Neighbourhood densities in the vocabularies of Dutch children with a familial risk of dyslexia

Elise de Bree, Tania Zamuner, Frank Wijnen

1. Introduction

This research aims to increase our understanding of the linguistic abilities of children with a family risk of dyslexia, i.e., children who have at least one dyslexic parent. These children run an increased risk of developing dyslexia (between 25-60% van Bergen et al., 2012; Snowling, Gallagher & Frith, 2003). Specifically, in order to gain more understanding about the linguistic underpinnings of the disorder, we investigate whether phonological neighbourhood density in lexical development develops the same way by children with a familial risk (FR) of dyslexia, and typically developing children.

Dyslexia is a language-based disorder characterised by specific difficulties in reading and/or spelling that are unexpected in relation to cognitive abilities and age (Snowling, 2001). Apart from problems with written language, symptoms that typically surface in children and adults with dyslexia include impairments/deficits in phonological awareness, rapid naming, and verbal short term memory. These findings have lead to the proposal that dyslexia is characterised by a 'core' deficit in the phonological system (e.g. Snowling, 2001). The deficit leads to slow literacy development, poor generalisation of word reading skills to non-word reading, and poor spelling development (see Snowling 2001).

Further specification of the nature of the phonological deficit is needed (e.g. Ramus, 2001), as this will provide information on the loci of the difficulties and the developmental stages in which difficulties can be attested. Additionally, the variables underlying the phonological deficit demand identification. For instance, it is debated whether deficits in general auditory processing cascade into speech perception difficulties, which in turn leads to poorer lexical phonological representations (e.g. Hämäläinen, Salminen & Leppänen, 2012; Messaoud-Galusi, Hazan & Rosen, 2011).

De Bree et al., ND in the vocabularies of Dutch children with a familial risk of dyslexia.

Related, it is a matter of debate whether phonological representations of children with (a FR of) dyslexia are more poorly specified than those in control groups or whether *access* to these representations is problematic (e.g., Boets et al., 2013; Ramus & Szenkovits, 2008). By studying neighbourhood densities in the vocabularies of young FR and TD children, we can address the question of whether this phonological information, (partly) reflecting the quality of phonological representations, is used differently, potentially affecting phonological representations as measured by the types of sound similarities across words in children's lexicons.

Neighbourhood density (ND) refers to the number of words that differ by one phoneme from a given word (Vitevitch & Luce, 1999). Thus, neighbours are (existing) words that are created by substituting, adding or deleting a phoneme in/of a particular target word (Luce & Pisoni, 1998). When many words resemble the target, the neighbourhood is referred to as dense. When few words resemble the target word, the neighbourhood is said to be sparse. ND influences word learning in young children, with high-density words being acquired and produced earlier than words in sparser neighbourhoods (e.g., Coady & Aslin, 2003; Stokes, 2010; Storkel & Lee, 2011; Storkel & Maekewa, 2005). However, this effect seems relevant only when some vocabulary has been acquired (Maekawa & Storkel, 2006) and the effect diminishes again with age (e.g. Storkel, 2009).

Many studies focus on global measures of ND, such as the number of similar sounding words in the lexicon. However, ND can also be analysed related to the position of phonological overlap (DeCara & Goswami, 2002). A study examining English, Dutch, German, and French found that NDs are not evenly distributed across different word positions (Ziegler & Goswami, 2005). Rather, most neighbours are rhyme neighbours (e.g. *hat/cat*) (also see DeCara & Goswami, 2002). Thus, languages contain more rhyme neighbours (RN, *hat/cat*) than consonant neighbours (CN, *hat/hit*) and lead neighbours (LN, *hat/ham*).

