Conflict monitoring in bilingual language comprehension? Evidence from a bilingual flanker task

Charlotte Eben

RWTH Aachen University, Department of Psychology, Aachen, Germany

Laboratoire de Psychologie Cognitive, Aix-Marseille Université and

Centre National de la Recherche Scientifique, Marseille, France

Mathieu Declerck

Laboratoire de Psychologie Cognitive, Aix-Marseille Université and

Centre National de la Recherche Scientifique, Marseille, France

This article was accepted in Language, Cognition, and Neuroscience. This article may not exactly represent the final published version. It is not the copy of record.

Address for correspondence:

Charlotte Eben

RWTH Aachen University

Department of Psychology

Jägerstrasse 17-19

52066 Aachen, Germany

Charlotte.eben@rwth-aachen.de

Abstract

Conflict monitoring, which is a process that detects conflict and initiates control processes to resolve said conflict, is assumed to be implemented in production-based language control. As conflict monitoring is a domain-general process, it should follow that it is also implemented in bilingual language comprehension. However, conflict monitoring is not explicitly implemented in models of bilingual language comprehension. With a bilingual flanker task, we investigated the Congruency Sequence Effect (CSE), which is a marker of conflict monitoring, in a bilingual language comprehension context. The results showed a congruency effect, but no CSE with the bilingual flanker, whereas both a congruency effect and CSE were observed with a non-linguistic numerical flanker. This pattern indicates that conflict monitoring might not arise in bilingual language comprehension.

Keywords: Conflict monitoring; Bilingualism; Language comprehension; Flanker task

Introduction

A remarkable function of human beings is to monitor and flexibly adjust our actions to circumstances or task demands. As soon as conflict arises, we are able to adjust our behavior to perform goals and tasks with few errors. There are several models which assume that conflict monitoring is involved in the initiation of production-based language control (Abutalebi et al., 2013; Abutalebi & Green, 2007; Branzi, Della Rosa, Canini, Costa, & Abutalebi, 2015; Green & Abutalebi, 2013; however, see Costa, Miozza, & Caramazza, 1999; La Heij, 2005), which is a process that restricts bilingual language processing to the target language (for reviews, see Abutalebi & Green, 2007; Declerck & Philipp, 2015). Most bilingual language comprehension models, on the other hand, do not explicitly assume that conflict monitoring is implemented in this modality. In the current study, we investigated the possibility of conflict monitoring in the context of bilingual language comprehension by investigating the congruency sequence effect (CSE) in a bilingual flanker task.

The conflict monitoring theory. The conflict monitoring theory proposes that a system (i.e., the anterior cingulate cortex; ACC) constantly monitors our actions. If this system detects conflict, for example in a nonroutine or challenging situation, control processes are engaged. The implementation of these control processes will persist for some time, and thus temporarily prevent conflict. Hence, a sequential modulation based on control takes place (Botvinick, Cohen, & Carter, 2004; Botvinick, Braver, Barch, Carter, & Cohen, 2001).

Conflict monitoring has generally been studied with conflict tasks, such as a typical flanker task (e.g., Eriksen & Eriksen, 1974), where there is a target presented in the middle that is flanked by two other stimuli on each side of the target stimulus. These target and flanker stimuli can either require the same response (congruent; e.g., when both the target arrow and the flanking arrows point to the left) or a different response (incongruent; e.g., when the target arrow points to the left, whereas the flanking arrows point to the right). There is more conflict in incongruent trials than in congruent trials, due to the target and flanker stimuli being different and requiring different responses. The increase in conflict that occurs in incongruent trials will be observed by the conflict monitor, and in turn the conflict monitor will signal for control processes to be implemented, as this conflict needs to be resolved in order for the task to be completed successfully. The increase in cognitive control is assumed to persist for some time, which will prevent any disruption of performance due to conflict in the subsequent trial. Hence, when an incongruent trial follows an incongruent trial, performance will be better than when an incongruent trial follows a congruent trial (e.g., Gratton, Coles, & Donchin, 1992). This effect is called the CSE and is considered to be a form of conflict adaptation within the conflict monitoring theory. The CSE has thus been regarded as a marker for conflict monitoring (e.g., Akcay & Hazeltine, 2008; Botvinick et al., 2001; for a review; see Egner, 2007), and has already been shown within and across different conflict types, such as spatial conflict in a Simon task (Simon & Small, 1969; Wühr, 2005; Wühr & Ansorge, 2005), conflict between different stimulus dimensions in a Stroop task (Stroop, 1935; Kerns et al., 2004), and conflict between different stimuli presented at the same time in a flanker task (Eriksen & Eriksen, 1974; Gratton et al., 1992; Ullsperger, Bylsma, & Botvinick, 2005).

