Developmental differences in sensitivity to semantic relations among good and poor comprehenders: evidence from semantic priming

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Abstract

Semantic priming for category coordinates (e.g. CAT–DOG; AEROPLANE–TRAIN) and for pairs of words related through function (e.g. BROOM–FLOOR; SHAMPOO–HAIR) was assessed in children with good and poor reading comprehension, matched for decoding skill. Lexical association strength was also manipulated by comparing pairs of words that were highly associated with pairs that shared low association strength. Both groups of children showed priming for function-related words, but for the category co-ordinates, poor comprehenders only showed priming if the category pairs also shared high association strength. Good comprehenders showed priming for category-related targets, irrespective of the degree of prime-target association. These findings are related to models of language development in which category knowledge is gradually abstracted and refined from children’s event-based knowledge and it is concluded that in the absence of explicit co-occurrence, poor comprehenders are less sensitive to abstract semantic relations than normal readers. © 1999 Elsevier Science B.V. All rights reserved.

Keywords: Comprehension difficulties; Semantic memory development

1. Introduction

Although there is a close developmental relationship between word recognition

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and reading comprehension skill, approximately 10–15% of children have impaired reading comprehension in the face of age-appropriate decoding skills (Yuill and Oakhill, 1991; Stothard and Hulme, 1992; Nation and Snowling, 1997). Such children have difficulties with text-level processing which include the ability to make inferences (Oakhill, 1984), to engage in constructive processing (Oakhill, 1982, 1983) and in using context efficiently (Nation and Snowling, 1998b). Furthermore, their difficulties are not restricted to written texts (Stothard and Hulme, 1992). Using tasks tapping word knowledge, we extended observations of poor listening comprehension in this group to poor semantic processing skills, relative to controls matched for decoding ability (Nation and Snowling, 1998a).

One limitation of previous work examining individual differences in children’s semantic knowledge is that off-line tasks requiring conscious processing have been used. In the study by Nation and Snowling (1998a), expressive vocabulary was measured by asking children to define words. It is possible, therefore, that the poor comprehenders’ lower performance was due to difficulties organising concise definitions for words, rather than a reflection of deficient understanding. Thus, results from such tasks do not allow us to make claims concerning the status of children’s underlying semantic representations (cf. Moss and Tyler, 1995 for similar arguments regarding language comprehension in aphasia).

In this paper we investigate the nature of poor comprehenders’ word knowledge using a paradigm that provides an on-line measure of the effects of semantic similarity on lexical decision performance. It is well-established that skilled adults are faster at deciding whether a target item (e.g. NURSE) is a word or a non-word if they have previously encountered a semantically related prime (e.g. DOCTOR) relative to an unrelated prime (Meyer and Schvaneveldt, 1971). Semantic priming allows an assessment of the extent to which poor comprehenders show a normal pattern of priming for different types of semantic relation. If this pattern is normal, this would suggest that underlying semantic representations are adequate, despite poorer performance on off-line tasks such as word definitions.

### 1.1. Types of semantic relations

Developmental theorists have suggested that children are sensitive to the functional properties of spoken words from an early age (Mandler, 1994) and on some accounts of language acquisition, functional information is considered to be the driving force underpinning the development of semantic memory. Nelson (1977, 1982), proposed that young children represent information in generalized event-based scripts (e.g. ‘getting dressed in the morning’ or ‘eating lunch’) that maintain the spatial and temporal relationships between objects. For example, HEAD and HAT may be related in a script because the objects functionally re-late in the real world. From this script-based knowledge base, Nelson hypothesizes that children gradually abstract and refine category information. Consistent with this, in word association abstract and refine category information. Consistent with this, in word association abstract and refine category information.
(Petrey, 1977). Similarly, using cued recall, Blewitt and Toppino (1991) found that children were better at recalling pairs of words related through function (e.g. CHAIR—LIVING ROOM; AEROPlane—SKY) than pairs of words belonging to the same category (CHAIR—BED; AEROPlane—TRAIN).

