

Training mispronunciation correction and word meanings improves children's ability to learn
to read words

Hannah Dyson¹, Wendy Best¹, Jonathan Solity² and Charles Hulme³

¹Division of Psychology and Language Sciences,
University College London

²Optima Psychology

³University of Oxford

Correspondence concerning this manuscript should be addressed to Charles Hulme,
Department of Education, University of Oxford, 15 Norham Gardens, Oxford, OX2 6PY.

Email: charles.hulme@education.ox.ac.uk

Abstract

Previous research has suggested that learning to read irregular words depends upon knowledge of a word's meaning and the ability to correct imperfect decoding attempts by reference to the known pronunciations of a word. In an experimental training study 84 children aged 5-7 years were randomly assigned to an intervention or control group. Children in the intervention group participated in a 4-week programme in which they were taught to correct mispronunciations of spoken words as well as being taught the meanings of those words. Children in the control group received no additional teaching. The intervention group made significant gains in their ability to correct mispronunciations and to read and define the taught words; these gains also generalised to a comparable set of untaught control words. Children can be taught to correct errors in the pronunciation of irregular words and this may produce generalised effects on learning to read. [148 words]

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The development of children's word reading depends critically on a range of underlying language skills. Phonological (speech sound) skills seem particularly crucial and three of the strongest longitudinal predictors of the growth of word reading skills are phonemic awareness, letter sound knowledge and rapid automatised naming (RAN) (Caravolas, et al., 2013; Hulme, Caravolas, Malkova & Brigstocke, 2005; Hulme, Muter & Snowling, 1998; Muter, Hulme, Snowling & Stevenson, 2004). In comparison to work on the relationship between reading and phonological skills, relatively less attention has been paid to the role of broader (non-phonological) oral language skills in learning to read words.

One language skill that may influence the development of word reading is vocabulary knowledge. According to the lexical quality hypothesis (Perfetti, 2007) words vary in the extent to which aspects of their form (phonology, morphosyntax, orthography) and meaning (semantics) are represented, with skilled fluent reading depending upon words having good lexical quality. A similar idea is embodied in the triangle model of reading (Plaut, McClelland, Seidenberg, & Patterson, 1996) which proposes that a word's pronunciation can be accessed directly from orthography, or indirectly via semantics. According to the triangle model there is a "division of labour" such that irregular words depend more heavily on the operation of mappings from orthography to semantics than do regular words. A reasonable prediction from both of these theories is that variations in vocabulary knowledge (semantics), as well as phonological knowledge, should be related to learning to read words.

Studies of the effects of word meaning on word reading have yielded mixed findings (for a review, see Taylor, Duff, Woollams, Monaghan & Ricketts, 2015). However, longitudinal studies have shown that children's knowledge of word meanings is a predictor of later word reading skills. For example, Nation and Snowling (2004) found that vocabulary and listening comprehension predicted word recognition and irregular word reading both concurrently and 4.5 years later. Similarly, Ricketts, Nation and Bishop (2007) provided evidence that vocabulary knowledge was a longitudinal predictor of irregular, but not regular, word reading. The finding that learning to read irregular words is particularly dependent on knowledge of their meaning is consistent with predictions from the triangle model. According to that model, mappings from orthography to phonology operate less efficiently for irregular words, and therefore readers place more reliance on mappings from orthography via semantics to phonology when reading such words aloud (Plaut et al., 1996).

Evidence for a role of semantic knowledge in learning to read words also comes from experimental studies. For example, Laing and Hulme (1999) showed that learning to read abbreviated forms of novel words was facilitated if children knew the meanings of the words they were attempting to learn. In a second study they also found that imageable words were learned more effectively than abstract words, an effect that was attributed to the fact that imageable words had richer semantic representations (see also Duff & Hulme, 2012).

Taylor, Plunkett and Nation (2011) also demonstrated a link between semantics and reading accuracy using an artificial orthography with adults. They found that pre-exposure to a definition for a novel word increased decoding accuracy although by the end of the study semantic facilitation only occurred for low frequency, orthographically inconsistent words, suggesting that semantics is particularly important for reading irregular words.

Wang, Nickels, Nation and Castles (2013) also conducted a study which examined learning of novel words to examine whether word regularity affects orthographic learning. After learning the phonology and meaning of novel words, children aged 7-9 years were then introduced to either a regular or irregular orthographic representation of those words. The authors found an item-specific effect of learning the meaning of a word on reading accuracy, but only for irregular words.