Conflict monitoring during bilingual language processing. Conflict monitoring has also been used to explain bilingual language control regulation during bilingual language production (Abutalebi & Green, 2007; Green & Abutalebi, 2013). These models are supported by neuroimaging studies that have shown a connection between language control in bilingual language production and conflict monitoring regions (e.g., Abutalebi et al., 2007, 2012; Branzi et al., 2015). Abutalebi et al. (2007), for example, found that picture naming during language switching, relative to naming pictures in the same language throughout a block, engaged increased activation of the ACC.

However, unlike production models, models of bilingual language comprehension typically do not explicitly assume that conflict monitoring is used to instigate language control. The Bilingual Interactive Activation model (BIA; van Heuven, Dijkstra, & Grainger, 1998), for example, assumes a stimulus-driven activation of the target language node. This activation of the target language node results in inhibition of the non-target language. Thus, words that are not in the target language are inhibited and the activation level of a lexical representation is determined by this inhibitory process (for other bilingual language comprehension models that do not include conflict monitoring, see e.g., Dijkstra & van Heuven, 2002; Grainger, Midgley, & Holcomb, 2010; Schook & Marian, 2013; van Heuven & Dijkstra, 2010).

Nevertheless, conflict monitoring is considered to be domain general (e.g., Botvinick et al., 2001), thus it is highly probable that conflict monitoring is implemented to initiate comprehension-based language control if it is implemented to initiate production-based language control. Along these lines, some neuroimaging studies found that the ACC was active when language conflict arose during bilingual language comprehension (Hsieh et al., 2017; van Heuven, Schriefers, Dijkstra, & Hagoort, 2008).

The aim of the current study was to further investigate whether conflict monitoring is implemented during bilingual language comprehension. To this end, we used the novel bilingual flanker paradigm of Declerck, Snell, and Grainger (2018). Declerck et al. (2018) investigated the influence of language membership information on bilingual word processing in a flanker task with a lexical decision task. There were English and French words and non-words presented to French-English bilinguals, flanked by a word/non-word on either side. The critical manipulation was whether the flanker words were in the same language (congruent) or in the other language (incongruent) as the target word. This was the first study showing that language incongruent flankers can interfere with a central target word (i.e., bilingual congruency effect). While the methodology of the current study was similar to Declerck et al. (2018), the task was different: participants had to indicate whether the central target word was French or English (i.e., language decision task), instead of indicating whether the target word was a word or non-word (i.e., generalized lexical decision task). Due to this change of task, we would not lose all trials that followed a non-word when calculating the CSE, since these would not be followed by a language congruent or incongruent trial. Additionally, we conducted a numerical flanker task, next to the bilingual flanker task, in which the participants had to perform a numerical magnitude judgment (i.e., larger or smaller than five) with digits 1-9, except 5. The latter was a control task, to establish whether a CSE could be observed in a non-linguistic setting with our setup.

We expected a congruency effect (i.e., worse performance in incongruent trials compared to congruent trials) in the bilingual flanker task, since such an effect was observed in Declerck et al. (2018). Solving a conflict like this should also lead to performance improvement in subsequent conflict trials according to the conflict monitoring theory. More specifically, one could assume that this congruency effect would be reduced in trials following incongruent trials (i.e., CSE). This claim is based on the neuroimaging evidence for conflict monitoring in bilingual language comprehension. However, none of the current models of bilingual language comprehension have explicitly proposed a conflict monitoring process. Hence, it is unclear at the moment whether a CSE pattern would be observed in a bilingual language comprehension context.

