research. Recently, Van Maanen and Van Rijn (2010) examined the Gratton effect in PWI embedded in a dual-task paradigm (see below). Aside from reporting (expected) quantitative differences in RTs, they also argued that post-congruent and post-incongruent trials differ with respect to the functional locus of the PWI effect (i.e., the stage at which the incongruence of the picture and the distractor influences processing of the stimulus). We argue that the dual-task procedure might have contaminated the results. The aim of the research reported in the present article was to examine the Gratton effect in regular PWI and to use electroencephalography (EEG) to determine the functional locus of the PWI effect and its modulation by previous trial type.

In the following, we first describe the trial-to-trial manifestation of the Gratton effect in Stroop-like tasks in more detail. Next, we discuss the dual-task findings and locus-shift account of Van Maanen and Van Rijn (2010), and we present an alternative interpretation of their findings in terms of task scheduling rather than a shift in locus. Then, we discuss the results of previous EEG studies on the Gratton effect, which motivate an examination of the Gratton effect in the N400 component of the event-related brain potentials and in frontal theta power. Next, the results of our EEG study are reported. Finally, we discuss the consequences of our findings for the debate about the functional locus of the PWI effect.

1.1. *The Gratton effect in RTs*

Trial-to-trial sequential effects have been extensively studied using Stroop-like tasks, in which the participant is presented with stimuli that are combinations of a target dimension and a distractor dimension. The participant is instructed to respond to the target dimension while ignoring the distractor dimension. In a proportion of stimuli the target and the distractor dimensions activate the same response (i.e., congruent trials), while in the rest of stimuli the target and the distractor dimensions are associated with different responses (i.e., incongruent trials). For example, in the color-word Stroop task, the stimuli are color words that are printed in a certain color ink (e.g., the word *red* in red or green ink), and the participant is instructed to respond to the color while trying to ignore the word (MacLeod, 1991). In the Eriksen flanker task, the stimuli are strings of letters (e.g., HHSHH or SSSSS) and the participant is instructed to respond to the central (i.e., target) one, while ignoring the distracting flankers (i.e., Eriksen & Eriksen, 1974). The PWI task employs drawings of objects with superimposed object names, and the participant is instructed to name the picture while ignoring the word (Glaser & Düngelhoff, 1984). A common finding of Stroop-like tasks is that participants give slower and less accurate responses on incongruent trials as compared to congruent trials (Eriksen & Eriksen, 1974; Glaser & Düngelhoff, 1984; MacLeod, 1991). Critically, this Stroop-like effect is larger on trials following congruent trials than on trials following incongruent trials (e.g., Botvinick, Nystrom, Fissell, Carter, & Cohen, 1999; Gratton et al., 1992; Lamers & Roelofs, 2011; Ullsperger, Bylsma, & Botvinick, 2005, for the Eriksen flanker task; Egner & Hirsch, 2005; Kerns et al., 2004; Lamers & Roelofs, 2011; Notebaert, Gevers, Verbruggen, & Liefooghe, 2006, for the Stroop task). The Gratton effect has been taken to reflect adjustments in top-down control that a participant exerts in