Cognition 121 (2011) 196–206

Contents lists available at ScienceDirect

Cognition

journal homepage: www.elsevier.com/locate/COGNIT

Phonological priming and cohort effects in toddlers

Nivedita Mani [a,*], Kim Plunkett [b]

[a] Free-Floater Research Group in Language Acquisition, University of Göttingen, Germany
[b] Department of Experimental Psychology, University of Oxford, United Kingdom

ARTICLE INFO

Article history:
Received 25 May 2011
Accepted 28 June 2011
Available online 9 August 2011

Keywords:
Phonological priming
Lexical organisation
Cohorts
Neighbourhoods
Lexical development
Infant word recognition

ABSTRACT

Adult word recognition is influenced by prior exposure to phonologically or semantically related words (*cup* primes *cat* or *plate*) compared to unrelated words (*door*), suggesting that words are organised in the adult lexicon based on their phonological and semantic properties and that word recognition implicates not just the heard word, but also related words. We investigate the phonological organisation of the toddler lexicon with two experiments using a picture priming technique. Twenty-four month olds showed inhibition of target recognition in related primed trials compared to unrelated primed trials (Experiment 1) and also in related primed trials compared to unprimed trials (Experiment 2). Further analysis of children's responding found that this inhibition effect was modulated by the cohort and neighbourhood size of the words tested. Overall, the results indicate a lexical basis for the reported effects and suggest that the phonological properties provide an organisational basis for words in the toddler lexicon.

1. Introduction

The current study investigates the cognitive processes involved in toddler word recognition. We examine how words are represented in the toddler's mind, focussing on whether the phonological properties of words are important for their organisation in the toddler lexicon. The organisation of the adult lexicon has been rigorously studied by using priming techniques. For instance, adult word recognition studies report that hearing a word (e.g., 'cup') influences subsequent recognition of phonologically and semantically related words like 'cat' and 'plate' (Goldinger, Luce, & Pisoni, 1989; Marslen-Wilson & Zwitserlood, 1989; Slowiaczek & Hamburger, 1992): word recognition is primed by prior exposure to phonologically and semantically related words. These findings have been taken to suggest that hearing a word leads to the activation of phonologically and semantically related words, and that the phonological and semantic properties of words provide an organising principle for words in the adult lexicon.[1] We follow a similar rationale to that used in adult studies of the mental lexicon by testing phonological priming in toddlers to examine whether infant word recognition involves the activation of other phonologically related words.

A recent study shows that 18-month-old word recognition is influenced by prior activation of phonologically related words (Mani & Plunkett, 2010 – henceforth MP). MP (2010) presented infants with an image of a name-known object (the prime image) followed by two simultaneously presented images, one of which was labelled, i.e., the target image. In half of the trials, the label for the prime image began with the same onset consonant as the label for the target image, e.g., cake (prime image) – car (target image). In the other half of the trials, the label for the prime image was unrelated to the label for either the target or distracter image. MP (2010) reported that infants looked

* Corresponding author. Address: Goßlerstraße 14, 37073 Göttingen, Germany. Tel.: +49 551 3910889.

E-mail addresses: nmani@gwdg.de (N. Mani), kim.plunkett@psy.ox.ac.uk (K. Plunkett).

[1] We define "organisational basis" as similarity relations between sound-patterns or semantic properties of words (Luce & Pisoni, 1998), where such structural organisation impacts the speed and accuracy of spoken word recognition.

0010-0277/$ - see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.cognition.2011.06.013

longer at the target in related compared to unrelated primed trials and reasoned that facilitation of target recognition in phonologically related primed trials shows that infants internally generate the label for the prime image.

In adult word priming studies (Goldinger, Luce, Pisoni, & Marcario, 1992; Norris, McQueen, & Cutler, 2002; Radeau, Morais, & Dewier, 1989; Slowiaczek et al., 1987), a facilitation effect is considered inadequate evidence for the claim that hearing a word leads to the partial activation of other phonologically related words (Marslen-Wilson & Zwitserlood, 1989) for two reasons: First, the prime word may only activate its constituent sounds (e.g., *dread* activates /d/), making it easier for adults to achieve recognition of other words beginning with /d/ because the initial phoneme has already been activated. According to this explanation, facilitation can be understood as a pre-lexical level effect, tapping into the phonological realms of the priming process (Slowiaczek & Hamburger, 1992). Second, researchers have suggested that facilitation effects can arise from response biases developed during the experiment, and may provide little or no information regarding the organisation of the mental lexicon or the relationships between words (Goldinger et al., 1992; Hamburger & Slowiaczek, 1996; Norris et al., 2002). For example, participants may become aware of the sound similarities during the experiment and begin to predict that the target label will share some phonemes with the prime. This expectation can cause delayed responses to unrelated primed trials (where there are no similarities), and faster responses when participants' expectations are met.

Clearer evidence for a lexical level priming effect, at least in adult studies, comes from studies reporting interference effects in phonological priming tasks: adults are sometimes slower at recognising words given previous exposure to phonologically similar words compared to unrelated words (Goldinger et al., 1992; Radeau, Morais, & Segui, 1995; Radeau et al., 1989; Slowiaczek & Hamburger, 1992). The interference effect is explained by suggesting that priming activates a neighbourhood of words that are related to the target, creating a competitive environment, which slows down its recognition. The interference effect cannot be attributed to a phonological level effect, since the activation of shared phonemes between prime and target words should only facilitate recognition at the phonological level. Further evidence that the interference effect implies activation of phonologically related words in word recognition comes from studies showing a correlation between the level of interference with target recognition and the number of competitor words that can be simultaneously active (i.e., neighbourhood size: Dufour, Frauenfelder, & Peereman, 2007; Dufour & Peereman, 2003). Interference with target recognition (i.e., better recognition of the target following unrelated than related primes), therefore, provides more convincing evidence that hearing a word leads to the activation of phonologically related words, and, by extension, that the phonological properties of words form an organisational basis for words in the mental lexicon.

In keeping with the adult literature, the facilitation effect in MP's (2010) results cannot be taken as evidence for lexical neighbourhood activation at 18-months of age: Improved recognition of *car* when primed by *cake* does not show that infants activate the word *car* upon activating the word *cake*, since improved recognition could be driven purely by overlap at the phonological level or by strategic responding.