Nation and Cocksey (2009) further explored the link between vocabulary and decoding in a study of 7-year olds' knowledge of the meaning of a word and their ability to read it aloud. As with the above two studies, Nation and Cocksey (2009) report that the association is particularly strong in the case of words with irregular spelling-sound correspondences. However, they found no link between depth of semantic knowledge and word reading accuracy, and they suggest that a child's knowledge of whether the word is a lexical item (i.e. "is this a real word?") is more important for correct decoding than their semantic knowledge.

According to the triangle model (Plaut, et al., 1996) these effects of semantic knowledge on reading aloud isolated words, reflect the existence of a route that maps orthography onto phonology via semantics. Another explanation for the link between vocabulary knowledge and the reading of irregular words, comes from Tunmer and Chapman (2012). They suggest that the link between vocabulary knowledge and the ability to read irregular words is mediated by a skill called "set for variability" (Venezky, 1999). This skill depends upon children having a set of words in their lexicon which could potentially be substituted for an irregular word decoded using regular phonetic rules. Set for variability refers to a child's ability to derive an approximate pronunciation for a printed word, and then use context and their lexical knowledge to correct their imperfect pronunciation. This is a form of problem-solving which is likely to depend in part on

vocabulary knowledge. So, for example, if a child mispronounces the word STOMACH as STOW-MATCH, they will be more likely to be able to correct that to STOMACH if the word is known to them and readily retrievable from their stored spoken vocabulary. Set for variability, the skill to apply one's vocabulary knowledge to an orthographically irregular word and correct the mispronunciation derived by applying grapheme-phoneme translation, therefore provides a hypothetical explanation for the link between vocabulary knowledge and decoding. In this paper, we have used the term "mispronunciation correction" to describe set for variability, as it provides a more accurate and transparent description of the task.

Tunmer and Chapman (2012) operationalised set for variability by assessing children's ability to correct mispronunciations of spoken words. In a longitudinal study they found that mispronunciation correction measured around the end of Year 1 in school was predicted by variations in vocabulary knowledge and phonemic awareness measured at the same time. Furthermore, mispronunciation correction was a predictor of reading both words and non-words measured in Year 3. However, in their path model, vocabulary in Year 1 had no direct relationship with word reading in Year 3 (there was only a mediated relationship: Vocabulary (Year 1) -> Set for Variability (Year 1) -> Word Reading (Year 3)).

Mispronunciation correction is a complex task that has been the subject of little research to date. We lack a well-specified account of what cognitive mechanisms underlie performance on this task, though it is correlated with, and hypothetically may depend upon vocabulary knowledge and phonemic awareness (Tunmer & Chapman, 2012) as well as other skills. Kearns, Rogers, Korakin & Al Ghanem (2016) suggested that the term semantic and phonological ability to adjust recoding (SPAAR) be used to refer to the process children use to resolve discrepancies between the output of decoding a word and a

word's actual pronunciation and meaning. Using item response theory analyses they showed that the mispronunciation correction task (based largely on Tunmer & Chapman's (2012) items), was unidimensional and correlated concurrently with vocabulary knowledge, phoneme deletion and word decoding ability.

Current evidence for the influence of mispronunciation correction on the development of word reading skills is purely correlational and limited to a small number of studies (Elbro, de Jong, Houter and Nielsen 2012; Kearns et al., 2016; Tunmer & Chapman, 2012). To provide evidence for a causal relationship we need training studies to evaluate whether improving mispronunciation correction skills will transfer to improvements in word reading. In this paper we present the results of an experimental training study in which children were taught explicit strategies to help them correct mispronunciations of words. Such training should be particularly relevant to helping children learn to read irregular words, because for those words letter-by-letter decoding will result in an incorrect pronunciation which needs to be corrected using contextual and semantic information. Currently, children are often taught to read irregular words as "sight words" (Vaughn & Linan-Thompson, 2004). While this is a useful approach for high-frequency irregular words (such as some function words in English) it does not provide children with a general strategy to help them read aloud unknown, irregular words which they may encounter in context. In contrast teaching children a strategy for correcting the mispronunciations of irregular words should be of general benefit in helping them to decode, and subsequently recognise, irregular words - particularly when those words occur in context.

Method

An experimental study of the effects of mispronunciation correction training was conducted. Children in the intervention group received four weeks of teaching from research

assistants, while the control group received “business as usual” teaching. Ethical approval was obtained from the Research Ethics Committee of University College London (UCL). The head teacher of the school gave informed consent for children to participate. Parents were given the opportunity to withdraw their child from the study if they so wished, but none did.

