

Phoneme Sensitivity and vocabulary size in 2½- to 3-year-olds

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Abstract

Sixty Australian English speaking toddlers were tested in a longitudinal study at 30, 33, and 36 months on vocabulary size, phoneme sensitivity, language-specific speech perception, and articulation accuracy. Vocabulary size was measured with the Australian English adaptation of the MacArthur Communicative Development Inventory and the Peabody Picture Vocabulary Test III. Phoneme Sensitivity (PS) comprised scores from mispronunciation detection, rhyme detection, and nonword repetition tasks. Language Specific Speech Perception (LSSP) was calculated by subtracting the score for nonnative speech perception from the native score, indicating the degree of specialisation in the native language. Articulation Accuracy (AA) was measured with an adaptation of the Queensland Articulation Test. Results showed (i) linear improvements in all new measures, appropriately depicting the developmental trend; (ii) significant correlations between AA and vocabulary size; (iii) predictability of vocabulary size by PS and vice versa at 30, 33, and 36 months. The results provide further evidence for the important role phoneme-sensitive speech perception plays in the process of lexical acquisition.

1. Introduction

Speech perception bootstraps language acquisition. It is the basis for all later steps in language development, especially vocabulary acquisition, in the second year of life. Commonly, we differentiate four stages of language development: The *phonetic*, *phonemic*, *semantic*, and *orthographic stage*. During the first 6 months of life, infants perform well in both nonnative and native speech discrimination tasks. At the *phonetic stage* (Burnham, Tyler, & Horlyck, 2002), infants' specialisation in the native language is not yet evident. All speech sounds sound equally attractive. In the 2nd half of the first year, a perceptual shift occurs in favour of the native language, earlier for vowels than for consonants (Polka & Werker, 1994). At the *phonemic stage* of speech perception (Burnham, Tyler, & Horlyck, 2002), infants' nonnative speech discrimination performance starts to decline (Werker & Lalonde, 1988), while they continue to build their native language skills (Kuhl, Williams, Lacerda, & Stevens, 1992).

These skills extend to the ability of 8-month-olds to recognise words with which they have been familiarised (Jusczyk & Aslin, 1995). Infants as young as 9 months comprehend first words (Benedict, 1979) and begin to develop a primitive receptive lexicon in the *semantic stage* of language development. Hallé & Boysson-Bardies (1996) propose a shift in the phonological representation of these first words. Before the shift, infants are sensitive to small phonetic changes in just one segment of a word (Jusczyk & Aslin, 1995), but at 10½ months, their representations appear underspecified. Infants then show tolerance even to gross violations such as initial consonant suppression in a word recognition task (Hallé & Boysson-Bardies, 1996). With the onset of lexical meaning acquisition between 9 and 12 months of age, infants seem to lose their previous sensitivity to phonetic detail. Thus, their lexical representations take on holistic rather than phonemic character (Metsala & Walley, 1998). Stager and Werker

(1997) showed that in 14-month-olds semantic acquisition interferes with speech perception abilities, causing the toddlers to neglect fine-grained discriminations in favour of word meaning acquisition. At 14 months, it is also difficult for them to learn new phonetically similar words, whereas by 17 and 20 months they have overcome the difficulty of mastering word learning and phonetic processing at the same time (Werker, Fennell, Corcoran, & Stager, 2002). This indicates a second shift in the phonological representation of words within the *semantic stage*. This shift away from holistic word representation will be the main focus of the present study.

When children start school at around 6 years, they enter the *orthographic stage*. The acquisition of orthographic representations of spoken language through the acquisition of literacy is another example of a native language skill interacting with speech perception, this time nonnative speech perception. School children with good reading ability for their age are also those children with high LSSP scores – they score relatively well on native (N) and relatively poorly on nonnative (NN) speech contrasts. LSSP is a relatively new concept that is measured by subtracting discrimination scores for nonnative speech from native speech (LSSP = N-NN), and shows how much perceptual attention is paid towards native versus nonnative features of speech (Burnham, 2003). For the semantic stage, a decline in NN and therefore an increase in LSSP is expected, especially for toddlers with large vocabularies.