In this paper, we examine whether the phonological properties of words provide a basis for the organisation of words in the 24-month-old lexicon, such that word recognition involves the automatic activation of phonologically related words. In particular, we exploit the same picture priming technique used by MP (2010) to investigate whether phonological priming leads to interference effects in the 24-month-old lexicon and whether any such effects are modulated by the cohort size (number of other words beginning with the same sound) or the neighbourhood size (number of similar sounding words in the lexicon, based on a one phoneme difference between two words) of the words tested. In a lexicon organised on the basis of phonological properties of words, larger cohorts or neighbourhoods should produce greater inhibitory effects than smaller cohorts or neighbourhoods. We focus especially on children at 24-months of age because of the reported neighbourhood size effects on word learning at this age (Newman, Samuelson, & Gupta, 2008) and the large vocabulary size of these infants. Furthermore, both Mani (2010) and Huang, Khan, Wang, Geojo, and Snedeker (2011) report similar attenuation of target preferences in a related prime condition in a picture priming task with 24-month-olds.

Experiment 1 involves a direct replication of the study conducted by MP (2010) but with 24-month-olds instead of 18-month-olds. This experiment yielded very different findings to those obtained in MP (2010) but in line with Mani (2010) and Huang et al. (2011), which are also compatible with adult studies of work recognition in which lexical neighbourhood size can have an attenuating impact on target recognition. Experiment 2 attempts to identify the locus of this contrasting pattern of results obtained in Experiment 1 by systematically manipulating the cohort size of the target words and by comparing 24-month-olds' performance in a primed and an unprimed, baseline condition.

2. Experiment 1

2.1. Method

2.1.1. Participants

The participants were 32 toddlers at 24-months (M = 23.96 m; Range = 23.18–24.28). Five additional children were tested but were excluded due to fussiness, experimenter error or not completing all conditions. Participants had no known hearing or visual problems and were recruited via the maternity ward at the local hospital. Participants came from homes where British English was the primary language in use.

2.1.2. Procedure

During the experiment, children sat on their caregiver's lap about 80 cm away from a screen (88×24 cm). Two cameras mounted directly above the pair of pictures on the screen recorded children's eye movements. Synchronised signals from the cameras were then routed via a digital splitter to create a recording of two separate time-locked images of the child. Auditory stimuli were presented through a pair of centrally located loudspeakers situated above the screen.

We presented children with exactly the same experiment as in MP (2010) using the same physical stimuli and trial structure. Each child was presented with 16 trials. Each trial began with the presentation of a centrally located image (i.e., the prime image) of a familiar object on-screen for 1.5 s. The prime image was presented in silence. At the offset of the prime image, the screen was blank for 200 ms, followed by the presentation of two images of familiar objects (i.e., target and distracter images) side-by-side for 2.5 s with a separation of 16 cm between the two images. Fifty ms after the onset of these two images, children were presented with a label for the target image in citation form. As in many phonological priming studies with adults, half of the trials presented to children were related primed trials, and the other half were unrelated primed trials. In the related primed trials, the label for the target and prime images began with the same consonant. In the unrelated primed trials, the labels for the target and prime images did not overlap phonemically. The items presented as primes and targets were chosen because they were known by an average of 85% of children at 24-months of age, according to CDI reports (Hamilton, Plunkett, and Schafer (2000) for British infants, see also Fenson et al., 1993).

Note that, as in MP (2010), the prime image was never labelled. Exposure to a name-known image offers the child an opportunity to generate a label for herself, as is often observed in adults participating in visual world tasks (Huettig & McQueen, 2007; Jescheniak, Schriefers, Garrett, & Friederici, 2002; Meyer, Belke, Telling, & Humphreys, 2007). Allowing children to generate the labels associated with the picture prime removes the constraint of having to label the prime image. This can be advantageous, since the rapid succession of presentation of prime and target labels can prove distracting for children (Arias-Trejo & Plunkett, 2009).

Speech stimuli were produced by a female speaker of British English in an enthusiastic, child-directed manner. Visual stimuli were computer images created from photographs, with one image for each word. The prime image appeared in the centre of the screen, while the target and distracter images appeared side-by-side on the screen. Each image measured 36 cm × 24 cm. The prime, target and distracter items used in the current experiment along with the grouping of prime–target–distracter items in related and unrelated trials is given in Table 1.

All labels for the target and prime images, and the distracter and prime images were semantically and associatively unrelated (according to the Edinburgh Word Association Thesaurus and the Birkbeck Word Association Norms, Moss & Older, 1996). The distracter image was never labelled, and the label for the distracter image was, in addition, phonologically unrelated to the target or prime label. Children saw each image only once during the experiment. Across children, target and distracter pairings were maintained. Target–distracter pairs appeared in the primed and unrelated condition with equal frequency across children. Primes were counterbalanced, so that the same prime image appeared in the related primed and unrelated primed condition with equal frequency across children. Targets appeared equally often to the left and to the right in related primed and unrelated primed trials. Order of presentation of trials was randomised within subjects.

2.1.3. Scoring

A digital-video scoring system was used to assess visual events on a frame-by-frame basis (every 40 ms). This technique enabled blind coding of every eye fixation. A second well-trained coder evaluated the data from 10% of the participants (coder agreement: $r = .99$). We analysed eye-movements that were launched between 233 ms and 2000 ms after the onset of the target word, as has

Table 1
Target–distracter pairings and prime images in primed and unrelated trials.

Prime label				Target label			Distracter
Related trials			Unrelated trials	Item	Frequency	Neigh. size	
Item	Frequency	Neigh. size	Item				
Bath	519	1	Cow	Book	1289	2	Foot
Bed	979	4	Pig	Boot	187	1	Fork
Bee	177	5	Comb	Ball	980	5	Truck
Bib	110	2	Cake	Bird	485	2	Sheep
Bin	77	2	Deer	Bus	509	0	Sock
Boat	531	3	Pen	Bear	1348	4	Duck
Bowl	146	2	Cat	Bike	311	4	Hand
Cake	532	1	Bed	Car	2340	2	Eye
Cat	894	5	Teeth	Cup	640	3	Shoe
Comb	117	2	Bee	Cot	49	5	Train
Cow	897	2	Bin	Coat	187	4	Tree
Deer	52	3	Bib	Doll	357	1	Chair
Door	954	2	Boat	Dog	954	1	Hen
Pen	288	1	Door	Pup	161	2	Mouse
Pig	487	1	Bath	Peas	101	3	Hat
Teeth	155	2	Bowl	Toe	122	3	Key

previously been used in infant research (Canfield & Haith, 1991; Haith, Hazan, & Goodman, 1988; Swingley, Pinto, & Fernald, 1999). Analysis considered only those trials where children were reported to know the prime and target images (according to individual CDI reports, Hamilton et al., 2000). This criterion excluded 18.41% of all trials ($n = 88$). All other trials were included in the analysis, so long as the child was not fussy or inattentive during a particular trial and each infant provided at least four good trials per condition (all children). The coded video frames were used to determine the amount of time children looked at the target (T) and distracter (D) images. As is standard in the literature, we calculated the proportion of time (T/(T + D)) children spent looking at the target 233 ms after target word onset – a proportion of target looking measure (PTL).