Consistent with studies suggesting that functionality plays a central role in language development, Moss et al. (1995) found robust semantic priming for functionally related words in skilled adults; functional properties were activated more rapidly than other semantic properties (Moss et al., 1997) and functional knowledge was relatively impervious to breakdown in semantic dementia and progressive aphasia (Tyler and Moss, 1997). Taken together, these findings support the view that functional information, perhaps more so than category information, is central to word meaning and that this information is automatically accessed.

In this paper we compared semantic priming for words that were either category coordinate-related (e.g. CAT–DOG) or function-related (e.g. BROOM–FLOOR). Since sensitivity to functional information develops early, we anticipated that all children would show priming for functionally related words. Since awareness of category knowledge emerges later, however, we predicted poor comprehenders would show reduced or deficient semantic priming.

1.2. Semantic and associative priming

A second issue we considered concerns the distinction between semantic priming and associative priming. In many studies, these different kinds of priming have been confounded. For example, CAT–DOG are semantically related as they are co-ordinates within the superordinate category of animals or domestic pets. They are also associated: for example, the response DOG is a highly typical response to the word CAT in word association norms. Therefore, it is not clear whether significant priming between CAT and DOG is due to the activation of semantic information, or is more a consequence of the lexical co-occurrence of the two words in the language (Tannenhaus and Lucas, 1987). However, studies finding robust priming for non-associated words (e.g. BOTTLE–JAR; CRAYON–PENCIL) argue against the view that semantic priming is a direct consequence of lexical association (Fischler, 1977; McRae and Boisvert, 1998). Similarly, Moss et al. (1995) found words that are both semantically related and associated produce stronger priming than pairs that are only related semantically, an effect they term the associative boost.

We consider the role of association strength by comparing words that are highly associated with words that are not associated. This comparison will elucidate whether normal children show an associative boost, akin to that reported in adults (Moss et al., 1995). This has not been investigated in children using an on-line task although in a cued recall task, children are sensitive to association strength (Krackow and Gordon, 1998).

We adopted an auditory lexical decision paradigm for a number of reasons. Ten-year-old children do not have fully automatic written word recognition skills and we did not want priming effects to be masked by slow or inaccurate reading. This was a concern, particularly for the group comparisons: poor comprehenders have subtle
problems with some of the higher-level aspects of visual word recognition, an effect attributed to semantic processing weaknesses (Nation and Snowling, 1998a). To ensure that all words were attended to, we used a single word presentation method in which a lexical decision was made to all items, both primes and targets. Children found this task very easy; few errors were made and few trials were lost due to procedural problems. This method produces the same pattern of priming as the more traditional paired-presentation method, although the overall magnitude of priming tends to be smaller. This is probably because single-word presentation reduces strategic effects (Shelton and Martin, 1992).

2. Method

2.1. Participants

Sixteen normal readers and 16 poor comprehenders, matched for decoding skill, chronological age and non-verbal ability participated in this experiment. Decoding ability was assessed using the Graded Nonword Reading Test (Snowling et al., 1996) which provides norms for children aged between 6 and 11 years. Five complex non-words were added to make the test more difficult (strunbesh, delathode, tralisheht, grikimes, Pragendent). Non-verbal ability was assessed using the Matrix Analogy Test (short form, Naglieri, 1985). Text reading accuracy and reading comprehension were assessed using the Neale Analysis of Reading Ability-Revised (Neale, 1989). In this test, children read aloud short passages of text and are then asked questions to assess literal and inferential understanding.

Children were recruited into the study according to the following criteria. All of the normal readers had a least average-for-age non-word reading, reading accuracy and reading comprehension. Children in the poor comprehender group were matched with the normal readers as closely as possible for non-word reading and non-verbal ability. However, their reading comprehension was at least 1 year below the expected level. The performance of the two groups on the selection tasks is summarized in Table 1. Analyses confirmed that the two groups did not differ in terms of chronological age or non-verbal ability (both \( F \)'s < 1.0) although the poor comprehenders were slightly better at reading non-words \( (F(1,30) = 4.59, \text{MSE} = 3.30, P < 0.05) \). In contrast, the poor comprehenders' reading comprehension was significantly lower than that of the control children \( (F(1,30) = 115.01, \text{MSE} = 1.01, P < 0.001) \).¹