When reading is left out of the equation, and 4-year-old pre-readers are compared to 6- and 8-year-olds, LSSP scores are well-predicted by articulation ability. That phoneme awareness predicts articulation ability was established previously in 2-year-olds (Griffiths & Johnson, 1995) and 3-year-olds (Thomas & Senechal, 1998). However, for school children, articulation ceases to be a significant predictor for LSSP, with reading ability emerging as the better predictor. In summary, specialisation in the native language via phonemic attunement in the first year of life, articulation abilities in 4-year-olds, and reading in school-aged children appear to be well-predicted by

LSSP (Burnham, 2003). This study extends this paradigm to the *semantic stage*, attempting to obtain LSSP scores for the first time from children aged 30 to 36 months.

A major achievement in language development in toddlerhood is the rapid acquisition of new words. The focus in the following is on the second shift in the lexical representation mode during the *semantic stage* of language development. The Lexical Restructuring Model LRM (Walley, 1993; Metsala & Walley, 1998; Bowey, 2001) describes the relationship between phonological abilities and vocabulary size in the second year of life. It has its origins in Shvachkin's (1973) notion of the establishment of more detailed phonological representations at the onset of rapid vocabulary expansion, and proposes that vocabulary size predicts phonological abilities. Once vocabulary has reached a size of 50 to 100 words and the phonological neighbourhood within the lexicon has become denser (Smith, McGregor, & Demille, 2006), the need arises for lexical entries to be represented in a fine-grained segmental manner as opposed to the holistic word storage applied to early lexical items (Nazzi & Bertoncini, 2003). This process goes hand in hand with the vocabulary spurt. Typically, the onset of the vocabulary spurt ranges between 14 and 18 months, but does not necessarily occur in all children (Nazzi & Bertoncini, 2003). The relationship between vocabulary and phonological abilities is also evident in children beyond the 50-word-stage (Storkel & Morrisette, 2002) and in 24- and 30-month-olds (Smith et al., 2006) and is protracted into middle childhood (Metsala & Walley, 1998).

The first aim of this study is to longitudinally chart language development between 30 and 36 months on several dimensions, a task that in its comprehensiveness has never before been undertaken, mainly due to the difficulties of testing toddlers on multiple tasks. The measures under investigation are vocabulary size, three measures of Phoneme Sensitivity (PS), Language Specific Speech Perception (LSSP), and Articulation Accuracy (AA). In addition to devising new methods, existing ones were adapted to be appropriate to the age of the child participants. Using them to chart development should confirm their functionality.

The second aim of the study is to show the positive relationship between vocabulary size and sensitivity to phonemic detail in speech, as suggested by the traditional LRM (Metsala & Walley, 1998). As this is the first test of its kind, PS and LSSP will both be used to predict vocabulary size at each age as the first two steps in a hierarchical multiple regression analysis at 30, 33, and 36 months to discern which one represents phonological abilities better. PS was designed for toddlers as a precursor for phonemic awareness, a concept predominantly tested in preschool children and early readers. Three common phoneme awareness measures were adapted to 2½- to 3-year-olds, building the measure PS. This represents a more robust way of tapping into native speech perception ability than LSSP.

Two hypotheses concerning the relationship of vocabulary to phonemic detail are entertained: (1) Vocabulary size will be predicted by general PS as measured by mispronunciation detection, nonword repetition, and rhyme detection, as well as focused native language ability, LSSP. (2) Testing the traditional directional LRM, the better representative out of PS and LSSP will then be predicted from vocabulary size. If vocabulary predicts phonology and phonology predicts

vocabulary, there is reason to assume a bi-directional or even a cyclical relationship between them (Smith, McGregor, & Demille, 2006).

2. Method

2.1. Participants

Sixty Australian English speaking toddlers (30 male, 30 female) from the greater Sydney area were tested longitudinally at 30, 33 and 36 months on their vocabulary size, PS, LSSP, and AA.

