LANGUAGE AND COGNITIVE PROCESSES
2007, 22 (8), 1281–1286

Psychology Press
Taylor & Francis Group

On the modelling of spoken word planning: Rejoinder to La Heij, Starreveld, and Kuipers (2007)

Ardi Roelofs

Nijmegen Institute for Cognition and Information, and F. C. Donders Centre for Cognitive Neuroimaging, Nijmegen, The Netherlands

The author contests several claims of La Heij, Starreveld, and Kuipers (this issue) concerning the modelling of spoken word planning. The claims are about the relevance of error findings, the interaction between semantic and phonological factors, the explanation of word-word findings, the semantic relatedness paradox, and production rules.

In my article (Roelofs, 2007b this issue), I presented a critique of the simple name-retrieval models of spoken word planning proposed by La Heij and colleagues. I argued that these models have difficulty accounting for several empirical findings, including speech error biases, types of morpheme errors, and context effects on the latencies of vocal responding to pictures and words. In their reply, La Heij, Starreveld, and Kuipers (2007b this issue), henceforth LSK, dispute many of my claims. Here, I respond to some of their major counterarguments.

Relevance of speech error findings

LSK maintain that the error findings are irrelevant, because there was never an intention to model these findings. However, whether La Heij and colleagues actually intended to model certain empirical findings is not really important for using the findings in evaluating their models, as long as the findings are relevant. For example, although WEAVER++ has not been designed to account for speech errors, some of the key findings on speech

Correspondence should be addressed to Ardi Roelofs, Nijmegen Institute for Cognition and Information, Radboud University Nijmegen, Spinoza Building, B.02.32, Montessorilaan 3, 6525 HR Nijmegen, The Netherlands. E-mail: A.Roelofs@nici.ru.nl

http://www.psypress.com/lcp DOI: 10.1080/01690960701462291

errors have motivated assumptions made in the model, such as the assumption of levels of lemmas and phonemes. These error-motivated assumptions have determined the performance of WEAVER++ in simulations of results on response times. Thus, I maintain that error findings are relevant for evaluating the name retrieval models. LSK now seem to accept that phonemes are involved in spoken word planning. I note that this involves a change of the (implicit) theory underlying the name retrieval models. If the change of theory is endorsed, the simulation results reported by La Heij and colleagues in several articles can no longer be taken as support for the name retrieval models.

LSK seem to believe that phonemes can be included in the name retrieval models without a cost. However, this remains to be demonstrated. For example, Peterson, Dell, and O'Seaghdha (1989) presented simulations of phonological effects of written word distractors on picture naming latencies using a model consisting of letter, lexical, and phoneme nodes. Selection of phoneme nodes was based on level of activation only, as in the name retrieval models. Thus, an extension of the name retrieval models with phoneme nodes would presumably be similar to this model of Peterson et al. Simulations revealed that the model had great difficulty in selecting the correct phoneme nodes in the context of written distractors. In some distractor conditions, the error percentage was about 50%, whereas the real error percentage is typically below 5%. To account for the latency effects in the absence of a massive amount of errors, Peterson et al. suggested that the latency effects were due to error monitoring and repair, although they did not specify how this worked. In contrast, Roelofs (1997) showed how WEAVER++ explains the data. Thus, the challenge for LSK is to demonstrate that the name retrieval models with phoneme selection do not suffer from the problems that confront models such as those of Peterson et al. (1989).

Accounting for the word-word findings

LSK reject my claim that the name retrieval models cannot account for Stroop-like effects in the word-word task. They argue that the word-word effects reflect perceptual interference rather than response competition. Under the perceptual interference account, distractor word FISH interferes with reading aloud DOG compared to XXX, whereas DOG as distractor speeds up the reading of DOG. This is because the distractor FISH yields interference in the perceptual processing of DOG whereas the distractor DOG helps perceptual processing. However, the perceptual account fails to explain why response-set effects may be obtained in the word-word task (Glaser & Glaser, 1989). For example, if *fish* is a response and *bird* is not, FISH may yield more interference than BIRD. This suggests that the effects arise during response selection (Roelofs, 2003a).

Interaction between semantic and phonological factors

LSK contest my claim that the findings of Damian and Martin (1999) pose problems to the name retrieval models by arguing that these findings need to be replicated first. I have not attempted to replicate these findings, but I have conducted experiments that are closely related (yet unpublished data, described in Roelofs, 2005). According to WEAVER++, the interaction between semantic and phonological relatedness occurs because a mixed distractor (e.g., *donkey*) activates the target (e.g., *dolphin*) as cohort member. Research on spoken word recognition has shown that word candidates are activated to the extent that their initial phonemes are shared (see Roelofs, 2003b, for a review). Thus, whereas the cohort competitor *donkey* should yield the interaction in naming a dolphin, the rhyme competitor *robin* should not. In replicating the experiment of Damian and Martin (1999) using rhyme competitors, I obtained the regular semantic interference and phonological facilitation effects but no interaction. This result supports WEAVER++ and challenges the name retrieval models.