Zamuner (2009) found that this distribution of ND is also seen in the early lexicons of children acquiring English, aged 16 to 30 months based on lexical norm data from the MacArthur-Bates-CDI. Based on the words in the vocabulary checklist, parents indicated that their child produced more words with RNs than CNs or LNs (see examples previous paragraph). A similar pattern has also been found in the early vocabularies of children acquiring Canadian French (Zamuner, Morin-Lessard & Bouchat-Laird, in press), based on lexical norm data from the Quebec French-CDI. These French acquisition data also match those of the input, which shows a predominance of words overlapping in word-initial position compared to those overlapping in vowel and final consonant positions (Ziegler & Goswami, 2005). In the Canadian French data, when analyses focused on monosyllabic words, a distinct pattern of ND was seen at the earliest stages of development from 19 to 22 months. In child French, there was a high proportion of CNs, or words that overlap in vowel position. While adult French did not have as many CNs, one possibility is that the adult French included many low frequency words which children were unlikely to have acquired.

When the adult data was restricted to high frequency words, parallels were found between adult and child French (RNs > CNs > LNs). Thus, NDs also vary within a language based on frequency, with lower frequency words having different word shape patterns. Thus, this more detailed approach of ND shows the development towards the native language pattern as well as its relationship to exposure/input.

Here, we assess whether FR children show similar word level patterns as TD children. Phonological representations need to become more detailed with respect to phonemes to accommodate lexical growth (e.g. Metsala & Walley, 1998); high density words thus demand more phonological detail than low density words. If FR children possess poorer phonological representations (which may stem from a deficit in auditory or speech processing), ultimately leading to poorer phoneme awareness and letter-sound knowledge, it can be expected that FR children have a different pattern and development of ND in their earlier lexicons. We predict that FR children may show slower development; moreover, that their vocabularies might have qualitatively different types of neighbours compared to TD children, such as having different patterns of RNs compared to CN and LN neighbours.

Associations between ND patterns and development of phonological awareness skills have been reported in TD children (DeCara & Goswami, 2003; Metsala, Stavrinos & Walley, 2008). A study by Thomson, Richardson, and Goswami (2005) found that typical readers and dyslexic groups are able to benefit equally from high (rime) ND similarly in serial recall. ND thus seems equally informative for typical and poor readers in this production task. In contrast, Metsala (1997) found that reading-disabled children needed more speech input in a gating task to identify target words with sparse NDs than a group of TD children. Sparse neighbourhoods are argued to facilitate word identification, as less detailed phonological representations are needed to recognise a target. Thus different findings have been reported for children with diagnosed dyslexia. The design and domains tested are different (i.e. serial recall (production) vs. word recognition (perception)), affecting the interpretation of the role of ND. The question here is whether there are differences between TD and FR at a younger (pre-literate) age in terms of vocabulary and distribution of ND types.

In sum, the question addressed here is whether there are differences between NDs in the vocabularies of TD and FR Dutch children. Similar to previous studies, vocabularies of children at ages 19 and 31 months based on parental report will be studied to pursue at which ages differences in vocabulary size and quality could be expected to surface. NDs were evaluated in the same children at the two different time points, which allows us to examine development across the same groups of children. These will be compared to the ND distribution of Dutch. Finally, it will be assessed whether vocabulary size and NDs are correlated. Given that vocabulary growth drives the fine-tuning of phonological representations, it is expected that as vocabulary size grows, children's patterns of NDs will more closely approximate patterns in the ambient language.

De Bree et al., ND in the vocabularies of Dutch children with a familial risk of dyslexia.

2. Method

2.1. Participants

Two groups of children participated in this study, which is part of a broader study into language development of FR and TD children (e.g. de Bree et al., 2006; 2012, van Alphen et al., 2004). The first group consisted of 16 typically developing (TD) children, without a history of language and literacy delay in the family, as well as an absence of hearing or developmental difficulties. The second group consisted of 38 children with a familial risk of dyslexia (FR), i.e. children of whom at least one parent had literacy difficulties as assessed with standardised reading measures. For a child to be included in the family-risk group, the parent had to show poor performance on all tasks. Performance on the timed word reading or timed non-word reading task had to be below the 10th percentile, or below the 25th percentile on both timed reading tasks, and a discrepancy of at least 60% between verbal competence and performance on the timed reading tasks (based on Koster et al., 2005). The FR children did not include children whose parents or siblings had a history of language impairment or who were diagnosed with language difficulties.