Method

Participants. Thirty-two French-speaking participants (30 female), that spoke English as their second language, between 18 and 35 (*M* = 22; *SD* = 3.6) years of age were tested individually. They all had normal or corrected-to-normal vision and gave informed consent. Prior to the experiment, the participants filled in a questionnaire regarding their French and English proficiency. The questionnaire consisted of questions about the participants' ages of acquisition of the two languages, the average percentage of current language use, and the levels of speaking and reading skills in French and English on a 7-point scale, with 1 being *very bad* and 7 being *very good* (see Table 1). Furthermore, after the experiment the participants completed a French (Brysbaert, 2013) and English (Lemhöfer & Broersma, 2012) vocabulary test.

<Table 1>

Apparatus, materials, and task. The stimuli of the bilingual flanker consisted of 60 four-letter English target words (frequency: 5.37 Zipf; for information on Zipf, see van Heuven, Mandera, Keuleers, & Brysbaert, 2014), retrieved from the British Lexicon Project (Keuleers, Lacey, Rastle, & Brysbaert, 2012), and 60 four-letter French target words (5.65 Zipf) from the French Lexicon Project (Ferrand et al., 2010). All targets contained no diacritics and were not inflected forms. The participants had to perform a language decision task on the centrally presented target word by deciding whether the word was French (press “Q” on an azerty keyboard) or English (press “L”).

Each word was coupled with a four-letter English word and a four-letter French word serving as a flanker. Each target was only presented once to the participants and had either language congruent or incongruent flankers. The target and flanker words had no semantic overlap and were controlled for orthographic overlap across congruent and incongruent trials.

The stimuli of the numerical flanker task were digits between 1 and 9 without 5 (both targets and flankers). Here the participants had to perform a magnitude judgment, and thus decide whether the digit was smaller (press “Q” on an azerty keyboard) or larger (press “L”) than five. The flanking digits could either require the same response (congruent) or the alternative response (incongruent).

Procedure. The instructions were presented visually and orally, and the participants were instructed to react as fast and accurate as possible. For both flanker tasks (i.e., bilingual and numerical) there was a practice block of 16 trials and three experimental blocks of 40 trials each. Half of the trials in each block consisted of French words/digits smaller than 5, and the other half of the trials consisted of English words/digits larger than 5. Within a block, the amount of congruent and incongruent trials was the same, as well as the amount of sequential congruent and incongruent trials. The order of flanker task (bilingual vs. numerical) was counterbalanced across participants.

Every trial started with a blank screen. After 600 ms the target stimulus appeared centrally, with flanking stimuli, separated by one space, to the left and right of the target. They were presented until the participants' response.

Analysis. For the reaction time (RT) analyses, we excluded errors and trials following an error, the first trial of each block, as well as all RTs above and below 2 standard deviations from the mean per participant and per flanker task (bilingual: 4.5%; numerical: 3.8%).

The RT data were analyzed using mixed-effect models (Baayen, Davidson, & Bates, 2008), and the error data were analyzed using a logistic mixed model (Jaeger, 2008). Both, participants and items were considered random factors with all fixed effects (i.e. congruency [congruent vs. incongruent], congruency on trial n-1 [congruent vs. incongruent] and their interactions) varying by all random factors (Barr, Levy, Scheepers, & Tily, 2013)[1]. Finally, *t*- and *z*-values larger or equal to 1.96 were deemed significant (Baayen, 2008).

Results

The RT data in the bilingual flanker task revealed a significant main effect of congruency, b = 54.3, SE = 27.6, t = 1.97, indicating larger RT in incongruent than in congruent trials (854 ms vs. 806 ms; see Table 2). There was no main effect of congruency n-1 and we found no significant interaction, *t*s < 1[2]. There was also a trend of congruency in the error analysis, b = 0.5, SE = 0.3, z = 1.88, indicating that more errors occurred in incongruent than in congruent trials (7.2 % vs. 4.7 %). The main effect of congruency n-1 was not significant in the error analysis, and neither was the interaction, *t*s < 1[2]. The lack of a significant interaction in the RT and error analyses indicates that no CSE was observed with the bilingual flanker task.