2.2. Vocabulary size

Vocabulary production at 30 months was measured with the Australian English Communicative Inventory OZI (Schwarz, Burnham, & Bowey, 2003), an adaptation of the well-known parental checklist MacArthur CDI (Fenson et al., 1993) to Australian English, followed at 33 and 36 months with the Peabody Picture Vocabulary Test (PPVT), a receptive vocabulary measure (Dunn & Dunn, 1997).

2.3. Phoneme Sensitivity components and analysis

Three tasks were used to measure PS: Mispronunciation detection, nonword repetition and rhyme detection. All PS tasks were adapted from versions for older children. In the *mispronunciation task*, the child was asked to identify if the name for a picture was correctly or incorrectly pronounced. The 20 mispronounced words differed in one consonant on three levels of difficulty, with the consonantal substitution appearing either in initial or medial word position. The responses yielded a mispronunciation discrimination index (hits minus false positives). For the *nonword repetition task*, the child repeated 16 nonsense words presented by a puppet. The responses were recorded on a DAT recorder for later scoring (percent correct). *Rhyme detection* with 14 rhyming and 14 non-rhyming word pairs proved to be the most demanding PS task (percent correct); many children did not perform past chance level. All three PS tasks contained a sufficient number of training items to ensure the child had understood the objective. Correct answers were rewarded by animated pictures displayed on a computer screen and accompanied by a recording of cheering and clapping children. All speech targets were pre-recorded and presented via loudspeaker at 60dB.

Principal component analyses of the three PS tests revealed a similar single component at each test age (only Eigenvalues > 1.1 were retained). KMO measures of sampling adequacy were at a satisfactory level. Component weightings for PS at all test ages are shown in Table 1.

PS factor scores	30 m.	33 m.	36 m.
Mispronunciation	.653	.867	.783
Nonword	.781	.827	.822
Rhyme	.349	.285	.592

Table 1: Phoneme Sensitivity (PS) factor score components per test age

2.4. Language Specific Speech Perception

LSSP was measured with a go-no go computer task in which the toddlers were asked to press a red button when they could hear a change in a series of continuously presented native (N), nonnative consonant (NN), or nonnative tonal (T) speech contrasts¹. In the first phase, infants were familiarised with the task using animal sound contrasts to ensure they understood the task. Correct

responses (button press for a change trial or reject for a non-change trial) were rewarded by a short animated movie clip, frozen during trial stimulus presentation (see Figure 1). In the conditioning phase using English vowels, the children were required to reach a criterion of 6 correct responses in 8 trials in order to proceed to the experimental phase. In the experimental phase, separate native, nonnative and tone speech contrast blocks were given (each with a demonstration phase followed by 2 sets of 8 trials), and separate N, NN, and T scores were derived, each with a discrimination index of hits minus false positives. Two different types of LSSP scores were calculated to integrate nonnative consonant and nonnative vowel discrimination:



Figure 1: In the LSSP computer task, the child listens to the speech stimuli played by the loudspeaker on the right until a change, and then hits the red button to turn on the next sequence of the animated clip on the screen in front.

N-NN and N-T.

2.5. Articulation Accuracy

AA was tested with a subset of the Queensland Articulation Test QAT (Kilminster & Laird, 1978), using only consonants in initial word position. The naming responses to the 22 target pictures were recorded on a DAT recorder and subsequently scored as percent correct.

2.6. Other measures

At 36 months, a Stanford-Binet V subtest, Fluid Reasoning: Objects and Matrices, was used as a nonverbal measure of general cognitive functioning.

3. Results and Discussion

The results are presented in three parts: Parts 3.1. and 3.2. chart language development and compare the average scores for each language development measure over age as well as correlations between measures. Part 3.3. concerns stepwise multiple regression analyses in which PS and LSSP are used to predict vocabulary size at 30, 33, and 36 months in test of the hypothesis.

3.1. Language development measures over age: Means

Descriptive analyses of the language measures showed overall normally distributed scores at each age, and consistent developments over age. This was true for all measures except the OZI, which was used only at the upper limit of its validation range, 30 months, and therefore showed a slightly skewed distribution.