Participants

In accordance with the CONSORT guidelines (Schulz, Altman, & Moher, 2010) Figure 1 shows details of the recruitment, allocation and flow of participants through the study. Eighty-four children from years 1 (N=56) and 2 (N=28), aged 5- to 7-years old were recruited to the study. All children attended the same mainstream school. Children in Year 2 were selected to participate if they had relatively weak reading skills according to teacher ratings. Children with more proficient reading skills in year 2 were excluded in order to make the sample as homogenous as possible in terms of reading ability and to avoid ceiling effects. Children were subdivided according to year group and class and then within each class, were randomly assigned (using an online randomisation tool) to either intervention or control groups. Following randomisation 3 children were identified in the control group who had to be excluded from the study (1 child with a diagnosis of autism and two with very poor language skills) leaving 39 children in the control group and 42 children in the intervention group.

Procedure

Testing was conducted by trained speech and language therapy students or research assistants. Testers were blind to group membership. Children were tested individually on a range of measures before and after the intervention (table 1).

British Picture Vocabulary Scales (BPVS, adapted). An adapted version of the BPVS was used to test children’s receptive vocabulary. A target word was spoken by the tester and

children chose from one of four pictures to match the target word. The test contained 33 items of increasing difficulty; all items were administered ($\alpha = .81$)

Castles and Coltheart reading test (2nd Edition, Castles, Coltheart, Larsen, Jones, Saunders & McArthur, 2009). This test examines children's ability to read aloud 3 lists of regular, irregular and nonwords of increasing difficulty. There were 40 items of each type. Testing on each list was discontinued after 5 consecutive incorrect responses.

Early word recognition subtest (Hulme et al., 2009). The early word recognition subtest from the York Assessment of Reading for Comprehension (Early Years) test battery was administered. The test consists of 30 words of increasing difficulty. Children were asked to read all words on the test.

Mispronunciation correction task. Children were tested on the 40 items used in Tunmer and Chapman's (1998) mispronunciation correction task which was presented as a game with a puppet. Children were told by the examiner "My puppet is going to say some sentences, but he's going to say the word at the end wrong. Can you help him and tell him the correct word?" The examiner (puppet) gave a "regularized" pronunciation of each of the irregular word items. Children were asked to correct the mispronunciation of each item and their responses were scored as incorrect (0) or correct (1), ($\alpha = .86$)

Reading and defining the words used in mispronunciation correction task. Immediately after the mispronunciation correction task, children were shown a list containing each of the words from the task and asked to read each aloud (scored as incorrect (0), or correct (1)). Finally, immediately after trying to read each of these words, the child was asked to define each word when it was spoken to them. Scoring was based on the criteria typically used in tests of expressive vocabulary: a score of 2 was awarded for a complete definition, 1 for a

partial definition and 0 for no response on an incorrect definition. Full details of the stimuli used are provided in Appendix 1.

Intervention programme

Choice of words. The words taught in the programme were all irregular words taken from Tunmer and Chapman (1998). There were 20 taught words (kind, shoe, wash, body, money, treasure, biscuit, castle, heart, bowl, shoulder, piano, mystery, palace, referee, scissors, spinach, lizard, pudding, pigeon) and 20 untaught words (weather, watch, front, bread, river, banana, flood, lamb, glove, post, compass, camel, metal, devil, measles, onion, chemist, soup, muscles, wasp).

Content and materials. Children were taught that some words are “tricky words” which do not follow the “letter laws”. They were encouraged to use strategies to help them decode these words. Each week, a different aspect of “tricky words” was highlighted (irregular consonants, irregular vowels or silent letters). Children were given practice in correcting mispronunciations of the taught words and were taught their definitions. Once children were secure in their ability to correct mispronunciations of target words, they completed written worksheets (see supplementary online Appendix for details) focussing on phonological and semantic aspects of these words in their written form to consolidate their learning.

Teaching methods. Teaching was conducted in small groups of up to 8 children with two 20-minute sessions per week for 4 weeks (160 minutes intervention time in total). Each week, one group of 5 target words was taught along with general strategies for reading irregular words. The strategy children were taught to use when reading irregular words was as follows:

1. Say the word aloud;
2. Decide if you know the word;

3. If you don't, think of words that sound like the word;
4. Choose a word that sounds most like the word you said;
5. Check: does the word you have chosen make sense in context?

Each lesson began with reminding children of the difference between easy and tricky (irregular) words. A puppet was used to read aloud words in sentence contexts incorrectly and children were asked to correct the mispronounced words. The children were given explicit definitions of the taught words for which they had heard the mispronunciations corrected. After this teaching, children were given written work sheets with exercises involving matching the taught words to pictures and to written definitions, matching taught words to words that rhymed, and writing the taught words from prompts containing the first letter of each word. Examples of the teaching programme and materials used are given in the supplementary online materials.