¹Evidence suggests that some aspects of reading accuracy (namely reading in context and exception word reading) are related to underlying language comprehension skills (Nation and Snowling, 1997). Consistent with this, we find that poor comprehenders tend to achieve slightly lower reading accuracy scores on the Neale Analysis than normal readers to whom they are closely matched for decoding (non-word reading). Importantly however, only children with at least average-for-age reading accuracy are included in our studies. It is not the case, therefore, that poor comprehenders are generally poor readers. See Nation and Snowling (1998a) for a full discussion.
Performance of poor comprehenders and normal readers on selection tests

<table>
<thead>
<tr>
<th></th>
<th>Poor comprehenders</th>
<th>Normal readers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Age (years)</td>
<td>10.77</td>
<td>0.55</td>
</tr>
<tr>
<td>Reading comprehension</td>
<td>83.94</td>
<td>5.96</td>
</tr>
<tr>
<td>Reading accuracy</td>
<td>108.31</td>
<td>4.08</td>
</tr>
<tr>
<td>Non-word reading</td>
<td>23.38</td>
<td>1.59</td>
</tr>
<tr>
<td>Matrix Analogies Test</td>
<td>101.31</td>
<td>14.06</td>
</tr>
</tbody>
</table>

*Standard scores, M = 100, SD = 15.
*Maximum score is 25.

### 2.2. Materials

To select materials appropriate for children, we asked 16 adults, all with experience of working with young children, to rate how familiar the 224 words (112 targets and 112 primes) used by Moss et al. (1995) would be to 10-year-old children. They rated each word on a scale of one (very familiar to children) through to seven (unfamiliar to children). Only words rated two or less by all raters were included in this experiment.

From these familiar words, 48 related word pairs were selected (see Appendix A). Half were related through category membership and half were functionally related. Within each set of related pairs, half were strongly associated according to normative lists of word associations (mean association strength 37.65%). The other half were not associatively related (mean association strength 0.49%). Because of the constraints imposed by adapting this design for children, it was not possible to match for frequency across all four conditions. However, the associated and non-associated pairs were matched closely for frequency within the category-related and function-related conditions (using norms based on children’s reading materials, Carroll et al., 1971). This procedure resulted in the selection of 12 prime-target pairs of each type: category related/associated, category related/non-associated, function related/associated and function related/non-associated.

The materials were organized into two lists. Each target item appeared once in each list; in one list it was paired with its semantically related prime (e.g. DOG–CAT) and in the other list with a semantically unrelated control prime (e.g. BOAT–CAT). Control primes were formed by re-pairing targets with semantically unrelated primes from the set. Each list contained an equal number of related and unrelated pairs, fully counterbalanced across conditions. As we asked participants to make a lexical decision to both primes and targets, the experimental materials required 96 lexical decisions to be made in each version (24 to targets preceded by semantically related primes, 24 to targets preceded by semantically unrelated primes, and 48 to the two sets of primes). We added 96 non-words to each list, matched for length to the target words, to provide an equal number of ‘no’ lexical decision responses. In addition, and to break up the pattern of real words always appearing consecutively, a further 20 words and 20 non-words arranged in pairs were added to each list. This
made a total of 232 items in each list; 50% of the items were non-words and the
proportion of semantically related trials was 10.3%. Related pairs, unrelated pairs,
filler pairs and non-words were randomly distributed throughout each list.

2.3. Procedure

All of the items were recorded by a native British English female speaker onto
DAT tape in a sound-attenuated booth. The words were then digitized onto a
Macintosh computer and the experiment was run using PsyScope software
(Cohen et al., 1993). A lexical decision response was made to every item by pressing
either a ‘yes’ or ‘no’ button using the dominant hand for a positive response. RTs
were measured from the acoustic onset of each word. Following a response, a 500
ms interval preceded the presentation of the next word. Each list began with 14
practice trials followed by eight dummy trials. A few minutes rest was provided at
the halfway point. After this, an additional eight dummy trials preceded the second
half of the experiment.

