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

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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 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 give 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' 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.

References

Castles, A., Coltheart, M. , Larsen, L, Jones, P., Saunder, S. & McArthur, G. (2009). Assessing the basic components of reading: A revision of the Castles and Coltheart test with new norms. *Australian Journal of Learning Difficulties, 14*, 67-88. doi/abs/10.1080/19404150902783435

Caravolas, M., Lervåg, A., Defior,S., Seidlová-Málková, G., Hulme, C. (2013) Different patterns but equivalent predictors, of growth in reading in consistent and inconsistent orthographies. *Psychological Science, 23, 678–686. doi:10.1177/0956797611434536*

Christ, T., & Wang, X. C. (2011). Closing the Vocabulary Gap?: A Review of Research on Early Childhood Vocabulary Practices. *Reading Psychology, 32*(5), 426-458. doi: 10.1080/02702711.2010.495638

Duff, F. J., & Hulme, C. (2012). The Role of Children's Phonological and Semantic Knowledge in Learning to Read Words. *Scientific Studies of Reading, 16*(6), 504-525. doi: 10.1080/10888438.2011.598199.

Dunn, Lloyd M., Dunn, Leota M., Whetton, C. & Burley, J. (1997) *British Picture Vocabulary Scales* (2nd ed.) NFER-Nelson.

Elbro K., de Jong, P. Houter, D., & Nielsen, A-M. V., (2012). From spelling pronunciation to lexical access: A second step in word decoding. . *Scientific Studies of Reading, 16*, 341-359. DOI: 10.1080/10888438.2011.568556

Hulme, C, Caravolas, M., Málková, G. & Brigstocke, S. (2005) Phoneme isolation ability is not simply a consequence of letter-sound knowledge. *Cognition, 97,* B1-B11.

Hulme, C, Muter, V., & Snowling, M. J. (1988) Segmentation does predict early progress in learning to read better than rhyme: A reply to Bryant. *Journal of Experimental Child Psychology, 71,* 39-44.

Hulme, C., Stothard, S. E., Clarke, P. J., Bowyer-Crane, C., Harrington, A., Truelove, E., & Snowling, M. J. (2009). York Assessment of Reading for Comprehension (YARC): Early Reading. London: GL Assessment.

Kearns, D., Rogers, H.J. , Koriakin, T., Al Ghanem, R. (2016). Semantic and Phonological Ability to Adjust Recoding: A Unique Correlate of Word Reading Skill? Scientific Studies of Reading, 20:6, 455-470, DOI: 10.1080/10888438.2016.1217865

Laing, E., & Hulme, C. (1999). Phonological and Semantic Processes Influence Beginning Readers' Ability to Learn to Read Words. *Journal of Experimental Child Psychology, 73*, 183-207.

Marulis, L. M., & Neuman, S. B. (2010). The Effects of Vocabulary Intervention on Young Children's Word Learning: A Meta-Analysis. *Review of Educational Research, 80*(3), 300-335. doi: 10.3102/0034654310377087

Morris, S. (2008). Estimating effect sizes from pretest-posttest-control group designs. *Organizational Research Methods, 11*, 364-386. doi: 10.1177/1094428106291059

Moyer, D. et al., (2010). CONSORT 2010 Explanation and Elaboration: updated guidelines for reporting parallel group randomised trials. BMJ 2010;340:c869 doi: 10.1136/bmj.c869.

Muter, V., Hulme, C., Snowling, M. J., & Stevenson, J. (2004). Phonemes, rimes, vocabulary, and grammatical skills as foundations of early reading development: evidence from a longitudinal study. *Dev Psychol, 40*(5), 665-681. doi: 10.1037/0012-1649.40.5.665

Nation, K., & Cocksey, J. (2009) The relationship between knowing a word and reading it aloud in children's word reading development. *Journal of Experimental Child Psychology, 103*, 296-308. doi: 10.1016/j.jecp.2009.03.004.

Nation, K., & Snowling, M. J. (2004). Beyond phonological skills: broader language skills

contribute to the development of reading. *Journal of Research in Reading, 27*(4), 342-

356.

Perfetti, C. (2007). Reading Ability: Lexical Quality to Comprehension. *Scientific Studies of

Reading, 11*(4), 357-383.

Plaut, D. C., McClelland, J. L., Seidenberg, M. S., & Patterson, K. (1996). Understanding

Normal and Impaired Word Reading: Computational Principles in Quasi-Regular

Domains. *Psychological Review, 103*(1), 56-115.

Ricketts, J., Nation, K. & Bishop, D.V. M. (2007). Vocabulary Is Important for Some, but

Not All Reading Skills. *Scientific Studies of Reading, 11*(3), 235-257. doi:

10.1080/10888430701344306

Rabe-Hesketh, S. & Skrondal, A. (2012) Multilevel and Longitudinal Modeling Using Stata.