	30 m.	33 m.	36 m.	F _{linear}	F _{quadr.}
PPVT		37 (12)	47 (13)	82.8	
NW	.55 (.19)	.62 (.17)	.63 (.16)	9.37	1.36
Mispr.	.27 (.22)	.41 (.26)	.54 (.24)	73.8	.000
Rhyme	.46 (.13)	.51 (.14)	.52 (.18)	5.19	1.46
N	.26 (.28)	.38 (.34)	.48 (.27)	24.0	.110
NN	.21 (.23)	.31 (.31)	.4 (.28)	19.0	.019
T	.25 (.3)	.36 (.32)	.5 (.29)	32.2	.115
N-NN	.05 (.32)	.07 (.32)	.08 (.26)	0.29	.028
N-T	.01 (.38)	.02 (.32)	-.02 (.3)	0.39	.265
QAT	.52 (.14)	.62 (.13)	.68 (.13)	89.1	1.42

Table 2: M (SD) of the measures vocabulary size (PPVT), PS (NW, Mispr., and Rhyme), LSSP (native, nonnative, tone, N-NN, and N-T), and AA (QAT) at 30, 33, and 36 months: Planned contrasts show significant linear trends (critical F value = 4.00, p = .05) are marked bold, no quadratic trends were evident

Means and standard deviations of all five measures at each age are shown in Table 2. The developmental changes in the data were tested via planned within-participant contrasts for linear and quadratic trends using ANOVAs (α set at 95%) using PSY2000. All measures apart from the LSSP measures N-NN and N-T show the expected significant linear increase over age, with critical F (1,60) = 4.00 ($p < .05$), and none reveal quadratic age trends. Unexpectedly, both nonnative and tonal contrast discrimination also show a linear increase, although theoretically, N and T should decline or at least remain stable over age. Figure 2 depicts the significant linear increase in each of the LSSP measures, making both N-NN and N-T unusable. Only N-NN was retained for the regression analyses testing hypothesis 1, as the unexpected improvement in T was even stronger than in NN. This could be due to tone being both novel and salient, or not being processed as speech by young children. The improvement over age observed in N, NN, and T could be explained by the presence of other influences, factors such as attention and task mastery that gradually cease to interfere.

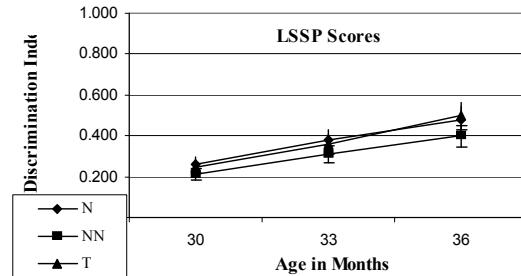


Figure 2: Development of the scores for native (N), nonnative (NN), and tone (T) speech perception (bars indicate Standard Error): Contrary to the expectation, there is no decline in NN and T perception as needed for a usable LSSP score

On the other hand, all three subtests of PS, mispronunciation detection and nonword repetition, show a significant linear increase over age, suggesting that PS is a sensitive, reliable and stable measure of fine-grained native language discrimination in toddlers (Table 2).

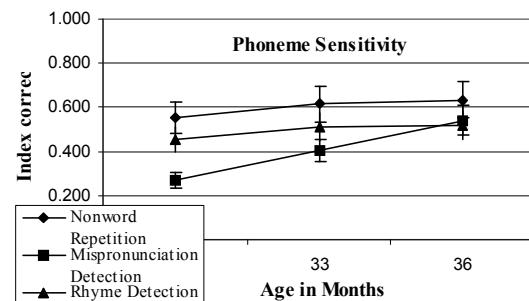


Figure 3: Development of the Phoneme Sensitivity factor components nonword repetition, mispronunciation detection, and rhyme detection over age (bars indicate Standard Error)

The graphs in Figure 3 illustrate this further: Mispronunciation detection shows the steadiest improvement over age, but even the slight increase in rhyme detection starting around chance level is significant. It contributes to making PS a stable and robust measure of the attunement to phonemic detail in spoken language. PS is therefore expected to be the better predictor for

