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The benefit of expecting no conflict — Stronger influence of self-generated than cue-induced conflict expectations on Stroop performance☆

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ABSTRACT

The role of expectations in sequential adaptation to cognitive conflict has been debated controversially in prior studies. On the one hand, a sequential congruency effect (SCE) has been reported for trials in which participants expect a repetition of conflict level. On the other hand, conflict level expectations vs. the SCE have been shown to develop differentially across runs of trials with the same conflict level, arguing against the theory that the SCE is purely driven by expectation. The current verbal Stroop experiment addresses this controversy by two means. First, we tested which specific type of expectation (cue-induced expectations vs. self-generated predictions) might affect the SCE. Second, we assessed the impact of expectation on the SCE as well as the development of SCE and expectation with congruency level run length in one design. We observed a dissociation between expectations and SCE, demonstrating that the SCE is not exclusively driven by expectations. At the same time, we found evidence that (self-generated) expectations do have an impact on the SCE. Our data document especially high performance for one specific combination of task events: congruent trial accompanied by congruent prediction and conflict level repetition. Our results are in line with theories attributing conflict adaptation effects to the "adaption to the lack of conflict". We discuss our results in a broader context of theories about conflict monitoring.

1. Introduction

Behavioral adaptation to cognitive conflict is subject of controversial debates (e.g., Schmidt, Notebaert, & Van Den Bussche, 2015). It has often been studied in terms of impact of conflict level of trial n-1 on the conflict effect in the current trial. Since its discovery (Gratton, Coles, & Donchin, 1992), the sequential congruency effect and its source(s) have been discussed on several levels and in different theoretical frameworks. Discussions focus on the extent to which the effect is based on reactive (e.g., Egner, Ely, & Grinband, 2010) or proactive control mechanisms (e.g., Duthoo, Abrahamse, Braem, & Notebaert, 2014). This variation in perspective is mirrored by a variation in terms (sequential congruency effect — SCE, congruence sequence effect, conflict adaption effect, Gratton effect, etc.). There is some evidence that the effect might be caused by different processes. Notebaert, Gevers, Verbruggen, and Liefooghe (2006) reason that the SCE has two distinct components: a fast bottom-up process that relies on repetitions and a slower top-down process including conflict level expectations. Tied to the issue of proactive vs. reactive control (e.g., Braver, 2012), accounts differ with respect to whether or not expectations are involved. Gratton et al. (1992) suggested (proactive) repetition expectations to be responsible for the effect. Conversely, according to the conflict monitoring theory (Botvinick, Nystrom, Fissell, Carter, & Cohen, 1999) conflict experienced in the last trial(s) functions as a feedback to adjust control processes. Thus conflict previously experienced rather than conflict expected is proposed to be the basis for adaptation.

Gratton et al. (1992) proposed that a bias to expect repetition of conflict level steered attentional control. Duthoo, Wühr, and Notebaert (2013) tested this proposition by investigating the influence of self-generated conflict level predictions on the sequential congruency effect in the Stroop task. Participants indeed showed a repetition bias concerning the conflict level. Furthermore, the SCE was only present after trials for which participants predicted a conflict level repetition. When participants expected a repetition of conflict level, the authors found a significant interaction between previous and current congruency in the RT (a smaller RT difference between congruent and incongruent trials after incongruent than after congruent trials). Such a modulation was absent when an alternation of conflict level was expected. For instance, the second congruent trial after a congruent trial was faster than the first one — if the participant expected to encounter

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a congruent trial again. Based on this, Duthoo et al. argued for the involvement of a proactive control process in the SCE, rather than for the exclusive operation of conflict-induced reactive control adjustments.

Asking participants to indicate what they expect seems to be more than a measure of expectation. It seems to favor the reported option substantially. For instance, Hacker and Hinrichs (1974), even found large RT benefits for stimuli reported to be expected the second most or stimuli expected least (Hacker & Hinrichs, 1979) — compared to options not mentioned when asked a question on expectation. Reporting might transfer the object into the focus of attention in working memory (Oberauer, Souza, Druey, & Gade, 2013; see also Gaschler, Schwager, Umbach, Frensch, & Schubert, 2014). Effects of reporting expectations might explain an apparent contradiction between expectation studies employing performance measurement (RT) and expectation report on the same trials (Duthoo et al., 2013) vs. in different blocks: Jiménez and Méndez (2013, 2014) assessed how expectations and how the RT-based Stroop effect developed across runs with repetition of the same conflict level, they measured the expectations in different blocks than the RTs. The more repetitions in conflict level, the more a change in conflict level was expected. For instance, the more congruent trials in a row, the larger was the Stroop effect, yet the more an incongruent trial was expected. Based on the dissociation of how expectation vs. performance developed with run length, the authors argued against the SCE being driven by expectation. The claim that conflict adaptation is possible without expectation was further supported by the fact that the SCE was observed despite that the Response–Stimulus-Interval was set to zero (Jiménez & Méndez, 2013; Notebaert et al., 2006), granting little time for an expectation to develop.