Children's vocabularies were assessed through the Dutch adaptation of the MacArthur-Bates Communicative Development Inventories (N-CDI, Zink & Lejaegere, 2001) at 19 months (TD group mean age 19.2 months, SD 0.9 months, FR group mean 19.5 months, SD 1.1 month) and 31 months (TD group mean 30.9 months, SD 1.8 months, FR group mean 31.10 months, SD 1.7 months). At 19 months, parents filled in the N-CDI Words and Gestures, and at 31 months the N-CDI Words and Sentences. Both age groups were too old for standardisation of the N-CDI version they received. This was not deemed problematic, as qualitative scores, not percentile scores are required for the ND calculations. Furthermore, scores were far from ceiling in all cases. The number of FR children exceeds the number of TD children in this study as there is typically substantial variation reported in FR groups of children developing literacy difficulties (e.g. van Bergen et al., 2012; Snowling et al., 2007).

2.2. Procedure

ND calculations. Neighbourhood densities were calculated based on phonetic transcriptions of the CVC words from the N-CDI. Children's receptive vocabulary sizes were calculated by tabulating the number of words coded by parents as 'understands' (*begrijpen*) and 'understands and says' (*begrijpen en zeggen*). Children's expressive vocabulary scores were calculated by tabulating the number of words coded by parents as 'understands and says' (*begrijpen en zeggen*). Note that the child's realisation of the target need not be correct in order to be ticked as 'understands and says'.

The N-CDI Words and Gestures includes 69 CVC words and the N-CDI Words and Sentences contains 107 CVC words. Different vocabulary items appeared on the different lists, for example, the words *boot* 'boat' and *douche* 'shower' only appear on the N-CDI Words and Sentences. Analyses were based on the 65 CVC words that were shared across these different vocabulary lists to eliminate potential differences in

children's vocabulary sizes which may result from the checklists having a different number of items. The pattern of findings remains the same even when using the different vocabulary items, but for conciseness these are not reported here.

3. Results

3.1. Vocabulary

For each child, the CVC words in their lexicon according to the N-CDI were identified. The range of lexicon sizes at the different ages and for the two groups is given in Table 1. Repeated measures analyses with group as between-subjects variable and age (19 and 31 months) as within-subjects variable was done for the number of CVC words in children's receptive vocabulary. There was a main effect of Age ($F(1,53) = 410.08$ $p < .001$, $\eta^2_p = .89$ indicating an increase in vocabulary between 19 and 31 months, but no effect of Group ($F = 1.907$, $p = .17$) or interaction between group and age ($F = 1.139$, $p = .29$). A similar pattern was found for the number of CVC words in children's expressive vocabulary, with a main effect of Age ($F(1,53) = 520.919$ $p < .001$, $\eta^2_p = .91$), no effect of group (group, $F = 1.406$, $p = .24$) or interaction ($F = .091$, $p = .76$). Thus, vocabulary size did not differ between the TD and FR groups on either receptive or expressive vocabulary measures.

Table 1. *CVC words in children´s vocabularies (max = 65) per group and age group*

Group		Receptive	Expressive
TD 19 months (16, 6 female)	Range	10-65	2-33
	Mean	34.6	13.7
FR 19 months (38, 19 female)	Range	7-57	0-50
	Mean	31.1	15.3
TD 31 months (16, 6 female)	Range	42-65	35-65
	Mean	59.4	55.0
FR 31 months (38, 19 female)	Range	36-65	20-65
	Mean	56.8	52.5