	OZI 30	PPVT 33	PPVT 36	PS 30	PS 33	PS 36	N-NN 30	N-NN 33	N-NN 36	N-T 30	N-T 33	N-T 36	Art. 30	Art. 33	Art. 36
PPVT 33	.379														
PPVT 36	.352	.792													
PS 30	.386	.421	.467												
PS 33	.419	.432	.454	.636											
PS 36	.511	.384	.468	.509	.723										
N-NN 30	.164	.193	.107	-.013	.070	.120									
N-NN 33	.210	.214	.080	.106	.085	.083	.167								
N-NN 36	.073	-.147	-.030	-.070	-.071	-.028	.004	.320							
N-T 30	.118	.231	.092	.092	.089	.180	.495	.342	.058						
N-T 33	.060	.159	.040	.117	.023	.021	.032	.562	.128	.226					
N-T 36	.083	-.015	.145	.273	.228	.264	.072	.179	.359	.268	.121				
Art. 30	.521	.357	.363	.667	.699	.559	.030	.203	.028	.063	.056	.157			
Art. 33	.512	.516	.505	.607	.660	.549	.010	.299	.107	.004	.289	.252	.737		
Art. 36	.455	.220	.262	.379	.386	.458	.112	.267	.201	.008	.283	.022	.502	.625	
IQ	.159	.068	.052	.137	.032	.066	.148	.160	.062	.109	.214	.039	.185	.166	.168

Table 3: Correlation matrix (Pearson coefficients) for vocabulary scores (OZI and PPVT), Phoneme Sensitivity (PS), Language Specific Speech Perception (LSSP) N-NN and N-T, Articulation Accuracy and nonverbal IQ at 30, 33, and 36 months (significant correlations in bold font)

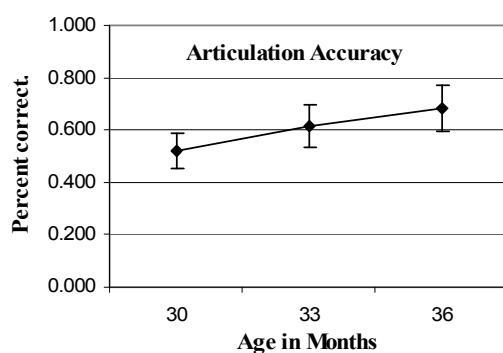


Figure 4: Development of articulation accuracy (bars indicate Standard Error)

vocabulary size than LSSP and will be used in the hierarchical regression as the first step, before LSSP (N-NN only) is entered.

AA shows also a strong significant linear improvement between 30 and 36 months (Figure 4). The measure proved to be reliable and will form the third step in the hierarchical regression.

3.2. Correlations between language measures

Correlations between all language development measures are shown in Table 3. Correlations explore general relationships between the variables, revealing strength and stability across age. There are high correlations between PS and both vocabulary measures at all three ages, pinpointing the strong and stable relationship between PS and vocabulary size.

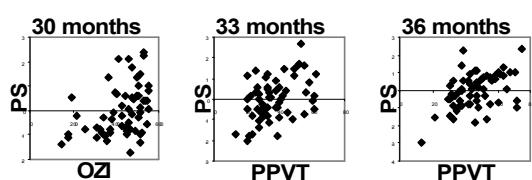


Figure 5: Scattergrams illustrating the correlation between Phoneme Sensitivity (PS) and vocabulary (OZI and PPVT) at 30, 33, and 36 months

The two vocabulary measures, OZI and PPVT, also correlate at significant levels with each other, demonstrating the consistency across the different vocabulary tests despite the slight ceiling effect in the OZI (see Figure 5 at 30 months). This is particularly noteworthy because the OZI is a production measure of lexicon size and the PPVT a receptive vocabulary test. Consequently, the correlation between OZI and PS is the smallest, yet significant with $r = .386$ (at 30 months) of all correlations between PS and vocabulary.