Semantic relatedness paradox

In an English-to-Dutch word translation task, distractor pictures yield semantic facilitation, whereas Dutch distractor words yield semantic interference. LSK argue at length that WEAVER++ is unable to simulate this finding. However, the verbal description of why WEAVER++ presumably fails is not convincing. Given the complexity of the experimental situation and the number of factors involved, computer simulations would be critical. I have therefore performed these simulations. The simulations were equivalent to those reported in Roelofs (1992, 2003a, 2006), except that each concept (e.g., DOG(X)) was connected to two lemmas, one for each language (i.e., Dutch *hond*, English *dog*). Word translation began by activating the lemma of the to-be-translated English word (e.g., *dog*), which was followed by the selection of the corresponding concept. Finally, the lemma of the Dutch translation equivalent (*hond*) was selected. Picture distractors were simulated by activating the corresponding concept nodes and Dutch word distractors were simulated by activating the corresponding lemma nodes. The response selection threshold was 1.0, and the distractor duration was 125 ms for pictures and 150 ms for words (this difference is not crucial, but served to optimise the fit). Because of the requirement to include two languages, there were twice as many lemma nodes than in the simulations of Roelofs (1992, 2003a, 2006). Therefore, the overall spreading rate was reduced by half. In the simulations, picture distractors yielded 27 ms semantic facilitation and word distractors yielded 23 ms semantic interference. The real facilitation and interference effects were both 28 ms in Experiment 1 of Bloem and La Heij (2003). The simulations demonstrate that the semantic relatedness paradox in word translation may occur in WEAVER++, in contrast to what LSK claim. Latency effects of distractors in WEAVER++ are the outcome of intricate processing interactions within the word production architecture (e.g., Roelofs, 1992, 2003a, 2006). LSK mention a number of factors that may influence the latency outcome, such as network distance, but they ignore that the presence of two languages in a translation task may also have an effect.

Production rules

LSK notice that even after accepting the theoretical changes to the name retrieval models that I proposed, several important theoretical differences still remain between the name retrieval models and WEAVER++. In particular, WEAVER++ employs condition-action production rules, whereas the name retrieval models do not. LSK hold that the problem with production rules is that they result in error-free performance, lack independent motivation, and provide no insight.

Although it is true that WEAVER++ made no errors in most simulations (likewise, the error percentages in the simulated experiments were very low and typically followed the response time patterns), the model has been applied to error findings (Roelofs, 1992, 1997, 2003a, 2004, 2005) and has simulated error data (Levelt et al., 1999). Errors may occur in the model when noise is present in the production rule application. This account of errors may be extended by allowing for partial production rule matching (cf. Anderson, 1983). Although WEAVER++ may accept partial matches, it should prefer a full match to a partial match. Errors may occur because of goal neglect. Initial explorations of partial production rule matching in WEAVER++ through computer simulations suggested that partial matching not only does a good job in accounting for error patterns, but also for the latency effects of message and response congruency referred to by LSK.

According to LSK, another problem with production rules is that they lack independent motivation and provide no insight. It is not completely clear what LSK mean by a lack of independent motivation. Production rules do not lack neural plausibility. Evidence from single cell recordings and functional brain imaging studies suggests that primate prefrontal cortex is implicated in the retrieval, implementation, and maintenance of condition-action rules (e.g., Bunge, 2004; Bunge, Kahn, Wallis, Miller, & Wagner, 2003; Wallis, Anderson, & Miller, 2001). Moreover, the critique of LSK that production rules do not really provide insight misses a principled motivation. The use of production rules is grounded in a long explanatory tradition in psychology (e.g., Allport, 1980; Anderson, 1983; Anderson, Bothell, Byrne, Douglas, Lebiere, & Qin, 2004; Logan, 1985; Meyer & Kieras, 1997; Newell, 1990). Rejecting production rules, as LSK seem to do, amounts to the rejection of this successful tradition.

The task-activation approach that LSK advocate as an alternative to production rules may perhaps handle some simple, limited task situations, but it is inadequate in dealing with more complex circumstances (e.g., Roelofs, 2003a, 2007a). It seems that the task-activation approach of LSK can only be endorsed at the cost of oversimplifying experimental situations. Unlike what I described above for WEAVER++, Bloem and La Heij (2003) simulated word translation by providing the equivalent of picture input to the network of the discrete name-retrieval model, thereby making picture naming and word translation equivalent. However, the task was word translation, not picture naming. Moreover, the lexical phonological nodes of only one language (Dutch) were present in their simulations. By treating word translation as monolingual picture naming, Bloem and La Heij (2003) avoided the need to address the problem of how their model manages to select the lexical phonological node of a Dutch translation equivalent as response rather than the lexical phonological node of the English input word itself, which may be activated higher than the translation equivalent. Thus, the task-activation approach is insufficient even for the situations it was designed to explain.