Note. TD = typically developing, FR = family-risk of dyslexia

Once the individual CVC vocabularies had been tabulated for each child, NDs were calculated based on these CVC sets. Separate calculations were made for children's receptive and expressive vocabularies. Following Zamuner (2009), neighbours were defined as the words created from substituting a phoneme, but did not include neighbours that were created upon adding or deleting a phoneme because the analyses were restricted to CVC words. Resulting neighbours were coded for the position where the substitution occurred. Rhyme neighbours (RN, i.e, words sharing the same rhyme) were calculated by substituting the initial consonant (*peer*/*beer* 'pear/bear'), consonant neighbours (CN, i.e., words sharing the same consonants) were calculated by

substituting the vowel (*nat*/*niet* 'wet/not') and lead neighbours (LN, i.e., words sharing the same onset and nucleus) were calculated by substituting the final consonant (*bad*/*bal* 'bath/ball'). For each child, the proportion of RN, CN and LNs in the child's own CVC lexicon was calculated. In other words, neighbours had to be contained within the child's individual lexicon. For example, one child at 19 months had 55 words in her receptive vocabulary, which had a total of 68 neighbours. Of these neighbours, 36 (.53) were RNs, 20 (.29) were CNs and 12 (.18) were LNs.
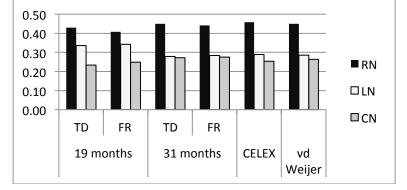
As a baseline comparison, analyses were also done on the CVC words from corpora of Dutch: the adult-based CELEX database (Baayen, Piepenbrock & Gulikers, 1995), and a corpus of child-directed speech (van de Weijer, 1998). These analyses revealed that Dutch has a higher proportion of RNs than CNs and LNs: CELEX: RN .458, CN .289, LN .253, Child-directed speech: RN .450, CN .286, LN .264 (see also Figures 1 and 2). Results from the CVC analyses are the same as the Dutch analyses reported by Ziegler and Goswami (2005), which were based on monosyllabic words in the CELEX database.

3.2.   ND in TD and FR children's lexicons
Receptive scores. The first analyses looked at NDs based on children's receptive vocabularies. Figure 1 presents a breakdown of neighbour types in children's receptive vocabularies (RN, CN and LN) per age (19 and 31 months). To assess whether the distribution differed for position, group or age, a repeated measures ANOVA was run with proportions per position and age as within-subject factors and group as a between-subjects factor. There was a significant effect of position $F(2, 104) = 40.13$, $p < .001$, $\eta^2_p = .44$, as well as a significant interaction between position and age $F(2, 104) = 5.99$, $p = .003$, $\eta^2_p = .10$. Follow-up comparisons on position (Bonferroni-corrected) show that all three positions differ from each other, with ranking of RN > CN > LN (all $p < .031$). The interaction is caused by the higher scores of RN and CN than LN (RN = CN > LN) at 19 months, whereas at 31 months, the ranking is RN > CN > LN. In other words, at 19 months, the words typically known to children have denser RNs and CNs than LNs, whereas at 31 months, the typical words known by children have denser RNs, followed by CNs followed by LNs. There are no further significant effects: group ($F = 2.64$, $p = .11$), age ($F = 2.33$, $p = .13$), group x age ($F = 2.54$, $p = .12$), position x group ($F = 0.13$, $p = .88$), and position x group x age ($F = 0.15$, $p = .86$).
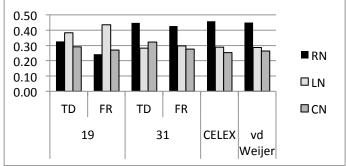
The graph further shows that the ND proportions resemble the proportions attested in the corpora (CELEX and vd Weijer corpus) more at 31 months than at 19 months. The patterns of outcomes of the analyses remain exactly the same when the raw numbers of words per position are entered in a repeated measures ANOVA.

De Bree et al., ND in the vocabularies of Dutch children with a familial risk of dyslexia.

Figure 1. *Proportions of neighbourhood densities for receptive vocabularies on words shared by N-CDI words and gestures and N-CDI words and sentences*

Expressive scores. Results on the expressive scores of the children are presented in Figure 2. The analyses were the same as in the analyses on children's receptive vocabulary scores above. There was a main effect of proportion of neighbours per position $F(2, 104) = 3.21$, $p < .044$, $\eta^2_p = .057$ and a significant interaction between position and age $F(2, 104) = 9.72$, $p < .001$, $\eta^2_p = .15$. Follow-up comparisons on position (Bonferroni-corrected) show that the ND between RN and LN differed significantly ($p = .027$) but that there were no differences between RN and CN ($p = .801$) or CN and LN ($p = .584$). The interaction between age and position shows that at 19 months, CNs are higher in proportion than RNs and LNs, whereas at 31 months, the ranking is RN > CN, LN. While NDs at the older age mirror distributions in the target language, the NDs at the younger age show a pattern that is distinct from patterns in the ambient language. The pattern of findings remains exactly the same when the raw numbers of words per position are entered in a repeated measures ANOVA.