<Table 2>

In the numerical flanker task, the RT data revealed no significant main effect of congruency, congruency n-1, or the interaction, *t*s < 1. However, we found a significant main effect of congruency in the error analysis, $b = 0.5$, SE = 0.2, $z = 2.15$, showing larger error rates in incongruent trials compared to congruent trials (3.2 % vs. 3.0 %; see Table 3), and a main effect of congruency n-1, $b = 0.7$, SE = 0.3, $z = 2.62$, showing larger error rates when trial n-1 was incongruent than when it was congruent (3.4 % vs. 2.8 %). We also found a significant interaction, $b = 0.9$, SE = 0.3, $z = 2.67$, showing reduced congruency effects when trial n-1 was incongruent compared to a congruent n-1 trial (-1.2 % vs. 1.4 %). Thus, a CSE was observed in the numerical flanker task.

<Table 3>

Discussion

In the present study, we investigated conflict monitoring in bilingual language comprehension. To this end, CSE, as a marker of conflict monitoring, was examined in a bilingual flanker task and a non-linguistic numerical flanker task. The RT results showed a congruency effect in the bilingual flanker and a trend towards this effect in the error rates. However, the congruency of the previous trial had no influence on the congruency effect of the current trial (i.e., no significant CSE). In contrast, in the numerical flanker, we found a congruency effect in the error data, which was larger after congruent trials (i.e., a significant CSE).[3]

The data of the bilingual flanker task supports the findings of Declerck and colleagues (2018), as we also found a bilingual congruency effect. Yet, we found no sign of CSE, which is a marker of conflict monitoring (e.g., Botvinick et al., 2001), in the bilingual flanker. This was confirmed by a Bayesian null hypothesis analysis (see footnote 2). Additionally, we found a congruency effect, even though this was based on a very small difference between congruent and incongruent trials, and a CSE in a similar non-linguistic flanker task with digits. This indicates that our setup allowed for CSE, and consequently provides further support that CSE, and thus conflict monitoring, might not arise in bilingual language comprehension.

Observing no evidence for conflict monitoring indicates that bilingual language comprehension models do not necessarily have to include a conflict monitoring process (e.g., Dijkstra & van Heuven, 2002; Grainger et al., 2010; Schook & Marian, 2013). This is currently not the case, as these models explain the initiation of comprehension-based language control without conflict monitoring. For example, according to the BIA model (van Heuven et al., 1998), a stimulus-driven activation of both language nodes takes place in incongruent trials, as the target word activates the target language node and the flanker words activate the non-target language node. In turn, the non-target language node inhibits the target word. Because the non-target language node is not activated in congruent trials, and thus does not inhibit the target word, worse performance in incongruent trials relative to congruent trials should occur according to the BIA (cf. Declerck et al., 2018). However, since no conflict monitor is implemented in the BIA, no CSE is assumed to occur according to this model. Our data seems to confirm this assumption, as we found a bilingual congruency effect but no CSE.

However, it should be noted that prior neuroimaging studies did provide evidence for conflict monitoring during bilingual language comprehension (Hsieh et al., 2017; van Heuven et al., 2008). This contrasting evidence across studies indicates that more research is necessary before we can unequivocally indicate whether bilingual language comprehension relies on conflict monitoring to identify conflict and send a signal to resolve said conflict.

In sum, our data did not show a CSE in a bilingual flanker task, whereas such an effect did occur in a non-linguistic numerical flanker task. As CSE is a marker for conflict monitoring, these findings indicate that conflict monitoring might not arise in bilingual language comprehension. This is in line with models of bilingual language comprehension, such as the BIA model, as these models do not explicitly incorporate a conflict monitoring process.

Authors' Note

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 706128.

Disclosure of interest

The authors report no conflict of interest.