Results

The means and standard deviations for the raw scores on each variable for each group at pre-intervention (time 1, T1) and post-intervention (time 2, T2) are shown Table 1. The table also shows Cohen's *d* for the size of the intervention effect calculated as the marginal mean difference between groups at T2 divided by the pooled SD at pretest (see Morris, 2008). Preliminary analyses showed that there were no meaningful differences between the pattern of results for the Year 1 and Year 2 children, and all analyses reported are for the sample as a whole. The effects of the intervention at T2 on each measure were assessed in a series of regression (ANCOVA) models with intervention group dummy coded and the T1 score on the same measure as the covariate. For each model the assumption of homogeneity of regression slopes across groups was tested and confirmed.

Participant-level analyses

These analyses focussed on the overall number of items correct on each task at pretest and posttest. The critical results from the ANCOVA models are shown in Table 1. The intervention resulted in significant improvements in children's ability to correct mispronunciations of the taught words, read those words aloud and define them. There was also evidence that the intervention generalised to produce small improvements in children's ability to read ($d = .23$; $p = 0.043$) and define ($d = .57$; $p = 0.050$) the matched untaught words, though the latter effect was not statistically significant. The effects of the intervention did not generalise to produce improvements in reading aloud the Castles and Coltheart irregular word set ($d = .12$; $p = 0.864$), or to any of the other single word measures of reading. Finally, we found evidence of improvement from the intervention on the BPVS ($d = .41$; $p = 0.041$); such an effect is unexpected and would require replication in a study with greater statistical power to confirm it.

Item-level analyses

The extent to which children's ability to read words aloud following the intervention was related to their ability to correct mispronunciations of, or to define the meanings of, taught words was assessed by a series of mixed effects logistic regression models with items and subjects treated as crossed random effects in Stata 13.0. In these data differences amongst participants accounted for a substantial proportion of the variance in T2 reading scores (ICC = .33; 95% CI [.25, .40]) as did differences between items (ICC = .09; 95% CI [.05, .14]).

These item-level analyses allow us to assess the extent to which the reading of a word following training is related to how well that word can be defined and how well its pronunciation can be corrected in the mispronunciation correction task. In other words these analyses allow us to identify the unique effects of two aspects of our training (teaching word

meanings and correction of mispronunciations) on how well children can read those same words.

A preliminary analysis assessed whether the intervention and control groups differed at T1 in their ability to read the taught and untaught words. There was no sign of a statistically significant difference (odds ratio = 0.83, 95% CI [0.29, 2.42]; $z = -0.34$, $p = 0.734$) and therefore reading at T1 was not included in subsequent models as a covariate, since cross-lagged effects in mixed models can lead to severe bias (see e.g. Rabe-Hesketh & Skrondal, 2012)

We first conducted an analysis on all words (taught and untaught). We tested a simultaneous logistic regression model with intervention group, mispronunciation correction at T2 and word definitions at T2 as predictors of whether each word could be correctly read at T2. The results are shown in the path diagram in Figure 2a. It is clear that both mispronunciation detection and knowledge of a word's meaning have independent effects on the ability to read a word at T2, with mispronunciation detection having the larger effect. Furthermore, the effect of group (intervention vs. control) is also significant in this model showing that the difference in word reading at T2 produced by the intervention is not entirely accounted for by levels of mispronunciation detection or word definition achieved at T2. It would not be expected that the effect of group was entirely mediated by mispronunciation correction and knowledge of word meanings, since the intervention also involved direct practice in both reading and writing the taught words.

We proceeded to conduct equivalent analyses on the taught and untaught word sets separately. For the taught words the pattern was the same as in the overall analysis with mispronunciation detection, knowledge of a word's meaning and intervention group all having independent effects (Figure 2b). For the untaught words the only significant predictor

of children's ability to read words is their ability to correct mispronunciations of these items (Figure 2c). This effect is important since it reflects children's ability to generalise the strategy they have been taught to correct word mispronunciations to words they have not been exposed to during the training. Furthermore, this effect appears to reflect a process that depends upon lexical knowledge of the phonological form of words, rather than knowledge of word meanings (since the ability to define the untaught words did not predict how well they could be read).

Discussion

Our intervention involved teaching children strategies that would help them to read aloud irregular words. All the words taught had irregular spelling-to-sound correspondences: children were taught to correct mispronunciations of those words, taught their meanings and performed exercises involving reading and writing the words. We found effects of the intervention on children's reading and on their vocabulary knowledge. We will consider each in turn.