Figure 2. *Proportions of neighbourhood densities for expressive vocabularies on words shared by N-CDI words and gestures and N-CDI words and sentences*

De Bree et al., ND in the vocabularies of Dutch children with a familial risk
   of dyslexia.

3.3.   Vocabulary size and neighbours
To explore the relationship between vocabulary size as measured through the NCDI and
NDs in the different positions, correlation analyses between vocabulary size and the ND
proportion scores on the different positions were run. They render moderate/weak
positive correlations for RN and moderate/weak negative correlations for LN (see Table
2). The pattern is the same for both receptive and expressive scores. The results imply
that the larger the child's vocabulary, the higher the proportion of RN, whereas the
inverse relationship is true for LN. Thus, positional ND is related to lexicon size
measured through the NCDI.

Table 2. *Correlations between the position scores and vocabulary size, on receptive and
expressive outcomes per group*

| | Receptive | | | Expressive | | |
| | Position | | | Position | | |
Vocab size	RN	CN	LN	RN	CN	LN
19 months	0.485**	-0.046	-0.342**	0.270*	-0.013	-0.345**
31 months	0.621**	-0.217	-0.615**	0.321*	-0.068	-0.375**

**$p < .001$, *$p < .05$

4. Discussion

The present study assessed NDs in Dutch children's lexicons at 19 and 31 months,
following the same children at two different time points. The goal was to establish
whether patterns of NDs were the same in the vocabularies of typically developing
children and those with a familial risk of dyslexia. Consistent with previous findings in
the literature, young children's receptive vocabularies show a greater proportion of RNs
at 19 and 31 months, and at 31 months more closely approximate the adult Dutch
pattern. When looking at expressive vocabularies, at 19 months, more CN than RN and
LN neighbours were found, though this pattern changed at 31 months to adult language
where there were more RNs than CNs and LNs. Lastly, the present study found a link
between vocabulary size measured through the N-CDI and the distribution of
neighbours, as vocabulary size moves in tandem with proportion of RNs, whereas the
inverse pattern is attested for LNs.
      These patterns were the same for both FR and TD children: There were no
group effects or interactions on the ND analyses. Furthermore, the correlations between
vocabulary size measured through a parental questionnaire and proportions of
neighbours showed the same pattern for both groups with a development towards the
distribution of Dutch. There are at least two interpretations for these findings. The first is
that the FR children in this sample are not those who will go on to develop literacy
difficulties and therefore might not show any language development difficulties. This
seems an unlikely option, as findings show between 25 and 60% of FR children to

develop literacy difficulties (e.g. van Bergen et al., 2012, Snowling et al., 2007), which
would mean that this FR group would also contain affected FR children. Furthermore,
previous research has shown that even those FR children who do not develop overt
literacy difficulties show poorer performance on measures of language and specifically
phonology (e.g. de Bree et al., 2010; Moll et al., 2013). This implies that the FR group as
a whole might have been expected to a have different ND pattern from the TD group.
Thus, the line of reasoning that none of the FR children will become dyslexic cannot be
ruled out, but seems unlikely to account for the findings.

