Modeling Lexical Effects in Language Production: Where Have We Gone Wrong?

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1 Introduction

Words have their own conceptual representations, semantic properties, and physical forms. These lexical characteristics not only set words apart as a distinct item in the lexical repertoire but also provide valuable insight into the processes and mechanisms of language production.

Over the past decades there has been a large body of research examining how word meaning, form, and usage directly affect the speed of monolingual speakers' production (e.g. Alario et al., 2004; Barry, Morrison, & Ellis, 1997; Bates et al., 2003; Bonin, Chalard, Méot, & Fayol, 2002). Of note, almost all these studies have failed to accommodate the fact that word usage, given it is a behavioral outcome (Zevin & Seidenberg, 2002, 2004), likely mediates the relationship between meaning/form and spoken production. Moreover, lexical characteristics have been predominantly examined as discrete variables in the literature, but in fact, some of them may correspond to the same layer of language production or the same aspect of lexical knowledge. Additionally, little work has been done on children's emerging bilingual lexical representations, especially those learning an L2 within input-limited contexts, possibly due to the fact that this population has only recently begun to receive focused attention in the research field.

In order to delineate the exact manner in which lexical effects come into play, the present study used structural equation modeling to perform a simultaneous test of the complex relationships among a variety of lexical variables and to assess their direct, indirect and total effects on L2 lexical processing efficiency. Furthermore, attempts were also made to estimate and then to compare three types of hypothesized models, in which the lexical relationships were specified differently with respect to spoken production in L2 learners.

2 Lexical characteristics that contribute to the speed of spoken production

This study considers three lexical layers (i.e. Meaning, Form, and Usage), each of which is underpinned by its own manifest indicators. The lexical variables under examination all have been found to significantly influence the speed of lexical processing, as will be briefly reviewed below.

Meaning. (1) Word concreteness (WC): A main difference between concrete and abstract words lies in the existence of sensorimotor attributes of the former. A number of studies have revealed that concrete words exhibit preferential processing relative to abstract words (e.g. De Groot, 1992; Jin, 1990; Schwanenflugel & Akin, 1994). (2) Word typicality (WT): The degree of a lexical item's typicality depends upon how many attributes that it shares with other members of the same category. Typical items are usually processed more accurately and faster relative to atypical items in a range of tasks (e.g. Bjorklund & Thompson, 1983; Jerger & Damian, 2005; Southgate & Meints, 2000). (3) Semantic neighborhood density (SND): Words with high SND are characterized by having a great deal of semantic neighbors and low semantic distance, whereas low-SND words typically have few semantic neighbors and high semantic distance. The superiority of high SND over low SND words for processing has been observed in lexical decision, word naming, and semantic categorization (e.g. Buchanan, Westbury, & Burgess, 2001; Siakaluk, Buchanan, & Westbury, 2003; Yates, Locker, & Simpson, 2003). (4) Number of related senses (NoRS): Many words are polysemous in terms of having several different but related senses. Compared to monosemous words, polysemous words exhibit preferential processing in a variety of tasks (e.g. Beretta, Fiorentino, & Poeppel, 2005; Klepousniotou & Baum, 2007; Lichacz, Herdman, Lefevre, & Baird, 1999).

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Form. Word length can be measured orthographically (i.e. NoL: number of letters) or phonologically (i.e. NoP: number of phonemes and NoS: number of syllables). The presence of length effects has been reported in several previous studies (e.g. Alario et al., 2004; Cuetos, Ellis, & Alvarez, 1999; De Groot, Borgwaldt, Bos, & Van den Eijnden, 2002) although the predictive power of each specific measure varies across research contexts possibly due to their examination of different languages (Bates et al., 2003).