Each child was tested individually in a quiet room in their school. All of the
children completed both versions of the materials but each session was separated by
a period of at least two weeks. The order of presentation of the two lists was
counterbalanced across children in each group.

To confirm whether the results reported by Moss et al. (1995) replicate when only
a subset of their materials are used, we also tested 22 students at the University of
York. They were tested individually and paid for their participation.

3. Results

To avoid possible bias induced by trimming RT data, we report analyses based on
all correct RTs, as recommended by Ulrich and Miller (1994). As each participant
was tested individually, we are confident that all extreme responses were indeed
genuine and not due to equipment failure or some other extraneous factor.

First, we briefly describe the results from the adult participants (Table 2). It is
important to be cautious when interpreting these data as the materials were not
selected to be matched across conditions for adult participants. Nevertheless, parti-
cipants were significantly faster at making a lexical decision to related words than
unrelated words in both category related (51 ms, F1(1,21) = 14.77, MSE = 3716.81,
P < 0.01; F2(1,11) = 1.89, MSE = 15540.92, P < 0.1) and functional related (50
ms, F1(1,21) = 15.75, MSE = 3552.14, P < 0.001; F2(1,11) = 3.78, MSE =
8180.78, P < 0.07) conditions. There was significant priming to both associated
and non-associated category coordinates although the associated words primed more
than the non-associated words by subjects (78 ms vs. 22 ms, F1(1,21) = 3.5,
MSE = 5163.12, P = 0.07; F2 < 1.0). For the functionally related words, both
associated and non-associated pairs primed significantly although there was no
difference in amount of priming for the associated and non-associated words (52
vs. 49 ms, F’s < 1.0). In summary, normal adults demonstrate robust priming for
words that are semantically related either through shared category membership or through functionality, regardless of whether or not the pairs are also normatively associated. There was evidence for an associative boost for the category related word pairs only. These results are broadly in line with those reported by Moss et al. (1995), (Experiment 2).2

With these findings as a backdrop, we turn to discuss the children’s results. The mean RT values and error rates for the poor comprehenders and normal readers in each condition are shown in Table 2. For clarity, we discuss the results for the category coordinate relations and functional relations separately. In both conditions, the data were analysed using a 2 (prime) × 2 (association type) × 2 (reader group) analysis of variance with repeated measures on the first two factors. Two sets of analyses are reported with both children (F1) and items (F2) as random variables.

3.1. Category coordinate relations

There was a significant overall priming effect with RT values to words in the related condition being 75 ms faster than in the unrelated condition (F1(1,30) = 24.83, MSE = 7210.05, P < 0.001; F2(1,11) = 19.07, MSE = 6717.81, P < 0.01). There was no main effect of association type (F’s < 1.0). However, there was more priming in the associated condition (127 ms) than in the non-associated condition (22 ms) leading to a significant interaction between

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Table 2

Mean RT in ms (error rates) in each condition for poor comprehenders, normal readers and adults

<table>
<thead>
<tr>
<th>Category items</th>
<th>Associated R</th>
<th>U</th>
<th>U - R</th>
<th>Non-associated R</th>
<th>U</th>
<th>U - R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor comprehenders</td>
<td>1039 (0)</td>
<td>1180 (0.3)</td>
<td>141</td>
<td>1129 (0.1)</td>
<td>1122 (0)</td>
<td>-7</td>
</tr>
<tr>
<td>Normal readers</td>
<td>1003 (0)</td>
<td>1116 (0.3)</td>
<td>113</td>
<td>1037 (0.1)</td>
<td>1088 (0.3)</td>
<td>51</td>
</tr>
<tr>
<td>Adults</td>
<td>882 (0.1)</td>
<td>960 (0.2)</td>
<td>78</td>
<td>861 (0)</td>
<td>883 (0.1)</td>
<td>22</td>
</tr>
</tbody>
</table>

Function items

| Poor comprehenders | 1099 (0.1) | 1166 (0.1) | 67 | 1153 (0.1) | 1176 (0.1) | 23 |
| Normal readers | 1071 (0) | 1112 (0.3) | 41 | 1080 (0.1) | 1096 (0.2) | 16 |
| Adults | 884 (0.04) | 933 (0.1) | 49 | 911 (0.2) | 963 (0.1) | 52 |

R, related prime; U, unrelated control prime; U-R, priming effect in ms; maximum number of errors in each condition is 12.