References

Abutalebi, J., Annoni, J., Zimine, I., Pegna, A. J., Seghier, M. L., Lee-Jahnke, H., Lazeyras, F., Cappa, S. F., & Khateb, A. (2007). Language control and lexical competition in bilinguals: An event-related fMRI study. *Cerebral* C*ortex*, *18*, 1496-1505.

Abutalebi, J., Della Rosa, P. A., Green, D. W., Hernandez, M., Scifo, P., Keim, R., Cappa, S. F., & Costa, A. (2013). Bilingualism tunes the anterior cingulate cortex for conflict monitoring. *Cerebral* C*ortex*, *22*, 2076-2086.

Abutalebi, J., & Green, D. (2007). Bilingual language production: The neurocognition of language representation and control. *Journal of Neurolinguistics*, *20*, 242-275.

Akçay, Ç., & Hazeltine, E. (2008). Conflict adaptation depends on task structure. *Journal of Experimental Psychology: Human Perception and Performance*, *34*, 958-973.

Baayen R. (2008). *Analyzing Linguistic Data*: *A pratical introduction to stati*stics. Cambridge University Press.

Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language, 59,* 390–412.

Barr, D. J., Levy, R., Scheepers, C., & Tily, H. J. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language, 68,* 255–278.

Botvinick, M. M. (2007). Conflict monitoring and decision making: reconciling two perspectives on anterior cingulate function. *Cognitive, Affective, & Behavioral Neuroscience*, *7*, 356-366.

Botvinick, M. M., Braver, T. S., Barch, D. M., Carter, C. S., & Cohen, J. D. (2001). Conflict monitoring and cognitive control. *Psychological Review*, *108*, 624-652.

Botvinick, M. M., Cohen, J. D., & Carter, C. S. (2004). Conflict monitoring and anterior cingulate cortex: an update. *Trends in Cognitive Sciences*, *8*, 539-546.

Branzi, F. M., Della Rosa, P. A., Canini, M., Costa, A., & Abutalebi, J. (2015). Language control in bilinguals: monitoring and response selection. *Cerebral Cortex*, *26*, 2367-2380.

Brysbaert, M. (2013). Lextale_FR: A fast, free, and efficient test to measure language proficiency in French. *Psychologica Belgica, 53*, 23–37.

Costa, A., Miozzo, M., & Caramazza, A. (1999). Lexical selection in bilinguals: Do words in the bilingual's two lexicons compete for selection?. *Journal of Memory and Language*, *41*, 365-397.

Declerck, M., & Philipp, A. M. (2015). A review of control processes and their locus in language switching. *Psychonomic Bulletin & Review*, *22*, 1630-1645.

Declerck, M., Snell, J., & Grainger, J. (2018). On the role of language membership information during word recognition in bilinguals: Evidence from flanker-language congruency effects. *Psychonomic Bulletin & Review, 25,* 704-709.

Dijkstra, T., & van Heuven, W. J. (2002). The architecture of the bilingual word recognition system: From identification to decision. *Bilingualism: Language and Cognition*, *5*, 175-197.

Egner, T. (2007). Multiple conflict-driven control mechanisms in the human brain. *Trends in Cognitive Sciences*, *12*, 374-380.

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*, 143-149.

Ferrand, L., New, B., Brysbaert, M., Keuleers, E., Bonin, P., Méot, A., . . . Pallier, C. (2010). The French Lexicon Project: Lexical decision data for 38,840 French words and 38,840 pseudowords. *Behavior Research Methods, 42,* 488–496.

Grainger, J., Midgley, K., & Holcomb, P. J. (2010). Re-thinking the bilingual interactive-activation model from a developmental perspective (BIA-d). *Language Acquisition across Linguistic and Cognitive Systems*, *52*, 267-283.

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*, 480-506.

Green, D. W., & Abutalebi, J. (2013). Language control in bilinguals: The adaptive control hypothesis. *Journal of Cognitive Psychology*, *25*, 515-530.