Usage. Usage is represented by subjective word frequency (SWF) and /or age of acquisition (AoA), both of which have been observed to significantly affect the speed of spoken production in such a way that individuals take less effort to access high-frequency and early-acquired words relative to low-frequency and late-acquired ones (e.g. Balota, Cortese, Sergent-Marshall, Spieler, & Yap, 2004; Barry et al., 1997; Morrison, Ellis, & Quinlan, 1992). AoA effects interact with frequency effects in such a way that the former is partly dependent on the latter (Brysbaert & Ghyselinck, 2006).

3 Methodology and analytical strategies

3.1 Methodology

Participants. Thirty-nine 5th grade children (aged 10-11 years) and 94 undergraduates (aged 17-20 years) were recruited. All had Chinese as their native language and English as their second. The child sample had been learning English as a foreign language for about 2.5 years, and the adult sample for approximately 10 years.

Stimuli. The experiment consisted of two blocks of stimulus words and one block of filler words. Each block had 35 (in the child group) / 66 (in the adult group) valid trials. The stimuli were selected from ten semantic categories in almost equal numbers. They were all presented in the same format over the course of the experiments.

Procedures. The participants were tested individually in a quiet room. They performed picture naming in L2 (English) and then L1 (Chinese)-to-L2 (English) translation. As a stimulus appeared on the screen, the participants were asked to produce the L2 word as rapidly and accurately as possible. The SuperLab software (Cedrus Corporation, 2007) generated stimulus presentations. Response latencies (RLs), defined as the duration between the presentation of a stimulus and the initiation of a vocal response, were recorded using the Audacity software, and then manually calculated for analysis.

Norms of lexical variables. The values of WC, WT, and SWF were rated by the participants on Likert scales. The values of other lexical variables were obtained from psycholinguistics databases such as the Irvine Phonotactic Online Dictionary (Vaden, Halpin, & Hickok, 2009) and the Wordmine2 (Durda & Buchanan, 2006).

3.2 Analytical strategies

Structural equation modeling (SEM), which combines path analysis, confirmatory factor analysis, and analysis of structural models, was used to estimate the goodness-of-fit of three types of hypothesized models. This analytical strategy, as an extension of multiple regression, enables researchers to estimate not only the direct effects but also indirect effects that one variable has upon another. Moreover, SEM can be used to measure the proportion of variance explained by the models proposed in the present study so as to hold general implications for the lexical processing system as a whole, although it should be acknowledged that this type of analysis might lack a specific focus on certain variables through purposeful manipulation of experimental materials. Additionally, latent variables are formed to manifest different dimensions that are underpinned by their own indicators. In so doing, the present study moves away from the examination of each lexical variable to that of specified constructs and structural relations between constructs, thus a better understanding of the nature of lexical characteristics can be gained at a more macro level.

Conducting SEM typically involves six steps (Kline, 2011): model specification, model identification, select good measures, model estimation, model evaluation and modification, and interpreting and reporting results. Moreover, as recommended by Kline (2011), SEM was conducted in two steps in the present study, that is, the measurement models were validated in terms of convergent validity, discriminant validity, and reliability before the structural models proceeded to be estimated. One last thing to note is that the data entered for analysis were lexical items. The stimulus size in the adult group was considered sufficiently large for performing SEM analysis. In order to reduce the complexity of the hypothesized model specifying children's L2 lexical processing, composite variables rather than latent variables were constructed to decrease the number of stimulus words required for this type of analysis.

Three competing models were hypothesized and estimated to determine which one best fitted the data. The first model concerns only the direct relationship between the lexical variables, and picture naming and translation latencies. The second model identifies word usage as a mediator and examines the indirect effects of meaning and form variables on the recorded RLs. The third model considers both direct and indirect effects of word meaning and form on the outcome variable. To illustrate, an example of these three types of hypothesized models that specify the possible relationships between lexical variables and the speed of adults' picture naming is presented in Appendix A.