To conclude, the counterarguments of LSK do not refute my claim that existing data challenge the name retrieval models. It remains to be demonstrated (preferably by computer simulations) that new, modified versions of the name retrieval models can account for the problematic findings.

REFERENCES

Allport, D. A. (1980). Patterns and actions: Cognitive mechanisms are content-specific. In G. Claxton (Ed.), *Cognitive psychology: New directions* (pp. 26–64). London: Routledge & Kegan Paul.

Anderson, J. R. (1983). *The architecture of cognition*. Cambridge, MA: Harvard University Press.

Anderson, J. R., Bothell, D., Byrne, M. D., Douglas, S., Lebiere, C., & Qin, Y. (2004). An integrated theory of the mind. *Psychological Review*, *111*, 1036–1060.

Bloem, I., & La Heij, W. (2003). Semantic facilitation and semantic interference in word translation: Implications for models of lexical access in language production. *Journal of Memory and Language*, *48*, 468–488.

Bunge, S. A. (2004). How we use rules to select actions: A review of evidence from cognitive neuroscience. *Cognitive, Affective, and Behavioral Neuroscience*, *4*, 564–579.

Bunge, S. A., Kahn, I., Wallis, J. D., Miller, E. K., & Wagner, A. D. (2003). Neural circuits subserving the retrieval and maintenance of abstract rules. *Journal of Neurophysiology*, *90*, 3419–3428.

Damian, M. K., & Martin, R. C. (1999). Semantic and phonological codes interact in single word production. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *25*, 345–361.

Glaser, W. R., & Glaser, M. O. (1989). Context effects in Stroop-like word and picture processing. *Journal of Experimental Psychology: General*, *118*, 13–42.

La Heij, W., Starreveld, P. A., & Kuipers, J.-R. (2007). Structural complexity is not the (big) issue: A reply to Roelofs (2007). *Language and Cognitive Processes, 22,* 1261–1280.

Levelt, W. J. M., Roelofs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences*, *22*, 1–38.

Logan, G. D. (1985). Executive control of thought and action. *Acta Psychologica*, *60*, 193–210.

Meyer, D. E., & Kieras, D. E. (1997). A computational theory of executive cognitive processes and multiple-task performance: Part 1. Basic mechanisms. *Psychological Review*, *104*, 3–65.

Newell, A. (1990). *Unified theories of cognition*. Cambridge, MA: Harvard University Press.

Peterson, R. R., Dell, G. S., & O'Seaghdha, P. G. (1989). A connectionist model of form-related priming effects. *Proceedings of the 11th Annual Conference of the Cognitive Science Society* (pp. 196–203). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Roelofs, A. (1992). A spreading-activation theory of lemma retrieval in speaking. *Cognition*, *42*, 107–142.

Roelofs, A. (1997). The WEAVER model of word-form encoding in speech production. *Cognition*, *64*, 249–284.

Roelofs, A. (2003a). Goal-referenced selection of verbal action: Modeling attentional control in the Stroop task. *Psychological Review*, *110*, 88–125.

Roelofs, A. (2003b). Modeling the relation between the production and recognition of spoken word forms. In N. O. Schiller & A. S. Meyer (Eds.), *Phonetics and phonology in language comprehension and production: Differences and similarities* (pp. 115–158). Berlin: Mouton de Gruyter.

Roelofs, A. (2004). Error biases in spoken word planning and monitoring by aphasic and nonaphasic speakers: Comment on Rapp and Goldrick (2000). *Psychological Review*, *111*, 561–572.

Roelofs, A. (2005). Spoken word planning, comprehending, and self-monitoring: Evaluation of WEAVER++. In R. J. Hartsuiker, R. Bastiaanse, A. Postma, & F. Wijnen (Eds.), *Phonological encoding and monitoring in normal and pathological speech* (pp. 42–63). Hove, UK: Psychology Press.

Roelofs, A. (2006). Context effects of pictures and words in naming objects, reading words, and generating simple phrases. *Quarterly Journal of Experimental Psychology*, *59*, 1764–1784.

Roelofs, A. (2007a). Attention and gaze control in picture naming, word reading, and word categorizing. *Journal of Memory and Language, 57*, 232–251.

Roelofs, A. (2007b). A critique of simple name-retrieval models of spoken word planning. *Language and Cognitive Processes, 22,* 1237–1260.

Wallis, J. D., Anderson, K. C., & Miller, E. (2001). Single neurons in prefrontal cortex encode abstract rules. *Nature*, *411*, 953–956.