It was predicted that the intervention would improve the children's ability to read irregular, but not regular, words. As expected we found strong effects of the training on reading the irregular words in the trained set ($d = .95$) and also evidence of generalization to reading the matched untaught words ($d = .23$). However, the effects of the intervention on another pure test of irregular word reading (the Castles and Coltheart irregular word list) was small $d = .12$ and not statistically significant. Similarly, the intervention did not result in generalized improvements on our other tests of single word reading. It is hard to be sure why the results differed between our two measures of generalization for irregular word reading. One possibility is that this reflects differences between the word lists. Our taught and untaught word lists were both drawn pseudo-randomly from Tunmer and Chapman's list of 40 irregular words, making them closely comparable in difficulty level. In contrast the

Castles and Coltheart irregular word list contains words with a wider range of difficulty. It is plausible that the children could apply their newly learned strategies to decode the untaught words of equivalent difficulty to those directly taught in the intervention, but not to the more complex irregular words found on the Castles and Coltheart list. An alternative, and possibly more plausible, explanation relates to the fact that our intervention was brief and of low intensity (160 minutes teaching in small groups over 4 weeks). Further studies are needed over longer periods of time, and with more diverse sets of items, to provide robust evidence for the educational effectiveness of the teaching methods explored here. Nevertheless, we believe the current results suggest that our intervention is a potentially useful method for teaching children strategies to help them decode irregular words.

Perhaps the most novel finding from the current study is that at an item level, mispronunciation correction is a powerful predictor of a child's ability to read a word correctly. Training children to correct mispronunciations of spoken words with irregular spelling-sound correspondences (so that the pronunciation conforms to the form of a word stored in the child's phonological lexicon) has item specific effects: if a child can correct the mispronunciation of a particular word this increases the probability that they will be also be able to read that word aloud. This finding provides direct support for earlier work on "set for variability" (Venezky, 1999; Tunmer & Chapman, 2012). We believe that the current study provides the first experimental evidence for a causal link between a child's ability to correct mispronunciations of a word and their ability to learn to read it. Our results are relevant to the speculation of Kearns et al. (2016) that the correlation between mispronunciation correction and reading ability may reflect the role of both phonological and semantic processes in word reading. Our data show that semantic (word definition ability) and phonological (mispronunciation correction) processes make distinct contributions to allowing a child to read an irregular word aloud correctly with the phonological process

(mispronunciation correction using a stored lexical phonological form) being a stronger influence than knowing the meaning of the word.

Our study provides further evidence that semantic knowledge (the ability to define the meaning of a spoken word) is important for children's ability to learn to read words (see also Duff & Hulme, 2012; Laing & Hulme, 1999). In the current study, all the words were irregular, and in line with the triangle model of reading (Plaut et al., 1996), previous studies suggest that semantic knowledge is more important for learning to read irregular, than regular, words (e.g. Ricketts et al., 2007). It is important to note however, that the effect of a word's meaning on children's ability to read it appears to be independent of the ability to correct a mispronunciation of the word. This conclusion is at variance with the claims made by Tunmer and Chapman (2012), who asserted from correlational evidence that set for variability mediated the relationship between children's ability to define a word's meaning and their ability to read it aloud. That is, Tunmer and Chapman argued that vocabulary knowledge (knowledge of a word's meaning) only had an influence on the ability to read a word aloud because it improved the ability to correct a mispronunciation of that word. The models of our data (Figure 2) provide evidence that knowledge of a word's meaning has a positive effect on the ability to read a word aloud that is independent of the ability to correct the word's mispronunciation.

Finally, we should consider the effects on vocabulary knowledge. As expected, our intervention produced improvements in children's ability to define the words whose meanings they had been taught ($d=.76$). There was also a statistically marginal improvement in defining the equivalent untaught words ($d=.57$) and an improvement on small improvement on the BPVS ($d=.41$). Improvements in the ability to define the words that the children had been directly taught is as expected, but generalization to untaught items was not expected and is contrary to findings from some earlier research (e.g. Marulis & Neuman,

2010; Christ & Wang, 2011). It seems possible that the improvements in defining the untaught words we found here may reflect some familiarity with the task of giving definitions for words i.e. improvements in children's ability to express knowledge they have about words rather than changes in their underlying knowledge. Improvements in performance on the BPVS are not amenable to such an explanation and may perhaps reflect some increase in children's confidence in performing tasks due to familiarity with the testing environment. Further research is clearly needed to establish whether the methods used here truly do lead to generalized improvements in vocabulary knowledge.