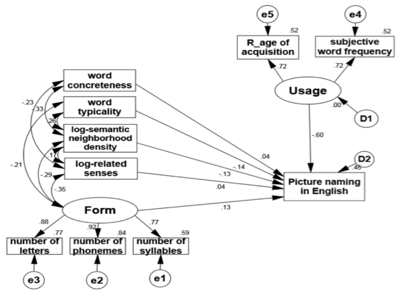
The goodness of model fit was estimated according to six types of indices, including model χ^2, CFI, RMSEA, AGFI, GFI, and NFI. A rule of thumb is that an RMSEA below .08 indicates reasonable fit, and values greater than .90 for the CFI, AGFI, GFI, and NFI suggest close approximate fit. SEM was run using IBM SPSS AMOS v.20.

It should be noted that, before performing SEM analysis, the whole RL data set was screened for incorrect and omitted responses, outliers (low cut-off: below 350ms, high cut-off: 3 SDs), and those participants and stimulus items with an exceptionally high error rate. As conventionally done, RLs were then averaged to generate a summary score for each lexical item, and these values were entered into final SEM analysis.

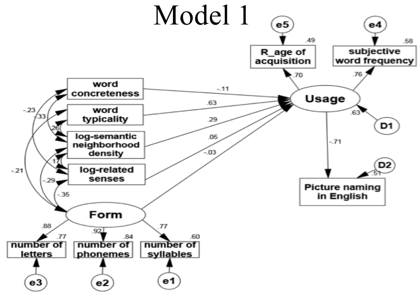
4 Results

The model-fit indices of the three models under examination across two types of productive tasks in both populations are presented in Appendix B. Comparatively, the child and adult data could best be modeled by the third model where word meaning and form not only make direct but also indirect contribution to the RLs.

Take picture naming in adults as an example (see SEM results in Appendix B and Figure 1), it is clear that Model 3 achieved a much better model fit than Model 1, and Model 3 explained more variance in naming latencies (59%) than Model 1 (45%) and Model 2 (51%). Additionally, among all the lexical variables included in Model 3, only word usage was found to make a significant and direct contribution to the naming latencies. Similar results held for adults' L1-to-L2 translation (see Appendix C for details).



Model 1



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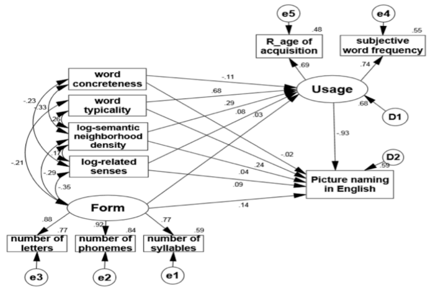
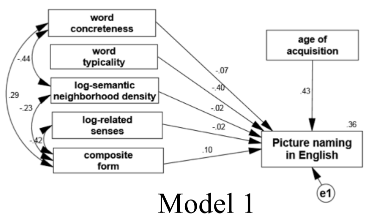


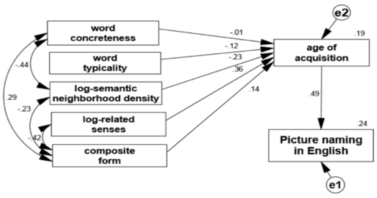
Model 3

Figure 1: SEM results: Picture naming in adults

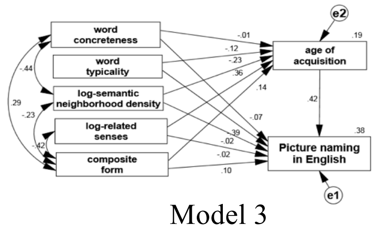
As regards children's picture naming, the results presented in Appendix B shows that Model 3 reached a better model fit than Models 1 and 2. Moreover, Figure 2 indicates that Model 3 (38%) explained more variance in naming speed than Model 1 (36%) and Model 2 (24%). In addition, word usage, as represented by age of acquisition, together with word typicality were found to significantly and directly predict the naming speed in Model 3. Similar results were observed with children's L1-to-L2 translation (see Appendix C for details).