2.2. Results

Fig. 1 depicts the average proportion of time that children spent fixating the target picture in both conditions of the experiment. Children looked at the target above chance in both related primed ($M = 58\%$, $t(31) = 3.77$, $p = .001$) and unrelated primed trials ($M = 63\%$, $t(31) = 7.97$, $p < .001$). However, children looked longer at the target in unrelated primed trials compared to related primed trials. This difference was statistically significant ($t(31) = 2.26$, $p = .031$). Note that this effect is not driven by children not knowing the names of the target images in some trials, since we only considered those trials where they were reported to know the prime and target images (according to individual CDI reports, Hamilton et al., 2000). Furthermore, each target picture appeared equally often in both conditions of the experiment. This finding contrasts directly with the performance of the 18-month old infants in the MP (2010) study where related primes

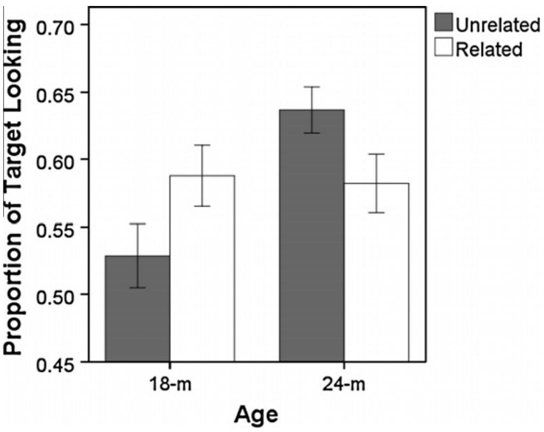

Fig. 1. Percentage of time spent looking at the target image in primed and unrelated trials at 18-months and 24-months of age using vocabulary corrected data from MP 2010. Note the data plotted in MP (2010) is not vocabulary corrected, i.e., does not exclude trials where parents indicated their children did not know either the target or prime labels presented to them. Since the current paper only considers trials where infants knew the words presented to them (as indicated using parental CDI reports), we reanalysed the 18-month-old data using our current exclusion criteria.

produced *greater* target looking than unrelated primes. In fact, re-analysis of the 18-month old PTL measures together with the current data using a two-way ANOVA (age × priming condition) found a significant main effect of age ($F(1, 55) = 4.68$; $p = .035$), no main effect of priming condition, but a significant interaction between priming condition and age ($F(1, 55) = 9.22$; $p = .004$). Fig. 1 also depicts the 18 month old performance reported in MP (2010) for purposes of comparison.

The contrasting direction of the priming effects in the 18- and 24-month old participants points strongly to the conclusion that phonological priming for the older children leads to interference with target recognition. In the adult phonological priming studies discussed earlier, interference with target recognition was interpreted as evidence for lexical-level rather than pre-lexical effects. Therefore, we explore the possibility that lexical-level interference effects are implicated in the pattern of target responding for the 24-month olds in this study.

2.2.1. Cohort effects

There are two loci for putative lexical-level interference effects. First, as argued in the adult literature, the activation of the prime label may lead to the concurrent activation of other words related to the prime label that may interfere with target recognition. This identifies the locus of the interference effects as the prime label and the other words phonologically related to the prime label. Interference in related primed trials may be caused by the target label sustaining the activation of the prime cohort due to phonological overlap between the prime and target labels. Alternatively, the process of activation of the target label may lead to the concurrent activation of other words related to the target label that may interfere with its recognition. This identifies the locus of the interference effects as the target label and the other words phonologically related to the target label. Interference, in this case, may be caused by the prime label sustaining the activation of the target cohort due to phonological overlap between the prime and target labels. Therefore, we separately analysed the influence of the prime cohort and the influence of the target cohort on children's responding.

2.2.1.1. Influence of prime cohort. The labels for the prime words presented to children began with one of five consonants /b/ (7), /d/ (2), /p/ (2), /t/ (1), and /k/ (4). Using the vocabulary data collected from parents, we calculated the number of other words known to children that began with the same sound. Vocabulary analysis indicated that children tested in the current study knew, on average, 39 words from the CDI beginning with /b/, 19 /k/ words, 18 /d/ words, 21 /p/ words, and 21 /t/ words. This difference in cohort size divided the experiment relatively evenly into large prime cohort trials (i.e., only those trials where the label began with /b/, $n = 7$) and small prime cohort trials (i.e., all other trials, $n = 9$). We analysed whether recognition in related and unrelated primed trials was influenced by prime cohort size by separately examining the priming effect in large and small prime cohort trials.

A repeated measures ANOVA with prime condition (related primed, unrelated primed) and prime cohort size

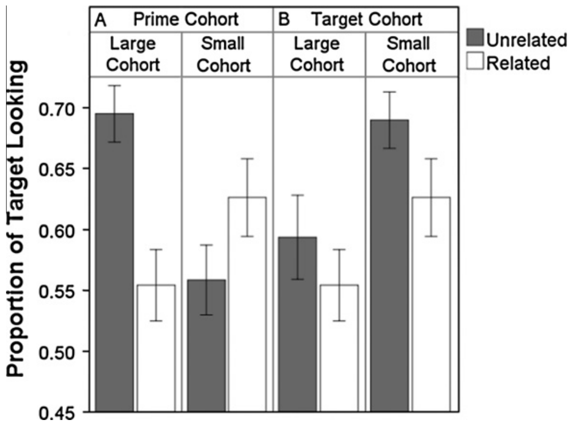

Fig. 2. Percentage of time spent looking at the target in related and unrelated primed trials separated according to prime cohort size (2A) and target cohort size (2B). Note that in the related condition target and prime cohort sizes are identical.

(large, small) as within subjects factors yielded a significant interaction between priming condition and cohort size ($F(1, 31) = 21.32$, $p < .001$). In large prime cohort trials, children looked longer at the target in unrelated primed trials compared to related primed trials ($t(31) = 2.38$, $p = .001$). In contrast, in small cohort trials, children looked longer at the target in related primed trials compared to unrelated primed trials ($t(31) = -2.17$, $p = .037$).[2]

2.2.1.2. Influence of target cohort. As with the prime cohort size, the difference in cohort size of the target labels divided the experiment into large target cohort trials (i.e., only those trials where the target label began with /b/, $n = 7$) and small target cohort trials (i.e., all other trials, $n = 9$). We analysed whether recognition in related and unrelated primed trials was influenced by target cohort size by separately examining the priming effect in large and small target cohort trials. Note that prime cohort and target cohort will be the same in related primed trials but will differ in unrelated primed trials.