In conclusion, the current study shows that it is relatively easy to teach children strategies that allow them to correct their mispronunciations of irregular words. As Venezky (1999) states, "If what is first produced does not sound like something already known from listening, a child has to change one or more of the sound associations (most probably a vowel) and try again". Our intervention can be seen as a direct implementation of this insight. One encouraging finding was that, in addition to the strong effects seen on taught words, our training produced improvements that generalised to a comparable set of untaught words. These transfer effects to untaught words demonstrate that children were able to apply the strategies that they were explicitly taught in our intervention to help them read novel items. While the use of an untreated control group means some effects here may be non-specific, we should note that the item level analyses do show specific relationships between children's mispronunciation correction and knowledge of word meanings and their ability to read individual words. Overall, our evidence suggests that larger scale trials, with alternative treatment control groups, are warranted to explore the effectiveness of these teaching strategies as a way of improving children's reading skills.

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Appendix 1: Mispronunciation Correction Task Stimuli (Tunmer & Chapman, 1998).

Taught words are indicated in bold.

1. Her granny is very **kind** (pronounced: to rhyme with wind) [κIvδ]
2. He got mud on his **shoe** (pronounced: show) [Σ≡Y]
3. The dog had to have a **wash** (pronounced: to rhyme with ash) [ω{Σ]
4. He put suntan lotion on his **body** (pronounced: boady) [β≡Yδvι]
5. He couldn't find his **money** (pronounced: moaney) [μ≡Yvνι]
6. In France they have great weather (pronounced: weet-her) [ωιτv≡]
7. The man repaired the broken watch (pronounced: to rhyme with catch)[ω{τΣ]
8. He spilt spaghetti all down his front (pronounced: froant)[φρ≡Yvτ]
9. The children's granny baked some bread (pronounce: breed)[βριδ]
10. We got very cold swimming in the river (pronounce: rive-er rhyme with fiver)[ρςIϖ v≡]
11. They searched for the **treasure** (pronounced: tree-sore)[τριvσO]
12. The friends shared a **biscuit** (pronounced: bis-coo-it)[βIσvκv: vIτ]
13. The child used the blocks to build a **castle** (pronounced: cast-el)[κ{στ vEλ]
14. The cake was shaped like a **heart** (pronounced: rhyme with hear-t)[ηι□ vτ]
15. He washed the plastic **bowl** (pronounced: bowel)[β≡Yλ]
16. For a snack he ate a banana (pronounced: ban-ay-nar)[β{vνvAιvνA:]
17. Last year there was a big flood (pronounced: fl-oo-d)[φλvYvδ]
18. The dog chased the lamb (pronounced: lam-b)[λ{μvβ]
19. He lost his glove (pronounced: to rhyme with clove)[γλ≡Yϖ]
20. The farmer dug a hole for the post (pronounced: to rhyme with cost)[κAστ]
21. He pushed the door with his **shoulder** (pronounced: showlder – first syllable like shower)[Σ8Yλvδ≡]
22. She put her glass on top of the **piano** (pronounced: pee-ay-no)[πιvAIvν v≡Y]
23. They could not solve the **mystery** (pronounced: my-ster-ee)[μAIvστEρvι]
24. The queen lived in a large **palace** (pronounced: pa-lace)[π{vλeIσ]
25. The man argued with the **referee** (pronounced: ree-fair-ree)]ριv φE:vρι]
26. When they went camping, they used a compass (pronounced: com-pars)[κΘμvπα:ζ]
27. At the zoo we saw a camel (pronounced: came-el)κεIμvEλ]

28. The toy was made of metal (pronounced: meat-al) $[\mu\iota\tau\forall\{\lambda\}]$
29. He came to the party dressed as a devil (pronounced: d-evil rhyme with weevil) $[\delta\iota\forall\omega E\lambda]$
30. She was sick with the measles (pronounced: meaz-lez) $[\mu\iota\zeta\forall\lambda E\zeta]$
31. The children collected the **scissors** (pronounced: sci-sss-ors) $[\sigma\kappa I\forall\sigma\forall O\zeta]$
32. My brother likes **spinach** (pronounced: spin-atch) $[\sigma\pi I\nu\forall\{\tau\Sigma]$
33. On the rock there was a **lizard** (pronounced: lies-ard) $[\lambda\varepsilon I\sigma\forall A\delta]$
34. We always like to eat **pudding** (pronounced: rhyme with budding) $[\beta\zeta\delta\forall I N]$
35. The cat chased the **pigeon** (pronounced: pig-eon) $[\pi I\gamma\forall\iota\Theta\nu]$
36. He cut up the **onion** (pronounced: own-eon) $[\cong Y\nu\forall\iota\Theta\nu]$
37. Mum paid the **chemist** (pronounced: tchem-ist) $[\tau\Sigma E\mu\forall I\sigma\tau]$
38. For lunch we had some **soup** (pronounced: sow-p rhyme with cow-p) $[\sigma\cong Y\pi]$
39. Sam has big **muscles** (pronounced: musk-les) $[\mu\zeta\sigma\kappa\forall\lambda E\sigma]$
40. He ran away from the **wasp** (pronounced: to rhyme with rasp) $[\omega\{\sigma\pi]$