A second option is that not all phonological abilities are affected in children
with (a FR of) dyslexia. Whereas phonological awareness and non-word repetition,
which target phonological processing capacity, seem affected in FR and dyslexic groups,
both FR and dyslexic children have been found to perform like their peers on tasks that
tap phonological representations without a substantial processing component (de Bree &
Kerkhoff, 2010; Ramus & Szenkovits, 2008; Ramus et al., 2013). It could be argued that
the use of NDs and the patterns of ND in FR children align more with the latter type of
phonological demands. FR children might thus be able to use ND as well as their peers
(see de Bree & Kerkhoff, 2010, for a similar finding in morphophonology). The
phonological deficit hypothesis might thus refer to a deficit in phonological processing
difficulties rather than phonological representations (e.g. Boets et al., 2013; Ramus &
Szenkovits, 2008). In order to evaluate this hypothesis with respect to ND, follow-up
data tapping phonological awareness and literacy outcomes of the FR and TD children
are necessary. Alternatively, the present ND data could be compared to a word learning
task in which ND is controlled, in which a processing component is added. Such an
approach would allow us to distinguish between ND as potential deficit in representation
vs. processing.

Positional ND could thus be argued to reflect the interaction between lexical
representations and phonology rather than tapping a phonological task (such as
phonological awareness). Whereas positional ND provides information about the
phonological representations and refinement needed for acquiring a lexicon, it also
provides information about the size of the lexicon: Children with a higher number of
words in their lexicon will have more target-like (positional) NDs. DeCara and Goswami
(2003), for example, found that five-year-olds with lower vocabulary scores did not
show ND effects in a rhyme oddity task, whereas children with a larger vocabulary did.
Absence of ND effects or sensitivity to ND could thus be related to lexicon size (see also
Stokes (201) who found that lexicon size drives ND development of 24-40-month-olds).
Given that the FR and TD children in the present study did not differ in lexicon size, the
interaction between lexicon and phonology might not differ between these groups. A
study with a larger sample of children could look into this potential interaction between
lexicon size and phonology, by assessing whether vocabulary size (i.e., low, middle and
high distributions) affects sensitivity to NDs.

Previous studies looking at positional NDs only examined expressive
vocabularies. We found that ND patterns were different for receptive and expressive

vocabulary data. This is most likely due to differences in children's receptive and expressive vocabulary sizes. Recall that the expressive vocabularies at 19 months were considerably smaller than children's expressive vocabularies at 31 months, and smaller than children's receptive vocabularies at both 19 and 31 months. To test the role of vocabulary size, we ran the same analyses with a larger sample of 19-month-old children who had a minimum of 25 CVC words in their expressive vocabularies. When analyses were restricted to these children, a preference for RNs was also seen at 19 months. Thus, a larger vocabulary seems to relate to more attunement to the target language (see also Stokes, 2010).

There was a higher proportion of CNs with children with small expressive vocabularies (see Figure 2) at 19 months. This pattern was also reported with 19 to 22-month-old children acquiring Canadian French (Zamuner et al., in press). This pattern is in line with findings by Fikkert and Levelt (2008) in their analysis of longitudinal data from 12 children acquiring Dutch between 11 and 35 months (CLPF database (Fikkert, 1994; Levelt, 1994; MacWhinney, 2000)). They found that in children's early words, the place of articulation feature was typically determined by that of the stressed vowel. They argue that this stems the salience of vowels in infant speech perception and the acquisition of language specific vowel categories at a young age (Kuhl, Williams, Lacerda, Stevens & Lindblom, 1992). Early phonological knowledge is reflected in early vocabulary acquisition, such that children's earliest vocabulary items are most likely to contrast in vowel position. Our results seem to agree with these findings.

An important caveat is that in our analyses no external measure of vocabulary was obtained, such as vocabulary produced in spontaneous speech or a large list with controlled neighbours. This could have an effect on the interpretation of positional NDs in expressive vocabularies. It is possible that children knew more words with different neighbours than those assessed in the N-CDI. To test for the possibility, similar ND analyses were also done with spontaneous data from the CLPF database, and similar patterns of ND were found, with more RNs than other neighbour types.

The current study has shown the close relationship between lexical acquisition and positional neighbourhood densities, as the acquisition of neighbourhood density is related to lexicon size as well as input frequency. It has also shown that children with a familial risk of dyslexia do not differ from their age peers in using this cue. These findings suggest that a phonological deficit as risk factor for the FR group does not extend to all areas of phonological abilities.