A repeated measures ANOVA with prime condition (related primed, unrelated primed) and target cohort size (large, small) as within-subjects factors yielded a significant main effect of priming ($F(1, 31) = 4.01$; $p = .054$) and cohort size ($F(1, 31) = 11.23$; $p = .002$) but no significant interaction between priming and cohort size ($F(1, 31) = .12$, $p = .72$).[3] The main effects indicate that children showed better target recognition in small target cohort trials compared to large target cohort trials. Furthermore, children showed better target recognition in unrelated primed trials compared to related primed trials (echoing the overall effects plotted for 24-month-olds in Fig. 1). Fig. 2 plots the mean proportion of target looking in related and unrelated primed trials separated according to prime cohort size (2A) and target cohort size (2B).

2.2.2. Neighbourhood effects

A further test of the interference effect hypothesised that the degree of interference would also be influenced by other words that sounded similar to the prime or target label, irrespective of whether they were from the same cohort of words. As with the cohort effects outlined above, we would expect greater interference when the prime or target label comes from a larger neighbourhood compared to a smaller neighbourhood (Dufour & Peereman, 2003; Dufour et al., 2007). Neighbours were calculated on the basis of words resulting from deleting, adding or substituting a phoneme from the prime and target labels. The total number of neighbours ranged from one to five words (see Table 1).

Prime neighbourhood size was negatively correlated with prime cohort size in both related primed and unrelated primed trials ($ps < .001$) and target neighbourhood size was positively correlated with target cohort size in unrelated primed trials ($p = .013$). There was no significant correlation between prime or target neighbourhood size and target recognition in unrelated primed trials. In contrast, there was a significant negative correlation between prime neighbourhood size and target recognition ($r = -.23$; $p = .001$) as well as target neighbourhood size and target recognition ($r = -.14$; $p = .04$). The direction of the neighbourhood size effects are in keeping with the cohort-wise analyses, with improved target recognition in trials where the prime and target are from smaller neighbourhoods compared to primes and targets from larger neighbourhoods.

Separate analyses confirmed that this was not due to children knowing these words better or them being more frequent. Indeed, in contrast to the direction of effects reported here, target labels from large cohorts were more frequent ($M = 744$; 95% CI: 470–1017) than target labels from smaller cohorts ($M = 546$; 95% CI: 191–901). Furthermore, the data presented here are all vocabulary corrected (i.e., only those trials where parents indicated their children knew the words presented to them were included in the analyses) so the words presented to children were equally likely to be known to the children.

2.3. Discussion

The current study presented 24-month-olds with phonologically related and unrelated primes to examine whether the phonological relationship between prime–target pairs would influence children's target recognition. Twenty-four month-olds spent longer looking[4] at the tar-

[2] For comparison purposes, similar analyses with the 18-month-old data from MP (2010) yields only a significant main effect of priming ($F(1, 24) = 5.47$; $p = .028$) and no effect of cohort size or interaction between cohort size and priming ($ps > .4$). There is no influence of the prime's cohort size on infants' responding at 18-months of age.

[3] As with the analysis of prime cohort size for 18-month-olds, a repeated measures ANOVA with target cohort size as the decisive factor, yields a significant main effect of priming ($F(1, 24) = 4.45$; $p = .045$) but no main effect of cohort size or interaction between priming and cohort size for 18-month-olds ($ps > .48$).

[4] Note that longer looking times at the target picture in an inter-modal preferential looking task are interpreted as indexing better target recognition in infants (e.g., Golinkoff, Hirsh-Pasek, Cauley, & Gordon, 1987; Johnson, McQueen, & Huetting, in press; Mani & Plunkett, 2007; Meints, Plunkett, & Harris, 1999; Swingley & Aslin, 2007).

Table 2
Target–distracter pairings and prime images in related primed and unrelated primed trials in Experiment 2.

Prime label				Target label			Distracter
Related trials			Unrelated trials	Item	Frequency	Neigh. size	
Item	Frequency	Neigh. size	Item				
Bath	519	1	Cake	Book	1289	2	Foot
Bed	979	4	Door	Boot	187	1	Fork
Bee	177	5	Deer	Ball	980	5	Truck
Bib	110	2	Teeth	Bird	485	2	Sheep
Bin	77	2	Cat	Bus	509	0	Sock
Boat	531	3	Comb	Bear	1348	4	Duck
Bowl	146	2	Cow	Bike	311	4	Hand
Cake	532	1	Bath	Car	2340	2	Eye
Cat	894	5	Bed	Cup	640	3	Shoe
Comb	117	2	Pig	Cot	49	5	Train
Cow	897	2	Bowl	Coat	187	4	Tree
Deer	52	3	Bee	Doll	357	1	Chair
Door	954	2	Bib	Dog	954	1	Hen
Pig	487	1	Boat	Peas	101	3	Hat
Teeth	155	2	Bin	Toe	122	3	Key

get following unrelated primed trials compared to related primed trials, despite showing target recognition in both conditions. We suggest that this pattern of responding is indicative of lexical-level interference effects influencing target responding at 24-months of age, i.e., indicative of the influence of other words phonologically related to either the prime or target labels (prime and target cohort/neighbourhood) interfering with target recognition in related primed trials. An analysis of cohort/neighbourhood effects demonstrated that small cohorts/neighbourhoods produce greater target looking than large cohort/neighbourhood trials, especially when considered from the perspective of the target cohort.

This pattern of results is in direct contrast to the results reported by Mani and Plunkett (2010) where 18-month-olds showed better recognition of the target following related primed trials compared to unrelated primed trials. However, the current finding parallels those reported by Mani (2010) as well as Huang et al. (2011) for 24-month-olds.[5] We suggest that the facilitation effects reported with the 18-month-olds can be explained by the pre-lexical or phonological level overlap between the prime and target labels easing target recognition (Marslen-Wilson & Zwitserlood, 1989). The contrasting pattern of results for the 24-month-olds points strongly to the conclusion that cohort activation leads to lexical-level interference effects in children with larger vocabularies.

Support for this interpretation comes from the finding of a significant influence of prime and target cohort/neighbourhood size on 24-month-old responding, but not on 18-month-old responding. At 18-months of age, target recognition is uninfluenced by the number of other phonologically related words known to the child (see Footnotes 3 and 4), whilst at 24-months of age, the other phonologically related words known to the child play a crucial role in influencing recognition.

Having established potential lexical-level interference effects in 24-month-old phonological priming tasks, our next objective was to identify the locus of the interference effects. On the one hand, the locus of this effect could be at the level of the prime label, i.e., activation of the prime label leads to activation of other words phonologically related to the prime label that interfere with target recognition. According to this explanation, the presentation of the related target in related primed trials sustains the activation of the prime's cohort whilst the presentation of an unrelated target disrupts processing of the prime cohort. On the other hand, the locus of this effect could be at the level of the target label. According to this explanation, the presentation of the target label activates other words phonologically related to the target in both related and unrelated trials. The prior presentation of a phonologically related prime sustains activation of this target cohort in related trials whilst the presentation of a phonologically unrelated prime interrupts processing of the target cohort in unrelated trials.