Hsieh, M. C., Jeong, H., Kawata, K. H. D. S., Sasaki, Y., Lee, H. C., Yokoyama, S., Suguira, M., & Kawashima, R. (2017). Neural correlates of bilingual language control during interlingual homograph processing in a logogram writing system. *Brain and Language*, *174*, 72-85.

Jaeger, T. F. (2008). Categorical data analysis: Away from ANOVAs (transformation or not) and towards logit mixed models. *Journal of Memory and Language*, *59*, 434–446.

Kass, R. E., & Raftery, A. E. (1995). Bayes factors. *Journal of the American Statistical Association*, *90*, 773-795.

Keuleers, E., Lacey, P., Rastle, K., & Brysbaert, M. (2012). The British Lexicon Project: Lexical decision data for 28,730 monosyllabic and disyllabic English words. *Behavior Research Methods*, *44*, 287– 304.

Kerns, J. G., Cohen, J. D., MacDonald, A. W., Cho, R. Y., Stenger, V. A., & Carter, C. S. (2004). Anterior cingulate conflict monitoring and adjustments in control. *Science*, *303*, 1023-1026.

La Heij, W. (2005). Selection processes in monolingual and bilingual lexical access. *Handbook of Bilingualism: Psycholinguistic Approaches*, 289-307.

Lemhöfer, K., & Broersma, M. (2012). Introducing LexTALE: A quick and valid Lexical Test for Advanced Learners of English. *Behavior Research Methods*, *44*, 325–343.

Rouder, J. N., Speckman, P. L., Sun, D., Morey, R. D., & Iverson, G. (2009). Bayesian t tests for accepting and rejecting the null hypothesis. *Psychonomic Bulletin & Review*, *16*, 225-237.

Shook, A., & Marian, V. (2013). The bilingual language interaction network for comprehension of speech. *Bilingualism: Language and Cognition, 16*, 304-324.

Simon, J. R., & Small Jr, A. M. (1969). Processing auditory information: interference from an irrelevant cue. *Journal of Applied Psychology*, *53*, 433.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18*, 643-662.

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.

van Heuven, W. J., & Dijkstra, T. (2010). Language comprehension in the bilingual brain: fMRI and ERP support for psycholinguistic models. *Brain Research Reviews*, *64*, 104-122.

van Heuven, W. J., Dijkstra, T., & Grainger, J. (1998). Orthographic neighborhood effects in bilingual word recognition. *Journal of Memory and Language*, *39*, 458-483

van Heuven, W. J., Mandera, P., Keuleers, E., & Brysbaert, M. (2014). SUBTLEX-UK: A new and improved word frequency database for British English. *Quarterly Journal of Experimental Psychology*, *67*, 1176-1190.

Van Heuven, W. J., Schriefers, H., Dijkstra, T., & Hagoort, P. (2008). Language conflict in the bilingual brain. *Cerebral Cortex*, *18*, 2706-2716.

Wühr, P. (2005). Evidence for gating of direct response activation in the Simon task. *Psycho-nomic Bulletin & Review*, *12*, 282-288.

Wühr, P., & Ansorge, U. (2005). Exploring trial-by-trial modulations of the Simon effect. *The Quarterly Journal of Experimental Psychology*, *58*, 705-731.

Footnotes

[1] Fully randomized models resulted in convergence issues. To circumvent these issues, we determined the maximal random effects structure permitted by the data (cf. Barr et al., 2013), which led us to take out the interaction in the by-participant slopes in the RT analyses, and in the error analysis, we took out the random slopes.

[2] We also performed a Bayesian null hypothesis analysis (Rouder, Speckman, Sun, Morey, & Iverson, 2009) on the CSE, which allows for a statistical test in favor of the null hypothesis. The results showed positive evidence favoring the null hypothesis over the alternative hypothesis in the RT (BF01 = 5.1; Kass & Raftery, 1995) and error data (BF01 = 4.7).

[3] A more pronounced CSE in the error rates of the numerical flanker data could be due to conflict monitor regulating error detection (e.g., Carter, Braver, Barch, Botvinick, Noll & Cohen, 1998).