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2Moss et al. (1995) reported a 30 ms associative boost for functionally related words. Within the function condition however, script related (e.g. RESTAURANT–WINE) pairs showed a bigger boost than instrument related pairs (e.g. BROOM–FLOOR) (49 ms vs. 10 ms). Most of our items were instrument pairs and thus our lack of associative boost in the function condition is consistent with Moss et al.’s (1995) results.
association type and prime (F1(1,30) = 24.77, MSE = 3568.22, P < 0.001; 
F2(1,11) = 6.89, MSE = 9447.58, P < 0.03).

Turning to the comparisons between the poor comprehenders and the normal 
readers, there was no main effect of group in the by subjects analysis 
(F1(1,30) = 2.36, MSE = 43023.14). Although this suggests that overall, the two 
groups responded equally quickly, this needs to be interpreted cautiously as by 
items, the normal readers were faster than the poor comprehenders 
(F2(1,11) = 12.94, MSE = 6243.45, P < 0.01). There was no significant interac-
tion between group and association type or between group and prime type (all 
F < 1.0). The three-way interaction between group, prime type and association 
type was significant across subjects (F1(1,30) = 4.28, MSE = 35268.9, P < 0.05) 
and marginally so across items F2(1,11) = 3.53, MSE = 5376.35, P = 0.08). Tests 
of simple main effects demonstrated that in the associated condition, the poor 
comprehenders and normal readers did not differ in RT to related targets 
(F1 < 1.0; F2 = 2.17, MSE = 4992.09). In the non-associated condition however, 
the poor comprehenders were significantly slower (F1 = 4.0, MSE = 1687.28, 
P < 0.05; F2 = 7.80, MSE = 6097.92, P < 0.02). Moreover, both groups showed 
significant effects of prime for associated words (Poor comprehenders: F1 = 27.69, 
MSE = 5816.20, P < 0.001; F2 = 49.96, MSE = 2343.81, P < 0.001; Normal 
readers: F1 = 17.50, MSE = 5816.97, P < 0.001; F2 = 19.72, MSE = 3723.02, 
P < 0.001). For non-associated words however, the poor comprehenders did not 
show any priming whereas the normal readers did (poor comprehenders: F < 1.0; 
normal readers: F1 = 4.21, MSE = 4968.1, P < 0.04; F2 = 3.16, MSE = 4944.21, 
P = 0.1). Thus, the two groups showed robust priming for the associated pairs but 
only the normal readers continued to show significant priming for the non-associated 
pairs.3

A second set of analyses confirmed these findings. Chapman et al. (1994) cau-
tioned against investigating between-group differences in priming using analysis 
of variance. Essentially, this procedure analyses difference scores but this can be 
problematic if one group is slower overall than the other: it is difficult to distinguish 
differences in priming from artifactual differences caused by differences in baseline 
speed. Moreover, our continuous lexical decision paradigm required children to 
respond to both primes and targets; if the poor comprehenders were slower to 
respond to primes, this would lengthen the ISI and potentially, this may induce 
differences in the time course of semantic activation for the two groups. Although 
differences in baseline speed between the two groups were not great (the main effect 
of group was not significant in the F1 analysis) and none of the very small differ-
ences in prime-processing speed were significant (in all conditions, df = 30, t < 1.7,