The results seem to provide evidence for both mechanisms. Separate analyses revealed a significant interaction between priming and *prime* cohort size, as well as a significant main effect of priming and a significant main effect of *target* cohort size. However, further inspection suggests that the size of the target cohort can explain the pattern of results obtained whereas that of the prime cohort does not. The main effect of priming reported in the target cohort analyses reflects the overall interference effect with target recognition in related primed trials compared to unrelated primed trials. The main effect of target cohort size indicates improved target recognition in trials where the target label is from a small cohort compared to when the target label is from a large cohort. The lack of an interaction between cohort size and priming indicates that the latter simply attenuates the degree of target preference in related trials.

The main effect of target cohort size also explains the interaction between priming and prime cohort size

[5] The pattern of results is also in keeping with recent as yet unpublished results from German children at 4-years of age who show attenuated looking at the target in related primed trials compared to unrelated primed trials using the same picture priming paradigm, where related prime-target labels share onset overlap (Mani, Fritzsche, König & Höhle, in prep).

(see Fig. 2A). Both conditions with reduced looking have predominantly large target cohorts (i.e., both large prime cohort related trials and small prime cohort unrelated trials). Similarly, both conditions with improved target recognition have small target cohorts (i.e., both large prime cohort unrelated trials and small prime cohorts related trials). Furthermore, the main effect of target cohort explains an additional difference that an influence of the prime cohort cannot, i.e., the difference between unrelated large prime cohort trials and unrelated small prime cohort trials. If the locus of the interference effects was at the level of the prime label, the size of the unrelated prime cohort should have limited or no influence on target recognition. In contrast, this difference can be explained by the fact that unrelated large prime cohorts have small target cohorts whilst unrelated small prime cohorts have predominantly large target cohorts. Therefore, pinpointing the target as the locus of the lexical-level interference effects explains more of the data compared to locating them at the prime.

This choice of the target cohort as the locus of lexical-level interference effects is post hoc and requires empirical validation. There are two ways to validate this explanation. One is a fully crossed design of prime and target cohort size, to compare the influence of both factors. However, this is very difficult using the vocabulary of the average 24-month-old – large cohort words are always /b/ onset, so we would be unable to construct a large prime cohort-large target cohort unrelated condition (all other conditions are already included in the current design). The next best option is to investigate the influence of the target cohort on target recognition in unprimed trials, i.e., where there is no prime image. Experiment 2, therefore, explores a manipulation with related primed trials, unrelated primed trials and, crucially, unprimed trials (i.e., with no prime image). If the prime cohort were the driving force behind children's responding, we should not find any difference between large target cohort and small target cohort unprimed trials. Such a finding would isolate the degree of lexical interference effects at the level of target word recognition.

3. Experiment 2

3.1. Method

3.1.1. Participants

The participants were 28 children at 24-months ($M = 23.4$ m; range = 22.5–25.6). Seven additional infants were tested but were excluded due to fussiness (4), experimenter error (1) or not completing all conditions (2). Participants had no known hearing or visual problems and were recruited via the maternity ward at the local hospital. Children came from homes where British English was the primary language in use.

3.1.2. Procedure

The timing of the trials was identical to Experiment 1. The only difference between the two experiments was the inclusion, in Experiment 2, of unprimed baseline trials, where children were presented with a cross in the middle of the screen in place of a prime image, followed by the simultaneous presentation of target–distracter images and subsequent naming of the target image (50 ms after the onset of the target–distracter images).

Each child was presented with 15 trials, five related primed trials (where the labels for target and prime images overlapped at onset), five unrelated primed trials (where there were no semantic, phonological or associative similarities between target and prime labels) and five unprimed baseline trials (with no prime image). In addition, we manipulated target cohort size systematically in Experiment 2 by presenting children with equal proportions of large and small target cohort trials in each condition across children. Each child, therefore, received a split of 2:3 small and large cohort trials in all three conditions.[6] At the same time, we also manipulated prime cohort size, so that children received an equal proportion of large prime cohort trials and small prime cohort trials in related and unrelated primed conditions. Since the unprimed condition does not have a prime, there can be no manipulation of prime cohort size in this condition. All target–distracter pairings appear equally often in each of the three conditions. Auditory and visual stimuli were identical to Experiment 1 (Table 2). All other criteria for counterbalancing employed in Experiment 1 were maintained.

3.1.3. Scoring

As in Experiment 1, a second well-trained coder evaluated the data from 10% of the participants (coder agreement: $r = .98$). We analysed eye-movements that were launched between 233 ms and 2000 ms after the onset of the target word and report the results using the PTL measure. Analysis considered only those trials where children were reported to know the prime and target images (according to individual CDI reports, Hamilton et al., 2000). All other trials were included in the analysis, so long as the child was not fussy or inattentive during a particular trial. Children who did not provide at least three good trials per condition were excluded from the analysis ($n = 2$), although analysis including these children produced a very similar pattern of results.

3.2. Results

Fig. 3 presents the mean proportion of target looking across the three conditions presented to children (unrelated primed, unprimed, related primed). Separate pairwise analyses revealed a significant difference between the unrelated primed and the related primed condition ($t(27) = 2.32$; $p = .028$), replicating the results of Experiment 1. There was a near-significant difference between the unprimed condition and the related primed condition ($t(27) = 2$, $p = .055$) but no significant difference between the unprimed condition and the related primed condition ($t(27) = .58$; $p = .56$). There was a significant effect of naming in the unrelated primed condition ($M = 57\%$; $t(27) = 3.44$; $p = .002$) and the unprimed condition

[6] This was counter-balanced across children: If Child A received three large cohort trials and two small cohort trials in the one condition, Child B received two large cohort trials and three small cohort trials in the same condition.

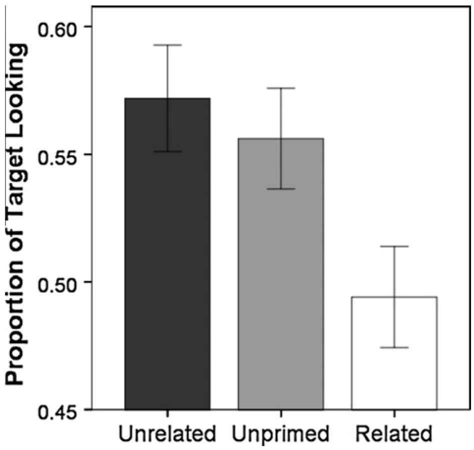

Fig. 3. Percentage of time spent looking at the target in related and unrelated primed trials and unprimed trials.