De Bree et al., ND in the vocabularies of Dutch children with a familial risk
of dyslexia.

References

Boets, B., Op de Beeck, H.P., Vandermosten, M., Scott, S.K., Gillebert, C.R., Bulthé, J., Sunaert, S., Wouters, J. & Ghesquiere, P. (2013). Intact but less accessible phonetic representations in adults with dyslexia. *Science*, 342 (6163), 1251-1254.

Baayen, R. H., Piepenbrock, R., & Gulikers, L. (1995). *The CELEX lexical database* (CD-ROM). Philadelphia: University of Pennsylvania, Linguistic Data Consortium.

Coady, J. A., & Aslin, R. N. (2003). Phonological neighbourhoods in the developing lexicon. *Journal of Child Language, 30*, 441–469.

de Bree, E., Wijnen, F. & Gerrits, E. (2010). Non-word repetition and literacy in Dutch children at-risk of dyslexia and children with SLI: Results of the follow-up study. *Dyslexia*, 16, 36-44.

de Bree, E. & Kerkhoff, A. (2010). Bempen or bemben: Differences between children at-risk of dyslexia and children with SLI on a morpho-phonological task. *Scientific Studies of Reading*, 14, 85-109.

de Bree, E., Wijnen, F. & Zonneveld, W. (2006). Word stress production in Dutch children at-risk of dyslexia. *Journal of Research in Reading,* 29, 304-317.

DeCara, B., & Goswami, U. (2002). Statistical analysis of similarity relations among spoken words: the special status of rimes in English. *Behavior Research Methods, Instruments, & Computers, 34*, 416-23.

DeCara, B., & Goswami, U. (2003). Phonological neighbourhood density: effects in a rhyme awareness task in five-year-old children. *Journal of Child Language, 30*, 695-710.

Fikkert, P.(1994) *On the acquisition of prosodic structure*. Doctoral dissertation. University of Leiden.

Fikkert, P., & Levelt, C.C. (2008). How does place fall into place? The lexicon and emergent constraints in the developing phonological grammar. In P. Avery, B. Elan Dresher, & K. Rice (Eds.), *Contrast in phonology: Theory, Perception, Acquisition* (pp. 231-268). Berlin: De Gruyter Mouton.

Hämäläinen, J., Salminen, H. and Leppänen, P. (2012). Basic auditory processing deficits in dyslexia: Systematic review of the behavioral and Event-related potential/field evidence. *Journal of Learning Disabilities, 46*, 413-427.

Koster, C., Been, P., Krikhaar, E., Zwarts, F., Diepstra, H., & van Leeuwen, T. (2005). Differences at 17 months: productive language patterns in infants at familial risk for dyslexia and typically developing infants. *Journal of Speech, Language, and Hearing research, 48,* 426-438.

Kuhl, P. K., Williams, K. A., Lacerda, F., Stevens, K. N., & Lindblom, B. (1992). Linguistic experience alters phonetic perception in infants by 6 months of age. *Science*, *255*, 606-608.

Levelt, C.C. (1994). Levelt, C. (1994). On the acquisition of Place, HIL dissertations in Linguistics 8, Den Haag: HAG.

De Bree et al., ND in the vocabularies of Dutch children with a familial risk of dyslexia.

Luce, P. A., & Pisoni, D. B. (1998). Recognizing spoken words: the neighbourhood activation model. *Ear and Hearing, 19*, 1–36.

MacWhinney, B. (2000). *The CHILDES project: Tools for analyzing talk.* Third Edition. Mahwah, NJ: Lawrence Erlbaum Associates.

Maekawa, J., & Storkel, H. L. (2006). Individual differences in the influence of phonological characteristics on expressive vocabulary development by young children. *Journal of Child Language, 33*, 439-459.

Messaoud-Galusi, S., Hazan, V. & Rosen, R. (2011). Investigating speech perception in children with dyslexia: Is there evidence of a consistent deficit in individuals? *Journal of Speech, Language, and Hearing Research*, *54*, 1682-1701.

