AUTHORS' RESPONSE

Models as hypothesis generators and models as roadmaps

MARC BRYSBAERT
NELE VERREYT
WOUTER DUYCK
Ghent University, Belgium

In this reply to Kroll, Van Hell, Tokowicz and Green (this issue) we present an analysis of the citations made to the Revised Hierarchical Model (RHM). This gives us a quantitative summary of the current use of the RHM, showing that RHM has been used equally often to guide research in word recognition as in word production. We also question the claim that Brysbaert and Duyck's (this issue) focus on word recognition leaves RHM unscathed for the explanation of word production and the interactions between lexical and conceptual representations. For these research topics too, we feel that more progress will be made by adapting computational monolingual models to the bilingual situation rather than by trying to understand the findings from the RHM framework.

No one doubts the huge contribution the Revised Hierarchical Model (RHM) has made to research on bilingualism. When it was published in 1994, it provided a much-needed synthesis of how the bilingual memory was organized and the way in which it functioned. As such, it offered researchers a framework to formulate new questions. The model also stayed close enough to people's intuitions to have immediate appeal. Indeed, every time we taught the model, we saw the students nod in agreement: this is how bilingualism SHOULD work. So, there was no doubt in our minds that RHM had to be the guide when we started our bilingual research in the late 1990s. And, truth be told, the model has been very rewarding to us, as it has been to many others. However, theoretical inspiration was not met with an equal amount of clarity, as the model mainly generated hypotheses that had to be rejected after empirical testing (at least for our type of bilinguals). Although this was gratifying in the spirit of scientific progress through falsification, after ten years of research we saw ourselves confronted with the question of whether we still thought that the model could serve as a roadmap for new students and practitioners. How many times must a theory fail the test before it becomes discredited?[1]

Because we agree with Kroll et al. that divergent results provide an opportunity for theoretical advancement, we considered it time to look back at the field's main source of inspiration, pinpointing those hypotheses that need refinement and those that do not. Within this spirit, we hope our critical review article, together with Kroll et al.'s reply, will benefit the field. By making unresolved controversies more explicit, we hope our joint effort will improve the field's orientation and guide it to new, fruitful research questions. We are grateful to Kroll et al. for their reply and the counterweight they offer to our reservations.

Kroll et al. are right that our analysis focused on word perception, as this is the field where the RHM has inspired our own research the most. However, it was with some surprise that we read we may have misunderstood the RHM in this respect, because "the RHM is fundamentally a model of word production" (pp. 000). This brings us to the wider issue of how the RHM has been used by researchers. Were we the only ones failing to understand that the RHM may not apply to perception? To answer this question, we thought it would be interesting to see what ideas from RHM researchers have focused on and how often they came to conclusions that supported the model. Kroll et al. rightly argue that RHM has been a fruitful model, leading to over 300 citations. So, we decided to analyze the citations to RHM between 1994 and 2009. To depersonalize the issue, we left out the papers co-authored by one of the authors involved in the present discussion (36). We were also unable to get hold of 56 papers, and 37 more were dropped because they did not contain empirical

[1] Popper changed his mind about this question during his career. Originally he thought researchers should give up a theory right away after the first falsification. Later he acknowledged that such an attitude would have left us with very few scientific theories and he even advised theorists to be dogmatic: "If we give in to criticism too easily, we shall never find out where the real power of our theories lies" (Popper, 1970, p. 55).

Address for correspondence:
Marc Brysbaert, Department of Experimental Psychology, Ghent University, Henri Dunantlaan 2, B-9000 Gent, Belgium. Tel: +32 9 264 94 25. Fax: +32 9 264 64 96.
marc.brysbaert@ugent.be

work. In the end, 166 articles remained, half of which (83) dealt with perception and half (82) with production (one could not be classified). So, if RHM is limited to word production, it looks like the underspecification of the initial model has lead to a lot of misguided research, perhaps addressing irresolvable issues. This is important information for future research.

The analysis of the citations to RHM allows us to quantify a few more trends. To classify the various articles, two axes were used. The first concerned the topic addressed; the second the conclusion reached. For the latter a distinction was made between (1) merely mentioning the feature, (2) actively supporting the feature or (3) rejecting a prediction made by RHM. Unfortunately, space restraints preclude us from listing the articles in full (readers can obtain the tables with the references from the authors[2]).

The most frequently tested aspect of the model is the asymmetry between L1 and L2 processing. Of the 64 articles addressing this topic, 29 found evidence in line with RHM, 25 reported counter-evidence, and 10 merely mentioned the feature. The second most frequently addressed characteristic was the developmental change taking place as people become more proficient in L2. Most of the articles referring to this aspect supported the RHM (19/30), only one found evidence against the model, and 10 mentioned it. Thirteen articles addressed the common conceptual system shared by L1 and L2, most of which supported it (8/13) or simply mentioned it (4/13). Again, only one study reported counter-evidence. The least supported aspect was the idea of selective access, with 3/6 articles rejecting the hypothesis, and only 2/6 supporting it. Interestingly, one more strength of the Kroll and Stewart (1994) article was the introduction of the semantic blocking paradigm to investigate semantic mediation in stimulus naming and translation: 25 articles referred to this aspect.

The above paragraph arguably presents the fairest summary of the current use of RHM. It will be interesting to see whether the co-publication of Brysbaert and Duyck (this issue) and Kroll et al. (this issue) is going to alter this pattern in the coming fifteen years. Will we see a decrease of perception-related experiments testing RHM

and an increase of production-related studies? Will we see other models gaining prominence? In this respect, we would like to make clear that we do not fully agree with Kroll et al.'s conclusion that Brysbaert and Duyck's focus on perception leaves RHM unscathed for explaining word production and the interactions between lexical and conceptual representations. Our message was that new progress can be made, not by starting to see how we can adapt RHM to incorporate the contradictory findings, or how we can develop a new model of bilingual memory, but by examining how we can adapt existing computational models of monolingual language processing to the bilingual situation. We discussed the BIA+ model as an example of word perception, because this model is an extension of the interactive activation model originally developed for single language processing. Similarly, we think that more insight will be gained in bilingual word production by looking at how computational models of monolingual word production can be extended than by trying to integrate the divergent empirical findings within the RHM framework. The same is true for the relationship between lexical and conceptual representations. There is a flourishing community investigating the semantic system, and it seems to us that we may learn a great deal by studying their models and findings. Indeed, some inroads from this research community into the organization of the bilingual memory have already been made (e.g., Ameel, Malt, Storms and Van Assche, 2009).

References

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[2] The tables are also available on the Journal's website as Supplementary Materials accompanying the present article (see journals.cambridge.org/bil, vol. 13 (3)).