($M = 55\%$; $t(27) = 2.84$; $p = .008$) but not in the related primed condition ($M = 49\%$; $t(27) = .29$; $p = .7$). Note that this effect is not driven by children's ignorance of the names of the target images in some trials, since the analysis only considered those trials where they were reported to know the prime and target images (according to individual CDI reports, Hamilton et al., 2000). The overall results of Experiment 2, therefore, confirm the pattern of interference found in Experiment 1, with children looking less at the target image in related primed trials compared to unrelated primed trials.

3.2.1. Influence of target cohort

As in Experiment 1, the labels for the prime and target images began with one of five consonants /b/ (7), /d/ (2), /p/ (2), /t/ (1), and /k/ (4). Once again, the difference in cohort size divided the primes into large cohort primes (i.e., those whose label began with /b/, $n = 7$) and small cohort primes (i.e., all others, $n = 8$). We analysed whether recognition in related and unrelated primed trials was influenced by target cohort size by examining large and small cohort trials. Furthermore, we examined the impact of cohort size in the unprimed baseline condition.

Fig. 4 plots the mean proportion of target looking in related and unrelated primed trials separated according to target cohort size for the three conditions. A repeated measures ANOVA with prime condition (related primed, unrelated primed, unprimed) and target cohort size (large, small) as within-subjects factors yielded a significant main effect of priming ($F(2, 26) = 4.02$; $p = .03$) and cohort size ($F(1, 27) = 14.97$; $p = .001$) but no significant interaction between priming and cohort size ($F(2, 26) = .12$, $p = .8$). The main effect of cohort size indicates that children showed better target recognition in small target cohort trials compared to large target cohort trials across all conditions. Despite the lack of a significant interaction between priming and cohort size, we separately confirmed this in each condition, as this is crucial to our understanding of the locus of interference effects. There was a significant difference between large and small target cohort trials in unrelated primed ($t(27) = 2.7$; $p = .011$) and a near-significant difference in related primed trials ($t(27) = 1.8$; $p = .08$) and in unprimed trials ($t(27) = 1.94$; $p = .06$). As for priming effects, in large target cohort trials, there was a significant difference between unrelated primed and related primed trials ($t(27) = 2.19$; $p = .03$), and between related primed and unprimed trials ($t(27) = 2.11$; $p = .045$). In small target cohort trials, there was a significant difference between unrelated primed and related primed trials ($t(27) = 2.01$; $p = .055$) and a near-significant difference between related primed and unprimed trials ($t(27) = 1.77$; $p = .08$).

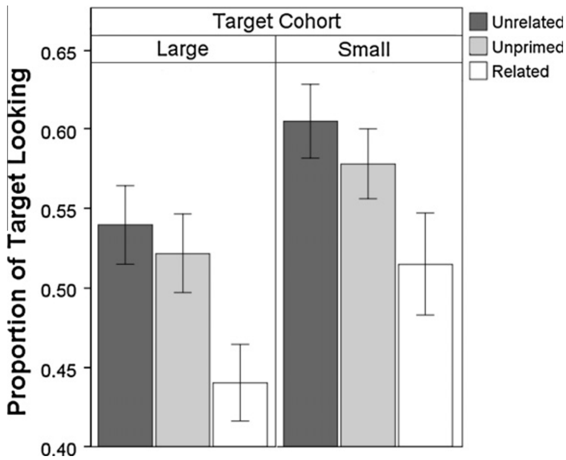

Fig. 4. Percentage of time spent looking at the target in related and unrelated primed and unprimed trials separated according to target cohort size.

3.2.2. Neighbourhood effects

Prime neighbourhood size was negatively correlated with prime cohort size ($p < .001$). Nevertheless, there was a significant correlation between increasing prime neighbourhood size and decreasing target looking in related primed trials ($r = -.24$; $p = .005$) and a significant correlation between decreasing prime neighbourhood size and decreasing target looking in unrelated primed trials ($r = .25$; $p = .003$). Target neighbourhood size was not correlated with cohort size both overall and within each condition ($ps > .8$; $p = .075$ for unrelated primed trials). Increasing target neighbourhood size was correlated with decreasing target preference in related primed ($r = -.23$; $p = .007$) and unprimed conditions ($r = -.2$, $p = .02$) but not in the unrelated primed condition ($p = .5$).

As in Experiment 1, labels from large cohorts were more frequent ($M = 744$; 95% CI: 470–1017) than target labels from smaller cohorts ($M = 546$; 95%CI: 191–901).

3.3. Discussion

Experiment 2 investigated the locus of the interference effects found in Experiment 1. We evaluated this by comparing target preferences in an unprimed, baseline condition with the related primed condition and the unrelated primed condition. In order to identify the impact of the target's cohort/neighbourhood, we systematically manipulated the size of the target cohort across unrelated and related primed, and more importantly, across unprimed trials (where there could be no influence of prime cohort).

The results of Experiment 2 highlight two crucial findings. First, replicating Experiment 1, we find that target preference was reduced in the related prime condition compared to the unrelated primed condition. Furthermore, target preference in the related primed condition was significantly reduced compared to the unprimed baseline condition. We attribute reduced looking in related primed trials to the interfering influence of the other phonologically related words being activated in these trials. In unprimed trials or unrelated primed trials, the activation of these other words is unsupported due to the absence of a prime or the absence of overlap between the prime and the target labels. In related primed trials, however, the activation of these other words is supported through the overlap between the prime and the target label.

Experiment 2 also highlights the role of the target's cohort. We find greater target looking in small target cohort trials compared to large target cohort trials even in the unprimed condition. This finding strongly supports our interpretation of the data, i.e., that the cohort or neighbourhood of words related to the target interfere with processing of the target label and recognition of the association between the target label and the target image.

It should be noted that target preferences were reduced across the board in Experiment 2, presumably owing to the smaller number of trials per condition. This reduction in the number of trials may not allow children sufficient opportunity to override the interfering effect of other phonologically related words, especially since, in half the infants there is an unequal balance (3:2) between large target cohort (with greater interference) and small target cohort trials (see Footnote 7). Nevertheless, there is a striking similarity in the pattern of results obtained in Experiments 1 and 2 not only with respect to the overall effect of reduced looking in related primed trials, but also with respect to the precise pattern of target cohort and neighbourhood effects.

4. General discussion

Two experiments examined whether phonologically related words impacted children's recognition of a target in a picture-primed adaptation of the Inter-Modal Preferential Looking task. Experiment 1 found that toddlers looked less at a named target image when primed by an image whose label was phonologically related to the target label (e.g., *bed-boot*) compared to an unrelated label (e.g., *bed-car*). We explain this effect by suggesting that other phonologically related words (i.e., related to the prime and target labels) interfere with children's recognition of the target word. Support for this interpretation of the results was provided by comparing target looking in trials containing labels with small cohorts of words known to the toddlers with trials containing labels with large cohorts: In Experiment 1, large target cohort trials produced less target looking than small target cohort trials in both related and unrelated conditions, with attenuation of target looking greater in the related than the unrelated priming condition. That this effect was more evident in related compared to unrelated primed trials suggests that the presentation of the related prime reinforced the competitive effect of the cohort of words activated by the target word.