Model 1



Model 2



Model 3

Figure 2: Path analysis results: Picture naming in children

Taken together, these results indicate that word usage does not exist independently of other lexical variables but rather mediates the impact of meaning and form on L2 children's and adults' productive performance. In comparison, the indirect effects of meaning and form on L2 lexical processing efficiency were found to be more noticeable with adults relative to with children.

5 Discussion and conclusions

The present study uses SEM as a methodological improvement to investigate the relationships between a range of lexical variables and L2 lexical processing efficiency in both children and adults. A comparison of the three different types of models indicates that word meaning and form makes not only direct but also indirect contribution to the speed of L2 lexical processing, and word usage likely mediates the extent to which meaning and form influence the processing outcome. Furthermore, a comparison between children and adults suggests that the importance of word usage tends to increase with age.

A note of caution thus should be raised when interpreting the results of previous studies where the mediating effects of word usage have not been adequately addressed. Accordingly, future research modeling lexical effects would be well advised to consider the indirect effect that word meaning and form have on L2 learners' productive performance via usage.

Although this study provides new insights into how lexical variables are related to each other, there are several limitations that should be acknowledged. First, since this research focuses only on L2 learners within input-limited contexts, whether or not the same results still hold for other L2 learner types, particularly those whose L1s are not Sino-Tibetan languages, as well as for monolingual speakers needs to be further investigated. Importantly, examining these issues would allow us to gain a better understanding of the nature of lexical characteristics by addressing the issue of whether lexical effects are language-dependent or universal across languages. Second, not all the variance can be explained the included lexical variables, partly due to the fact that it seems implausible to cover every possible feature of a lexical item because of theoretical and practical considerations. Third, given the use of a non-experimental design, it would be difficult to make unequivocal explanations of causality among the variables of interest.

To conclude, the model that considers both direct and indirect effects of meaning and form on L2 lexical processing efficiency may be superior to those that do not. As also observed in our study, word usage does play a mediating role in lexical processing, in part reflecting that 'only in the stream of thought and life do words have meanings' (Wittgenstein, 1967, p.31).

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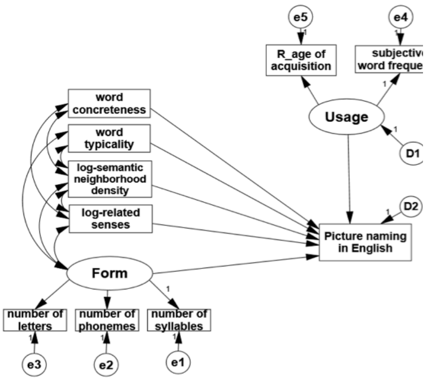
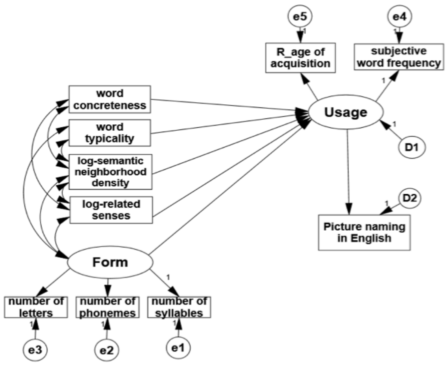
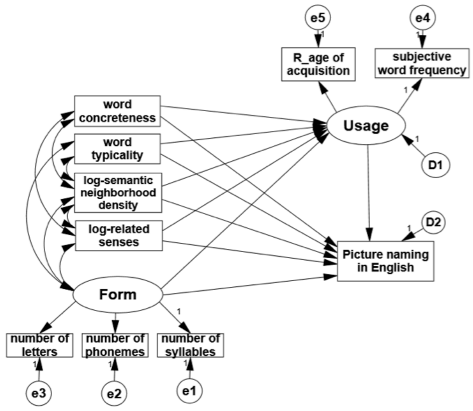
Appendix A. An example of the hypothesized models