3We are cautious about truncating children’s RT data: even when a conservative cut-off was used (±3 
SDs from the mean for each group in each condition) only 12 out of the 32 children (seven normal readers 
and five poor comprehenders) had less than 10% of their data removed. These children showed the same 
pattern of results as in the main analyses: normal readers showed priming for both associated and non-
associated words (95 ms and 34 ms) whereas the poor comprehenders only showed positive priming in the 
associated condition (87 and -28 ms). Thus, our findings are not attributable to extreme values skewing the 
results.
we reanalysed our data using regression, as recommended by Cohen and Cohen (1983). We regressed RTs to targets in the related condition (the dependent variable) on RTs to targets in the unrelated condition and RTs to the prime words, thus removing all of the variance in the dependent variable that is associated with baseline speed and the time taken to process the prime. Then, we entered a contrast comparing poor comprehenders with normal readers. A significant contrast would demonstrate that the two groups differed on the dependent variable (i.e. RTs in the related condition), independent of baseline speed and prime processing time. For the associated condition, the group contrast accounted for a tiny amount of variance (0.2%, $F < 1.0$) demonstrating that even when differences in baseline speed are statistically controlled, both groups showed the same degree of priming in the associated condition. For the non-associated words however, a different pattern of results emerged with the group contrast accounting for an additional 5.9% of variance ($F = 4.56$, $P < 0.05$). This confirms that even when differences in overall speed are controlled, poor comprehenders showed less priming to non-associated related words than the normal readers.

Very few errors were made but nevertheless, fewer errors were made to targets preceded by related primes ($F(1,29) = 9.59$, MSE = 0.1, $P < 0.01$; $F(2,11) = 8.25$, MSE = 0.18, $P < 0.02$). The interaction between prime and association type was marginally significant ($F(1,29) = 2.94$, MSE = 0.13, $P = 0.09$; $F(1,11) = 6.6$, MSE = 0.06, $P < 0.03$) due to greater priming for the associated than the non-associated condition. No other main effects or interactions approached statistical significance.

### 3.2. Functional relations

Children were 37 ms faster responding to a target word preceded by a related word ($F(1,30) = 12.36$, MSE = 3478.35, $P < 0.001$; $F(2,11) = 5.91$, MSE = 5482.81, $P < 0.03$). Although children showed greater priming in the associated condition (54 ms) than the non-associated condition (19 ms), neither the main effect of association type ($F$’s $< 1.0$) nor the interaction between prime and association type were significant ($F$’s $< 1.4$).

As in the category condition, there was no main effect of group by subjects, although by items, the normal readers were significantly faster than the poor comprehenders ($F(1,30) = 2.75$, MSE = 40335.86; $F(2,11) = 25.24$, MSE = 3380.32, $P < 0.001$). However, none of the interactions involving group were significant (group $\times$ association type: $F(1,10) = 1.0$; group $\times$ prime: $F$’s $< 1.0$; group $\times$ prime $\times$ association type: $F$’s $< 1.0$).

Using the regression method described earlier to control for any differences in baseline speed, we calculated the amount of variance in RTs to the related words accounted for by group differences, after variance in RTs to the unrelated words was controlled. For both the associated (0.15%, $F < 1.0$) and the non-associated pairs (0.74%, $F < 1.0$), the group contrast failed to account for further variance. Thus, for words related through function, poor comprehenders and normal readers showed equivalent priming, even when overall speed is controlled.
Very few errors were made and no significant effects emerged. However, the pattern of results is consistent with the RT analyses as fewer errors were made in the related than the unrelated conditions, regardless of whether the words were also associated.

4. Discussion

Using an on-line measure of semantic processing, the present findings indicate that when normally developing children hear a word, they automatically access semantic information pertaining to its meaning. Like skilled adults, children show robust priming for pairs of words that are category coordinates as well as for words that are related through function. Additionally, for the category related words, normal children show a significant associative boost, that is, stronger priming for words that are also associated.

Children with comprehension difficulties also showed robust effects of semantic priming. This suggests that they too automatically access semantic information, despite the fact that they have weaker semantic processing as measured by off-line tasks (Nation and Snowling, 1998a). Importantly, however, their pattern of priming across conditions was different to that shown by normal readers. Although they showed normal effects for functionally related words, poor comprehenders only showed priming for category coordinates if the word pairs were also highly associated. For non-associated category coordinate pairs, the poor comprehenders showed no priming.