Experiment 2 provided further support for this interpretation by replicating the difference between related and unrelated prime trials and the attenuation of target looking in large compared to small target cohort trials. More importantly, Experiment 2 contained an unprimed condition in which large cohort trials also resulted in reduced target looking compared to small target cohort trials, indicating that phonological priming is not a necessary condition for the observed lexical level cohort effects. The patterning of children's target preferences in the three conditions of Experiment 2 clarifies the interference account further. Target recognition in related primed trials was impaired, not just compared to unrelated primed trials, but also compared to the unprimed baseline condition (i.e., with no prime image). Such evidence provides further support for the suggestion that reduced target preference in the related primed trials was caused by other phonologically related words interfering with target recognition, and that this interference effect is enhanced by the phonological overlap between the prime picture's label and the target word.

We also considered the impact of the size of the prime label's cohort on target looking. In related prime conditions, the prime cohort is the same as the target cohort so the impact on target looking is identical (see Fig. 2) – the large prime cohort condition attenuates target looking compared to the small prime cohort condition. In contrast, in the unrelated prime condition, a large prime cohort results in greater target looking than a small prime cohort. This would appear to suggest a facilitative effect of large cohort size. However, it should be noted that in the unrelated prime condition, a large prime cohort *necessarily* involves a small target cohort – all non 'b' initial words have small cohorts for our 24-month-olds, whereas small prime cohorts may involve either large or small target cohorts. Hence, the patterning of results reported in these experiments need not invoke the prime's cohort as an explanatory factor. Of course, this is not to imply that the prime's cohort does not or cannot influence target recognition in these experiments. However, an experimental design in which prime cohort size is manipulated independently of target cohort size would be needed to demonstrate such effects. These designs are difficult to achieve given the exigencies of the 24-month-old lexicon.

The results of Experiments 1 and 2 provide support for a lexically based account of phonological priming where the activation of other words phonologically related to the target label is sustained by the presentation of a phonologically related prime, in comparison to an unrelated prime or no prime. The data, therefore, suggests that words in the 24-month-old lexicon are organised on the basis of phonological similarity, where other phonologically similar words are activated during word recognition.

A systematic comparison of the toddler's performance in Experiment 1 with that of the 18-month-olds in MP's (2010) study revealed a contrasting pattern of results. In particular, the 18-month-olds showed enhanced target recognition in the related prime condition compared to the unrelated prime condition, and no evidence of prime or target cohort effects. A plausible explanation for this contrasting pattern of results is that 18-month-old infants do not yet possess a lexicon organised on the basis of phonological similarity. Hence, the facilitative effects observed with the 18-month-olds in the related prime condition of MP (2010) can be interpreted as *pre-lexical* facilitation arising from phonological overlap between the prime and target labels, whereas the interference effects for the 24-month-olds in the current study are driven by *lexical* level cohort effects.

Evidence convergent with this developmental interpretation comes from semantic priming studies with 18–24 month olds: Styles, Arias-Trejo, and Plunkett (2008) and Arias-Trejo and Plunkett (2009) fail to find semantic priming between related words at 18-months but enhanced target recognition for related word pairs by 24 months of age. These authors interpret their findings as reflecting an emergent lexical structure in which the earlier organisation is best characterised in terms of "lexical islands" and the later organisation in terms of a "lexico-semantic network". It is not implausible that the emergence of a lexico-semantic network during the second year of life should go hand-in-hand with the emergence of a lexicon organised according to phonological principles.

The difference between the 18-month-old and 24-month-old results (across semantic and phonological priming experiments) may be directly caused by the sudden increase in vocabulary size between these two age-groups. Perhaps the larger vocabulary of the 24-month-olds requires organisation into phonological and semantic neighbourhoods in order to facilitate word recognition in these children. There may be too few words in the 18-month-old lexicon to create a competitive environment of sufficient force as to lead to relatedness effects. Alternatively, perhaps 24-month-olds are more familiar with the words in their lexicon compared to 18-month-olds. Given this, the absence of an interference effect with the younger children may be because of their inability to readily or speedily activate other phonologically similar words in their lexicon.

The experiments presented here complement the work by Newman et al. (2008) with 24-month-old infants, while clarifying the divide between the resources used in word learning and word recognition. As with Newman et al., the current study provides clear evidence of an influence of similar-sounding words in the infant lexicon on lexical processing. Interestingly, however, this effect is facilitative during word learning, whilst inhibitive during word recognition. This contrast can be readily understood by considering the different processes leading to word learning and word recognition. Children are more familiar with the sound structures (i.e., sequences of phonemes) of words from large neighbourhoods, having heard these sound structures more often in different contexts. In contrast, the phonotactic probabilities of phoneme sequences of words from smaller neighbourhoods should be lower.[7] Greater familiarity with the sound structures may, therefore, make it easier for infants to learn new words that follow similar phonotactic correspondences, thereby leading to a facilitative effect in word learning. Word recognition, as discussed above, is influenced by neighbourhood size differently. Now, larger neighbourhoods in the lexicon lead to greater competition and, thereby, greater inhibition of the target label. On this account, then, word learning in 24-month-olds is enhanced by larger neighbourhoods that produce facilitative effects at the phonological/phonotactic level, whereas word recognition is impaired by larger neighbourhoods that produce inhibitory effects at the lexical level.

In conclusion, Experiments 1 and 2 together provide clear evidence of phonological priming and cohort effects in word recognition by toddlers. Experiment 1 showed that target recognition was inhibited in related primed trials compared to unrelated primed trials, suggesting that the greater activation of other phonologically related words in related primed trials interferes with target recognition in these trials. Experiment 2 extended this finding to show that target recognition in related primed trials is impaired not only with respect to unrelated primed trials but also with regard to unprimed trials, providing clear evidence of the impact of the size of the target's cohort on recognition in both primed and unprimed trials. The cohort effects support a lexically-based explanation of the results, with greater interference in large target-cohort trials compared to smaller target-cohort trials. These results suggest that by 24-months of age, children's responding in word recognition tasks approximates to adult-like performance: words begin to cluster together in the toddler lexicon based on their phonological properties, such that word recognition involves the activation and processing of phonologically related words.