The two LSSP measures, N-NN and N-T, correlate with each other to some extent, but not consistently with other measures over age, and thus, do not appear to be stable and sensitive tests of attunement to the native speech sounds. As useful as LSSP is in infants and in school-aged children, between 2½ and 3 years of age and despite careful age-appropriate modifications it seems to be mediated by other factors such as attention span.

As found in the literature, AA correlates strongly with both vocabulary (Schwartz & Leonard, 1982) and Phoneme Sensitivity (Thomas & Senechal, 1998). As expected, nonverbal intelligence does not correlate with any of the other measures (Table 3) and did not significantly explain any variance when included in the stepwise multiple regression at 36 months (Table 4).

In summary, vocabulary (OZI and PPVT), and Articulation Accuracy (QAT) correlate highly with each other, and PS consistently correlates with both measures. This shows that there is a close relationship between vocabulary acquisition and perceptual attention toward phonemic detail in speech, and that this is also reflected in Articulation Accuracy.

3.3. Testing the relationship between the lexicon and PS: Multiple regression analyses

Stepwise multiple regression analyses were conducted to test the first hypothesis that native speech perception predicts vocabulary size, separately for children at 30, 33, and 36 months. To determine which of the two phonemic measures, PS or LSSP, proved to be more useful, both were included into the hierarchical regression as separate steps, testing with both a language-specific measure of native language ability (LSSP), and a language-general measure of native language ability (PS). Vocabulary was predicted

from the PS factor scores in step 1; from the LSSP scores (N-NN only) in step 2, and AA in step 3 at 30, 33, and 36 months (Table 4). PS significantly predicted both productive and receptive vocabulary size at all ages and reliably increased R^2 . At 36 months, even adding nonverbal IQ as forth step did not remove the significant contribution of PS towards explaining variance in lexicon size. The language measures appear to be a lot more stable at 3 years as most also show smaller standard deviations than previously (Table 2). Furthermore, AA also proved to be a strong predictor of vocabulary at 30 and 33 months (Table 4). At 36 months, nonverbal IQ was included as a measure of general cognitive functioning as step 4. It did not significantly contribute, as suspected from its lack of correlations with any of the other measures.

For LSSP, none of the regressions reached significance. N-NN did not predict vocabulary. Possibly, the LSSP was sensitive to other factors obscuring the underlying

Vocabulary at 30 months					
Step	Var.	Beta	t	sign.	R²
1	PS	.386	3.18	.002	.149
2	LSSP	.169	1.41	.165	.177
3	AA	.465	3.09	.003	.297
Vocabulary at 33 months					
1	PS	.432	3.65	.001	.186
2	LSSP	.178	1.52	.135	.218
3	AA	.373	2.35	.022	.288
Vocabulary at 36 months					
1	PS	.468	4.03	<.001	.219
2	LSSP	-.02	-.15	.883	.219
3	AA	.07	.51	.613	.223
4	nv. IQ	.014	.12	.908	.223

Table 4: Stepwise multiple regression predicting vocabulary from Phoneme Sensitivity (Step 1), Language Specific Speech Processing (Step 2), Articulation Accuracy (Step 3), and nonverbal IQ (Step 4, added only at 36 months); significance is marked with bold font

relationship between sensitivity to changes in speech contrasts and vocabulary found with PS.

Regression	Beta	t	sign.	R²
Voc.-PS30	.386	3.182	.002	.149
Voc.-PS33	.432	3.646	.001	.186
Voc.-PS36	.468	4.032	<.001	.219

Table 5: Testing the traditional LRM: Multiple regression predicting Phoneme Sensitivity from vocabulary at 30, 33, and 36 months; significance is marked with bold font

In order to test the traditional LRM's prediction that lexicon size drives phonology (hypothesis 2), PS was predicted from vocabulary in a series of linear regressions (Table 5). LSSP was not included this time, as it did not explain any variance when predicting vocabulary.

In conclusion, the relationship between vocabulary and phonology is supported for the language-general measure of PS, but not for the language-specific measure, LSSP. Using PS only, vocabulary predicts phonology, thereby confirming the directional LRM.