	Time 1				Time 2				
	Intervention		Control		Intervention		Control		
Variable (maximum score)	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Marginal mean difference in improvement between groups [95% CI]
BPVS (33)	17.46	3.80	17.53	3.40	19.37	3.47	18.03	2.97	1.40 [0.16, 2.63]; p=0.028, d=0.41
Castles and Coltheart regular words (40)	17.78	10.12	17.26	10.26	23.71	10.02	21.45	10.10	0.53 [-2.08, 3.14]; p=0.688; d=0.17
Castles and Coltheart irregular words (40)	6.83	4.73	6.18	5.15	9.5	5.51	8.24	5.29	0.13 [-1.37, 1.63]; p=0.864; d=0.12
Castles and Coltheart non-words (40)	12.10	7.96	11.79	9.54	17.68	8.42	14.92	9.85	1.95 [-0.95, 4.85];, p=0.185; d=0.25
YARC early word reading (30)	21.44	8.33	20.43	8.49	26	5.11	24.05	6.69	0.63[-0.46, 1.72]; p=0.251; d=0.10
Mispronunciation correction taught words (20)	8.51	3.31	8.90	4.73	16.71	3.19	11.42	3.13	5.28 [4.10, 6.46]); p<0.001; d=1.20
Mispronunciation correction untaught words (20)	8.46	3.57	8.20	4.63	11.45	2.88	9.63	3.58	1.45 [0.20, 2.70]; p=0.024; d=0.34
Read-aloud taught words (20)	6.71	5.57	6.58	5.72	14.87	6.07	9.34	6.17	5.21 [3.54, 6.88]; p<0.001; d=0.94
Read-aloud untaught words (20)	7.27	5.66	7.05	6.02	11.29	5.26	9.68	5.79	1.34 [0.05, 2.59]; p=0.043; d=0.23
Definitions taught words (40)	13.41	5.21	12.08	5.26	19.74	5.63	14.39	6.06	4.07 [1.70, 6.45]; p=0.001; d=0.76
Definitions untaught words (40)	13.54	5.62	13.15	5.59	19.08	5.69	15.53	7.28	2.68 [0.00, 5.37]; p=0.050; d= 0.57

Table 1: Means (SDs) for each measure at T1 and T2. Marginal mean difference in improvement [95% CI], significance level and Cohen's d are also reported.

Figure Legends

Figure 1: Outline of the flow of participants through the study.

Figure 2. Path diagrams representing the results of mixed effects logistic regression models predicting word reading at T2 (post-test). Path coefficients are odds ratios [with 95% Confidence Intervals]. Solid arrows represent statistically significant effects, dashed lines represent statistically non-significant effects.