Future research on this topic should attempt to disentangle the contribution of the prime and target cohort further. In addition, further research should examine whether an interference effect can be systematically modulated by neighbourhood size and/or cohort size, in order to provide an estimate of a criterial neighbourhood size for interference. The phonological priming effect reported in this paper derived from phonological overlap between the onset consonants of the heard and implicitly generated label. Are similar effects obtained with different phonological relationships between prime and target, such as rhyming words (e.g., *cat-hat*) and phono-semantically related pairs like *cup-dog* (*cup* is phonologically related to *cat*, which is semantically related to *dog*)? Further clarification of the conditions leading to interference in priming tasks have the potential to provide vital information about the processes involved in word recognition and inform current theoretical models of word recognition in infants and young children.

[7] Newman et al. use the example fowk and wat. Children would have been exposed to the rime /at/ in numerous words already making it easier for them to learn a new sequence with a different consonant tagged on, e.g., /w/. In contrast, the sequence /fo/ is highly uncommon in the infant lexicon, and it may be more difficult for children to master the phonotactics of a new sequence containing this onset.

References

Arias-Trejo, N., & Plunkett, K. (2009). Lexical priming effects during Infancy. *Philosophical Transaction of the Royal Society B, 364*, 3633–3647.

Canfield, R. L., & Haith, M. M. (1991). Young infants' visual expectations for symmetric and asymmetric stimulus sequences. *Developmental Psychology, 27*, 198–208.

Dufour, D., Frauenfelder, U. H., & Peereman, R. (2007). Inhibitory priming in auditory word recognition: Is it really the product of response biases? *Current Psychology Letters, 22*. <http://cpl.revues.org/document2622.html>.

Dufour, S., & Peereman, R. (2003). Inhibitory priming effects in auditory word recognition: When the target's competitors conflict with the prime word. *Cognition, 88*, B33–B44.

Fenson, L., Dale, P. S., Reznick, J. S., Thal, D., Bates, E., Hartung, J. P., et al. (1993). *MacArthur communicative development inventories: User's guide and technical manual*. San Diego, CA: Singular Publishing.

Goldinger, S. D., Luce, P. A., & Pisoni, D. B. (1989). Priming lexical neighbours of spoken words: Effects of competition and inhibition. *Journal of Memory and Language, 28*, 501–518.

Goldinger, S. D., Luce, P. A., Pisoni, D. B., & Marcario, J. K. (1992). Form-based priming in spoken word recognition – The roles of competition and bias. *Journal of Experimental Psychology: Learning, Memory and Cognition, 18*, 1211–1238.

Golinkoff, R. M., Hirsh-Pasek, K., Cauley, K., & Gordon, L. (1987). The eyes have it: Lexical and syntactic comprehension in a new paradigm. *Journal of Child Language, 14*, 23–46.

Haith, M. M., Hazan, C., & Goodman, G. S. (1988). Expectation and anticipation of dynamic visual events by 3.5-month-old babies. *Child Development, 59*, 467–479.

Hamburger, M. B., & Slowiaczek, L. M. (1996). Phonological priming reflects lexical competition. *Psychonomic Bulletin & Review, 3*, 520–525.

Hamilton, A., Plunkett, K., & Schafer, G. (2000). Infant vocabulary development assessed with a British communicative development inventory. *Journal of Child Language, 27*, 689–705.

Huang, Y., Khan, M., Wang, S., Geojo, A., & Snedeker, J. (2011). From sounds to concepts and back again: Cascaded processing during object and word recognition. In *Paper presented at the biannual meeting of the society for research in child development*, Montreal, Canada.

Huettig, F., & McQueen, J. (2007). The tug-of-war between phonological, semantic, and shape information in language-mediated visual search. *Journal of Memory and Language, 57*, 460–482.

Jescheniak, J. D., Schriefers, H., Garrett, M. F., & Friederici, A. D. (2002). Exploring the activation of semantic and phonological codes during speech planning with event-related brain potentials. *Journal of Cognitive Neuroscience, 14*(6), 951–964.

Johnson, E. K., McQueen, J. M., & Huetting, F. (in press). Toddler's language mediated visual search: They need not have the words for it. *Quarterly Journal of Experimental Psychology.*

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

Mani, N. (2010). When *Cup* primes *Dog*: Phono-semantic priming in the toddler lexicon. In *Proceedings of the 34th annual Boston university conference on language development* (pp. 291–302). Boston: Cascadilla Press.

Mani, N., & Plunkett, K. (2007). Phonological specificity of vowels and consonants in early lexical representations. *Journal of Memory and Language, 57*, 252–272.

Mani, N., & Plunkett, K. (2010). In the infant's mind's ear: Evidence for implicit naming in 18-month-olds. *Psychological Science, 21*, 908–913.

Marslen-Wilson, W. D., & Zwitserlood, P. (1989). Accessing spoken word: The importance of word onsets. *Journal of Experimental Psychology: Human Perception and Performance, 15*, 576–585.

Meints, K., Plunkett, K., & Harris, P. L. (1999). When does an ostrich become a bird: The role of prototypes in early word comprehension. *Developmental Psychology, 35*(4), 1072–1078.

Meyer, A. S., Belke, E., Telling, A., & Humphreys, G. W. (2007). Early activation of object names in visual search. *Psychonomic Bulletin & Review, 14*, 710–716.

Moss, H., & Older, L. (1996). *Birkbeck word association norms*. Associated Press.

Newman, R., Samuelson, L. & Gupta, P. (2008). Learning novel neighbours: Distributed mappings help children and connectionist models. In *Paper presented at the* 30th *annual meeting of the cognitive science society*, Washington, DC.

Norris, D., McQueen, J. M., & Cutler, A. (2002). Bias effects in facilitatory phonological priming. *Memory and Cognition, 30*, 399–411.

Radeau, M., Morais, J., & Segui, J. (1995). Phonological priming between monosyllabic spoken words. *Journal of Experimental Psychology: Human Perception and Performance, 21*, 1297–1311.

Radeau, M., Morais, J., & Dewier, A. (1989). Phonological priming in spoken word recognition: Task effects. *Memory & Cognition, 17*, 525–535.

Slowiaczek, L. M., & Hamburger, M. (1992). Prelexical facilitation and lexical interference in auditory word recognition. *Journal of Experimental Psychology: Learning, Memory and Cognition, 18*, 1239–1250.

Slowiaczek, L. M., Nusbaum, H. C., & Pisoni, D. B. (1987). Phonological priming in auditory word recognition. *Journal of Experimental Psychology: Learning, Memory and Cognition, 13*, 64–75.

Styles, S. J., Arias-Trejo, N., & Plunkett, K. (2008). Priming and lexical interference in infancy. In *Proceedings of the annual meeting of the cognitive science society*, Washington, DC.

Swingley, D., & Aslin, R. N. (2007). Lexical competition in young children's word learning. *Cognitive Psychology, 54*, 99–132.

Swingley, D., Pinto, J. P., & Fernald, A. (1999). Continuous processing in word recognition at 24 months. *Cognition, 71*, 73–108.