4. General Discussion

In this longitudinal study, language development in 30- to 36-month-olds has been comprehensively charted for the first time with specifically adapted measures for this age

group. The new measures work: They are generally normally distributed and show linear improvement over age. Particularly, the PS factor score with its three component measures allows consistent measurement of native speech perception ability across age:

Correlations show a coherent relationship between vocabulary, AA, and PS. On the other hand, LSSP - in neither of its measures N-NN and N-T - correlated consistently over age with vocabulary, AA, or PS. This is possibly due to attention span problems and affective variability difficulties that toddlers bring to the test sessions. Overall, the more general measure for native language attunement, PS, turns out to be more robust and hence effective.

Given the strong correlations, it comes as no surprise that support for hypothesis 1 was found when predicting vocabulary from PS rather than from LSSP. At 30, 33, and 36 months, PS is a significant predictor of vocabulary. This means that the perceptual attention paid to phonemic details in speech influences the number of entries in the toddlers' vocabulary. In other words, how many words children know depends on how well they listen to fine-grained detail in spoken words. This leads to the legitimate assumption that they use the referential acquisition mode when acquiring new vocabulary (Nazzi & Bertoni, 2003). It is of interest here that in addition to PS, AA also predicts vocabulary at 30 and 33 months. Thus, it is not only how well children listen to native speech sounds, but also how well they produce them that determines how many words children know. Given the finding that articulation ability predicted N-NN in 4-year-olds (Burnham, 2003), an age, at which LSSP works as a measure for native language attunement, this relationship is not unexpected. Furthermore, toddlers may avoid saying words containing sounds they are not yet able to produce and prefer to learn words containing sounds they have a command of (Schwartz & Leonard, 1982).

The traditional LRM is confirmed by all linear regressions, predicting PS from vocabulary at 30, 33, and 36 months. Although the vocabulary spurt should have levelled out by the ages tested here, nevertheless, the predictability of vocabulary by PS tightens over age. This could be due to an ongoing phonemic restructuring of the lexicon, originally initiated by the vocabulary spurt. It suggests that toddlers become more efficient in identifying phonemic detail when acquiring words and make good use of this skill as exponentially growing vocabulary acquisition rates even post-spurt demonstrate.

There are three possible explanations for the present relationship between PS and vocabulary size (Smith et al., 2006). (1) The perceptual shift to phonemic detail corresponds to a more fine-grained representational mode in the lexicon with the consequence of accelerated vocabulary growth. Thus, PS is seen as the motor of lexical acquisition. (2) ON the other hand, according to the LRM, a growing lexicon with increasing phonological neighbourhood density among the lexical items requires a more detailed storage mode and shifts the focus in speech perception accordingly to the restructured lexicon. Thus, PS is seen as a function of lexical acquisition (Smith et al., 2006). As multiple regression is based on correlations, a causal relationship cannot be stated at this point. Participant numbers were large, yet not sufficient to satisfy the requirements for structural equation modelling. (3) One more possibility must be considered: The relationship between phonological abilities and vocabulary could be

cyclical or at least bidirectional (Smith et al., 2006) as is the relationship between articulation and vocabulary. The reversibility of the predicting and predicted variable in the present study advocates this possibility.

5. Conclusions

For the first time in 30- to 36-month-olds, language development has been studied comprehensively on multiple dimensions, Phoneme Sensitivity (PS), Language Specific Speech Perception (LSSP) and Articulation Accuracy (AA). Apart from LSSP, all measures showed linear increase over age, therefore depicting developmental trends appropriately. In multiple regression analyses, PS predicted vocabulary size at 30, 33, and 36 months, providing the first longitudinal support for the role that attention to phonemic detail in speech perception plays in lexical growth. More specifically, vocabulary as a significant predictor for PS confirmed the Lexical Restructuring Model, indicating a bidirectional or cyclical relationship between phonology and the lexicon.

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8. Footnotes

1) English and Thai contrasts used in LSSP task:

N:	[ba-p ^h a]; [da-t ^h a]
NN:	[ba-pa]; [da-ta]
T:	[ka ² -ka ⁴]; [ka ¹ -ka ⁴]