These findings raise a number of important issues concerning individual differences in the development of semantic memory. For words that are related through function, all children showed significant priming, regardless of whether or not the prime and target were also associated. Words (and their referents) that are related through function tend to co-occur in the real world and this is true regardless of whether the word pairs share high association strength. For example, associated words such as BELT—TROUSERS or SHAMPOO—HAIR are experienced together, as are non-associated words such as HOSPITAL—DOCTOR or BROOM—FLOOR. On some accounts of language acquisition, experience with functional and script-based relations plays a crucial role in the early organization of semantic memory (e.g. Nelson, 1977, 1982). As children with comprehension impairments show normal priming for functional information, this suggests that they are sensitive to semantic relations that are built around functional overlap. This is consistent with the view that early in development, children are able to extract semantic knowledge from event-based experiences (Mandler, 1994).

In the category related condition, all children showed strong priming for associated category coordinates. As described earlier, whether priming in this condition is a reflection of the automatic activation of semantic information or is a consequence of intra-lexical form-based priming due to the common co-occurrence of prime and target in the language is ambiguous. To investigate this, we need to ask whether children show priming for words that are related but not associated. In this
condition, when priming could only be supported by semantic activation, the poor comprehenders did not show any facilitation. This suggests that their priming in the associated condition may be underpinned by lexical co-occurrence rather than genuine semantic activation. Thus, these results are consistent with the conclusion that poor comprehenders show reduced automatic spreading activation between category co-ordinates.

Unlike pairs of words related through functionality, category coordinates do not necessarily co-occur in the real world, particularly in children’s experiences (e.g. AEROPLANE–TRAIN). If it is the case that awareness of category structure emerges out of increasingly refined event-based experiences, our findings suggest that poor comprehenders are yet to develop a semantic memory organization that is categorically structured. Interestingly, poor comprehenders showed normal semantic priming for category coordinates that are also associated (e.g. CUP–SAUCER, TABLE–CHAIR) and in fact, they showed slightly more priming in this condition than the normal readers (141 ms vs. 113 ms respectively). However, the referents of these associated category coordinates tend to have an obvious instrumental association as they tend to occur together in the real world. That two words co-occur lexically is presumably not coincidental but rather a consequence of real-world co-occurrence; consistent with this, words that are associated according to word association norms (e.g. Moss and Older, 1996) are found to frequently co-occur in natural language as sampled from large language corpora (Spence and Owens, 1990). Our results suggest that poor comprehenders are sensitive to this co-occurrence.

In summary, poor comprehenders are sensitive to concrete semantic relations that are associated in the real world. However, they are not sensitive to more abstract semantic relations based solely on category coordinate knowledge. As awareness of this type of semantic relationship is considered to develop late, this suggests that poor comprehenders are developmentally delayed, relative to normal readers. In the absence of instrumental or temporal contiguity, children need to understand the more abstract semantic similarities that exist between category members. Previous work has highlighted the difficulties that poor comprehenders have with making inferences (e.g. Oakhill, 1984) and they are also slow and inaccurate at making semantic similarity judgements, particularly for low-imageability words (Nation and Snowling, 1998a). Whilst not hampering their understanding of semantic relations that are based on real-world contingencies, these weaknesses may impede poor comprehenders’ ability to extract category knowledge on the basis of semantic similarity, consistent with the pattern of priming seen in this experiment.

Acknowledgements

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Appendix A. Semantically related primes and targets used in priming task

<table>
<thead>
<tr>
<th>Associated Prime</th>
<th>Non-associated Prime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brother</td>
<td>Cow</td>
</tr>
<tr>
<td>Sister</td>
<td>Goat</td>
</tr>
<tr>
<td>Dog</td>
<td>Cat</td>
</tr>
<tr>
<td>King</td>
<td>Queen</td>
</tr>
<tr>
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*Items selected from those used by Moss et al., 1995.

References


Neale, M.D., 1989. The Neale Analysis of Reading Ability-Revised. NFER, Windsor, UK.