Adult picture naming







Model 1 Model 2 Model 3

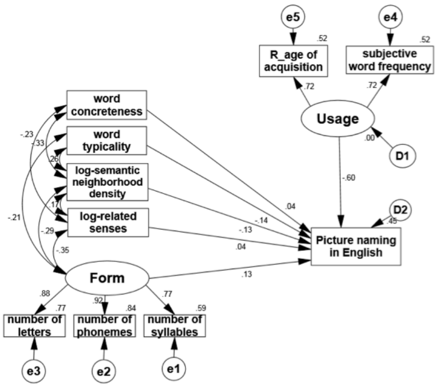
Appendix B. Fit indices for the hypothesized models

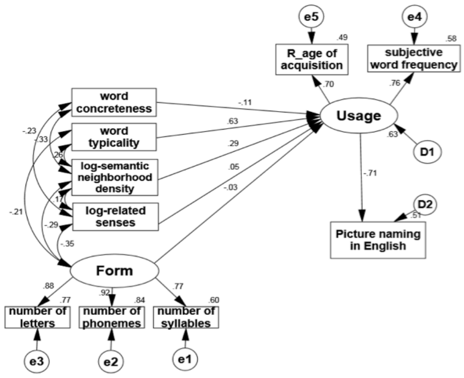
			χ^2 (p)	*df*	*CFI*	*RMSEA*	*AGFI*	*GFI*	*NFI*
Adults	Picture naming	Model 1	173.83 (.00)	27	.81	.17	.74	.87	.79
		Model 2	52.16 (.00)	27	.97	.07	.90	.95	.94
		Model 3	45.96 (.00)	22	.97	.08	.90	.96	.94
	Chinese-English translation	Model 1	169.46 (.00)	27	.81	.16	.75	.88	.79
		Model 2	45.69 (.01)	27	.98	.06	.91	.96	.94
		Model 3	41.87 (.01)	22	.97	.07	.90	.96	.95
Chil-dren	Picture naming	Model 1	28.17 (.00)	11	.85	.27	.82	.93	.79
		Model 2	28.52 (.00)	11	.88	.12	.83	.94	.79
		Model 3	5.67 (.46)	6	1.00	.00	.93	.99	.96
	Chinese-English translation	Model 1	28.17 (.00)	11	.81	.12	.82	.93	.74
		Model 2	23.09 (.02)	11	.86	.10	.87	.95	.79
		Model 3	5.67 (.46)	6	1.00	.00	.93	.99	.95

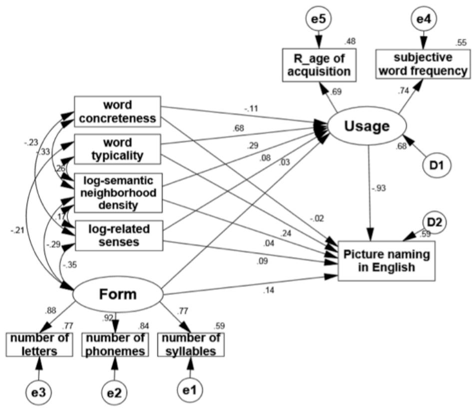
Appendix C. SEM results of the hypothesized models

Adults:

Picture naming

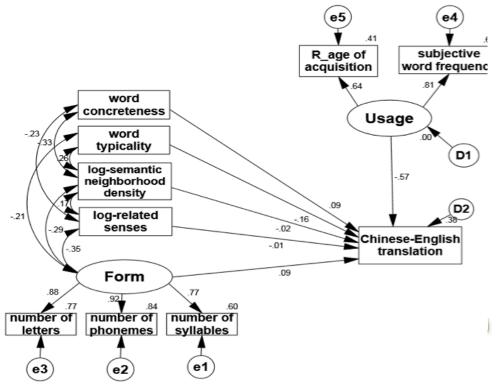






Model 1 Model 2 Model 3

L1-to-L2 translation



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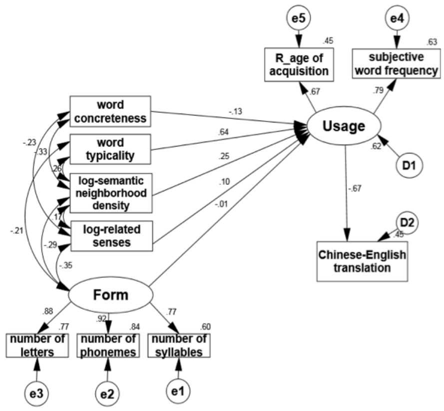
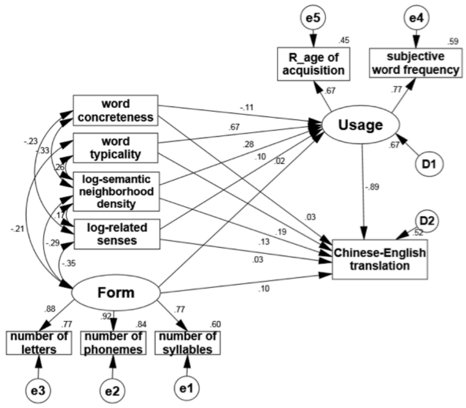


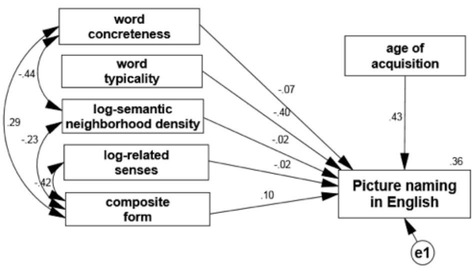
Model 2



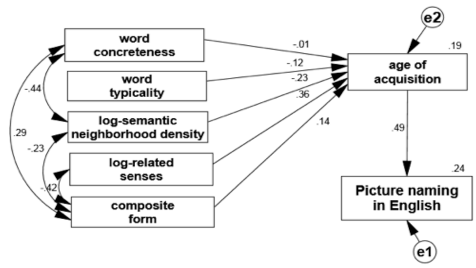
Model 3

Children:

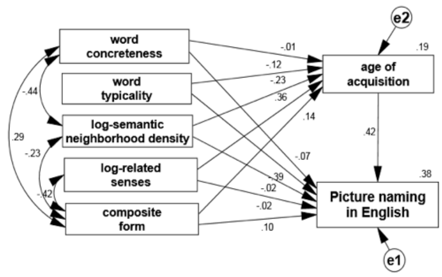
Picture naming



Model 1

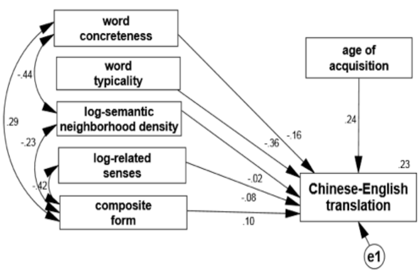


Model 2



Model 3

L1-to-L2 translation



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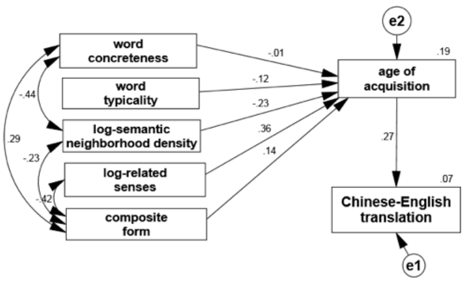

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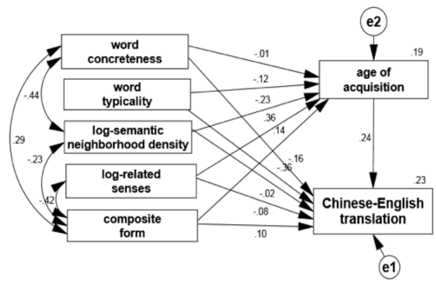

Model 3