Metsala, J. L. (1997). Spoken word recognition in reading disabled children. *Journal of Educational Psychology*, *89*, 159–169.

Metsala, J. L., & Walley, A. C. (1998). Spoken vocabulary growth and the segmental restructuring of lexical representations: precursors to phonemic awareness and early reading ability. In J. L. Metsala & L. C. Ehri (Eds.), *Word recognition in beginning literacy* (pp. 89–120). New York: Erlbaum.

Moll, K., Loff, A., & Snowling, M. (2013). Cognitive endophenotypes of dyslexia. *Scientific Studies of Reading, 00*, 1–13.

Ramus, F. (2001). Outstanding questions about phonological processing in dyslexia. *Dyslexia, 7*, 197-216.

Ramus, F., & Szenkovits, G. (2008). What phonological deficit? *Quarterly Journal of Experimental Psychology*, *61*(1), 129-141.

Snowling, M. J. (2001). From language to reading to dyslexia. *Dyslexia, 7*, 37–46.

Snowling, M. J., Muter, V., & Carroll, J. M. (2007). Children at family risk of dyslexia: a follow-up in adolescence. *Journal of Child Psychology & Psychiatry, 48*, 609-618.

Stokes, S. (2010). Neighbourhood density and word frequency predict vocabulary size in toddlers. *Journal of Speech, Language and Hearing research*, *53*, 670-683.

Storkel, H. (2009). Developmental differences in the effects of phonological, lexical and semantic variables on word learning by infants. *Journal of Child Language, 36*, 291-321.

Storkel, H.L. & Maekawa, J. (2005). A comparison of homonym and novel word learning: The role of phonotactic probability and word frequency. *Journal of Child Language, 32,* 827-853.

Storkel, H. L., Maekawa, J. & Hoover, J. R. (2010). Differentiating the effects of phonotactic probability and neighbourhood density on vocabulary comprehension and production: a comparison of preschool children with versus without phonological delays. *Journal of Speech, Language, and Hearing Research*, *53*, 933-949.

Thomson, J. M., Richardson, U. & Goswami, U. (2005). Phonological similarity neighbourhoods and children's short-term memory: typical development and dyslexia. *Memory & Cognition*, *33*, 1210-1219.

De Bree et al., ND in the vocabularies of Dutch children with a familial risk
  of dyslexia.

van Alphen, P., de Bree, E., Gerrits, E., de Jong, J., Wilsenach, C. & Wijnen, F. (2004).
  Early language development in children with a genetic risk for dyslexia.
  Dyslexia, 10, 265-288.

van Bergen, E., de Jong, P.F., Plakas, A., Maassen, B. & van der Leij, A. (2012). Child
  and parental literacy levels within families with a history of dyslexia.*Journal of
  Child Psychology and Psychiatry, 53*(1), 28-36.

van de Weijer, J. (1998). *Language input for word discovery* (Doctoral dissertation).
  Max Planck Series in Psycholinguistics 9.

Vitevitch, M. S., & Luce, P. A. (1999). Probabilistic phonotactics and neighborhood
  activation in spoken word recognition. *Journal of Memory and Language, 40*,
  374–408.

Zamuner, T. S. (2009). The structure and nature of phonological neighbourhoods in
  children's early lexicons. *Journal of Child Language, 36*, 3-21.

Zamuner, T.S., Morin-Lessard, E., & Bouchat-Laird, N. (in press). Phonological patterns
  in the lexical development of Canadian French. In. M. Yavas (Ed.), *Unusual
  Productions in Phonology: Universals and Language-specific considerations*.
  Benjamins.

Ziegler, J. C., & Goswami, U. (2005). Reading acquisition, developmental dyslexia, and
  skilled reading across languages: a psycholinguistic grain size theory.
  Psychological Bulletin, 131, 3–29.

Zink, I., & Lejaegere, M. (2002). *N-CDIs: Lijsten voor Communicatieve Ontwikkeling.
  Aanpassing en hernormering van de MacArthur CDIs van Fenson et al.* [A CDI
  user's manual with normative and validity data]. Leusden, The Netherlands:
  Acco.