Potentially, this divergence across studies can be explained by the effects that reporting an expectation has on performance in the next trial. Alternatively, the divergence might be explained by differences in level of analysis rather than differences in procedure. Jiménez and Méndez (2013, 2014) analyzed runs of trials with the same congruency level. Duthoo et al. (2013) focused on current and preceding trial. Therefore, one aim of this study is to investigate how these two types of results are combinable by applying the two types of analysis (an analysis based on repetition expectation and an analysis that compares the development of the Stroop effect and expectations for trial runs) on the same data set.

Following up on potential effects of generating an expectation, we additionally included a comparison between self-generated vs. cue-induced expectations. Gratton et al. suggested (without assessing it) and Duthoo et al. reported that participants tend to expect the same conflict level as encountered in the preceding trial. By cueing conflict level such a bias can be avoided. With self-generated expectations participants might express (and by this amplify) the level of conflict adaptation originating from the preceding trial. For instance, when the participant has just experienced a congruent trial and is expecting a repetition because of the trial just experienced, then reporting this expectation might boost conflict adaptation. This potential effect of boosting what you expect by reporting it might be reduced when expectation is induced by a cue, as the cue often does not announce the same level of conflict as in the preceding trial. This raises the question whether conflict adaptation can also be obtained in trials where a repetition of conflict level is announced by a cue.

2. Methods

2.1. Participants

Thirty participants (nine men) with a mean age of 25.8 years took part in the experiment. Two participants were left-handed. All had normal or corrected-to-normal vision. The participants were psychology students at Humboldt-Universität zu Berlin and participated in exchange for course credit or volunteers who received a compensation of € 10 for participating in the experiment with a duration of approximately 90 min. Participants gave their informed consent prior to the experiment.

2.2. Apparatus and software

The Experiment was programmed with MathWorks MATLAB and the Psychophysics Toolbox (Brainard, 1997; Pelli, 1997) and presented on a Windows computer. The participants' voice onset times were recorded using a headset microphone. The experimenter coded the verbalized expectations online.

2.3. Stimulus material and experimental manipulation

The stimuli were color words (the German equivalents for red, green, yellow and blue) written in different font colors, either matching the meaning of the word or one of the other color words used in the experiment. We followed Jiménez and Méndez in using four stimulus colors in alternating pairs of two colors. For example: yellow, written in green ink would be followed by blue written in red ink and then again a trial that only contains green and/or yellow as word/ink. This ordering strategy excluded feature repetitions (any color being used in the same or another role in two consecutive trials) in order to counter repetition-based explanations of the SCE (i.e., Duthoo, Abrahamse, Braem, Boehler, & Notebaert, 2014; Mayr et al., 2003). The stimuli were presented on a 17 inch computer monitor with a light gray background. The experiment consisted of two parts: a cue-induced (cue condition) and a self-generated expectation variant (prediction condition). The order of the conditions was balanced across participants.

In trials of the cue condition, the participants were presented with a one-syllable word that cued the difficulty of the upcoming stimulus. The words presented were the German equivalents for *difficult* and *easy* and had to be read aloud. During the training phase (prior to the main experiment) participants learned that easy meant that font color and word meaning matched i.e. a congruent trial, while difficult meant that they did not match i.e. an incongruent trial. In the prediction condition they saw a prompt – a question-mark – to which they should respond by naming the difficulty they expected for the current trial by the same one-syllable words used in cuing. Thus, verbal output consisted of the same words in both types of expectation generation conditions. Participants had to name the color in which the word was written as fast and accurately as possible.

The overall 704 trials of the experiment were administered in eight blocks with 88 trials each. Both types of expectation condition were assessed in four consecutive blocks. Trial sequences (runs) were matched to what would be expected by chance (cf. Jiménez & Méndez, 2013) and balanced for congruency and expectation condition. For each expectation condition, there were 16 runs of four consecutive trials with identical conflict level (8 runs of 4 consecutive congruent and 8 runs of 4 consecutive incongruent trials), 32 runs of three consecutive trials (16 of congruent and 16 of incongruent trials), 64 runs of 2 consecutive trials (32 runs of 2 consecutive in/congruent trials), and 64 single trials (32 in/congruent trials). These runs were randomly distributed over the 4 blocks of each expectation condition, alternating between congruent and incongruent runs. With this setup the probability of a conflict level repetition is 50%. Cues were valid in 50% of the trials. In the prediction condition, expectation validity is about 50%, too, because repetitions occur at chance level.

2.4. Task procedure and instructions

The experimenter sat next to the participant during the entire experiment in a two person lab room. The experimenter calibrated the software for recording voice onset latencies and administered written instructions and a training phase to accustom the participant to the procedure. Participants completed four practice phases. During the first