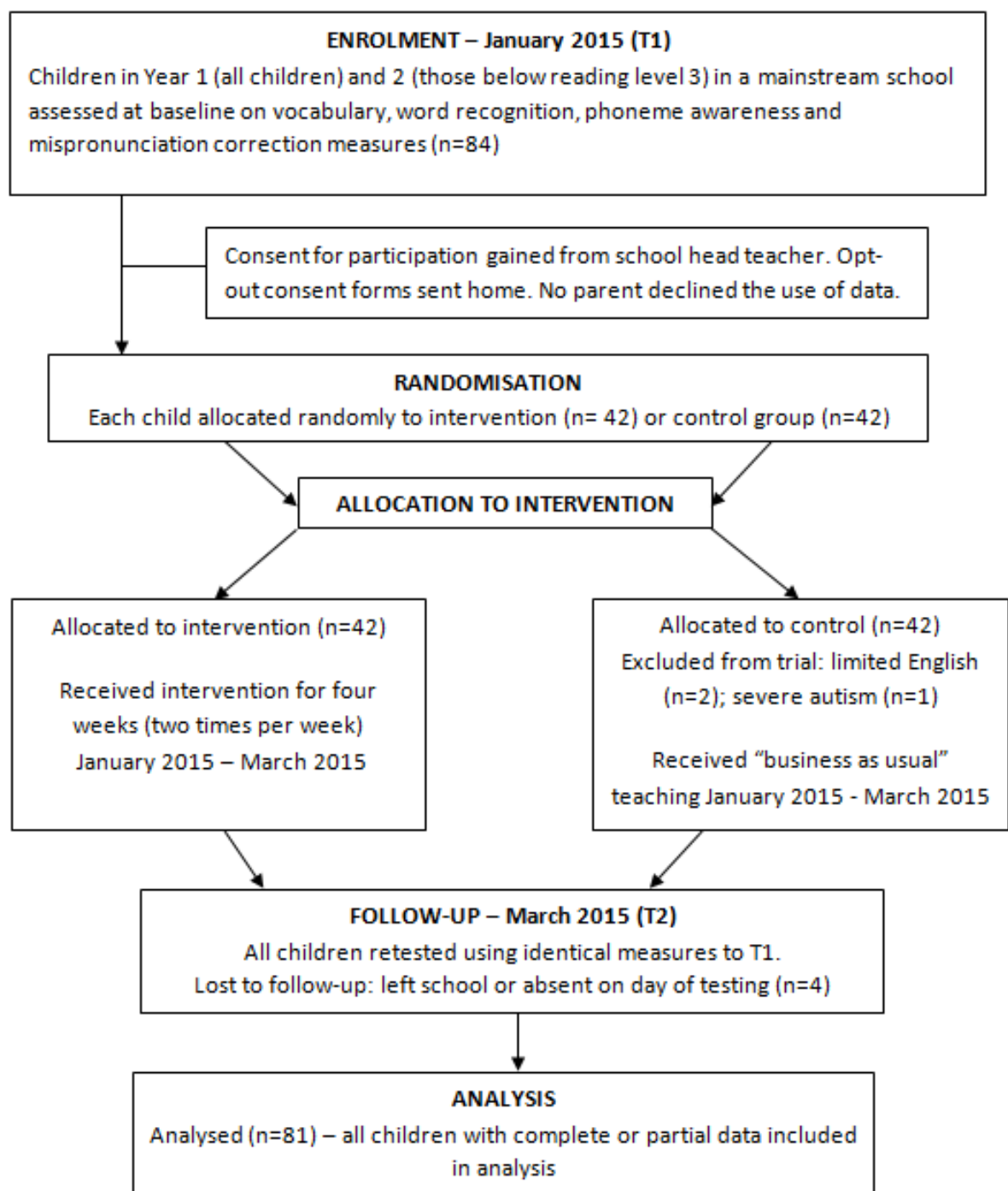


Figure 1: Outline of the flow of participants through study according to the CONSORT (2010) guidelines

Figure 2a. All words

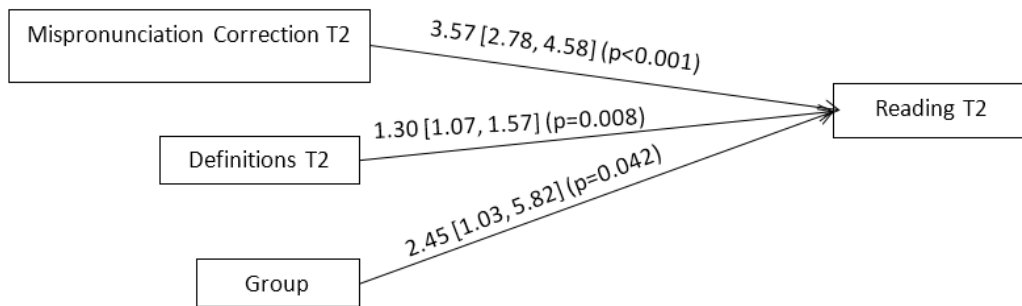


Figure 2b. Taught words only

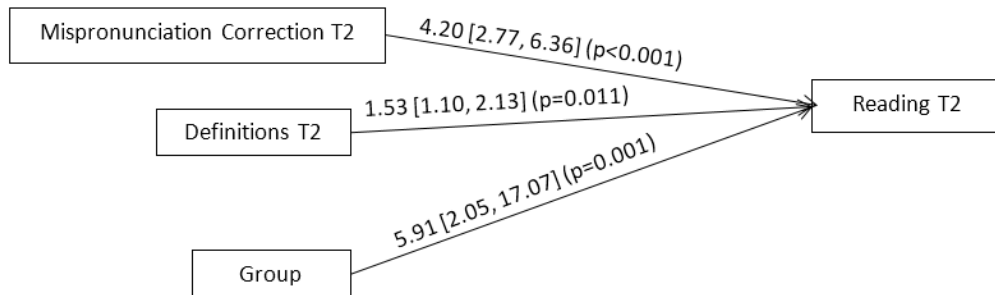


Figure 2c. Untaught words only