Volume 1: Continuous Responses. Third Edition. StataCorp LP.

Schulz, K.F., Altman, D.G., & Moher, D. (2010). Consort 2010 statement: updated guidelines

for reporting parallel group randomised trials. *British Medical Journal*, 340, c332.

DOI:10.1136/bmj.c332

Sénéchal, M., Ouellette, G., & Rodney, D. (2006). The misunderstood giant: On the

predictive role of vocabulary to reading. In S. B. Neuman & D. Dickinson (Eds.),

Handbook of Early Literacy Research (vol. 2) (Vol. 2, pp. 173-182). New York:

Guilford Press.

Taylor, J., Duff, F., Woollams, A., Monaghan, P. & Ricketts, J.. (2015). How word meaning

influences word reading. *Current Directions in Psychological Science, 24*, 322-328

Tunmer, W. E., & Chapman, J. W. (1998). Language Prediction Skill, Phonological

Recoding Ability, and Beginning Reading. In C. Hulme & R. M. Joshi (Eds.),

Reading and Spelling: Development and Disorders (pp. 33-68). New Jersey:

Lawrence Erlbaum.

Tunmer, W. E., & Chapman, J. W. (2012). Does Set for Variability Mediate the Influence of

Vocabulary Knowledge on the Development of Word Recognition Skills? *Scientific*

Studies of Reading, 16(2), 122-140. doi: 10.1080/10888438.2010.542527

Vaughn, S., & Linan-Thompson, S. (2004). *Research-Based Methods of Reading Instruction,*

Grades K-3. Alexandria, VA: Association for Supervision and Curriculum

Development.

Venezky, R. L. (1999). *The American Way of Spelling: The Structure and Origins of*

American English Orthography. New York: Guilford Press.

Wang, H.-C., Nickels, L., Nation, K., & Castles, A. (2013). Predictors of orthographic

learning of regular and irregular words. *Scientific Studies of Reading*, 17, 369-384.

doi:10.1080/10888438.2012.749879

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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) [κIνδ]

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≅Yδ∀ι]

5.   He couldn't find his **money** (pronounced: moaney) [μ≅Yν∀ι]

6.   In France they have great weather (pronounced: weet-her) [ωιτ∀≅]

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≅Yντ]

9.   The children's granny baked some bread (pronounce: breed)[βριδ]

10.   We got very cold swimming in the river (pronouncde: rive-er rhyme with fiver)[ρςIϖ ∀≅]

11.   They searched for the **treasure** (pronounced: tree-sore)[τρι∀σO]

12.   The friends shared a **biscuit** (pronounced: bis-coo-it)[βIσ∀κυ: ∀Iτ]

13.   The child used the blocks to build a **castle** (pronounced: cast-el)[κ{στ ∀Eλ]

14.   The cake was shaped like a **heart** (pronounced: rhyme with hear-t)[ηι□ ∀τ]

15.   He washed the plastic **bowl** (pronounced: bowel)[β≅Yλ]

16.   For a snack he ate a banana (pronounced: ban-ay-nar)[β{ν∀Aι∀νA:]

17.   Last year there was a big flood (pronounced: fl-oo-d)[φλ∀Y∀δ]

18.   The dog chased the lamb (pronounced: lam-b)[λ{μ∀β]

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)[Σ8Yλ∀δ≅]

22.   She put her glass on top of the **piano** (pronounced: pee-ay-no)[πι∀AIν∀ ≅Y]

23.   They could not solve the **mystery** (pronounced: my-ster-ee)[μAI∀στEρ∀ι]

24.   The queen lived in a large **palace** (pronounced: pa-lace)[π{∀λεIσ]

25.   The man argued with the **referee** (pronounced: ree-fair-ree)]ρι∀ φE:∀ρι]

26.   When they went camping, they used a compass (pronounced: com-pars)[κΘμ∀πα:ζ]

27.   At the zoo we saw a camel (pronounced: came-el)κεIμ∀Eλ]

28. The toy was made of metal (pronounced: meat-al)[μιτ∀{λ]

29. He came to the party dressed as a devil (pronounced: d-evil rhyme with weevel)[δι∀ϖEλ]

30. She was sick with the measles (pronounced: meaz-lez) [μιζ∀λEζ]

31. The children collected the **scissors** (pronounced: sci-sss-ors) [σκI∀σ∀Oζ]

32. My brother likes **spinach** (pronounced: spin-atch) [σπIν∀{τΣ]

33. On the rock there was a **lizard** (pronounced: lies-ard) [λεIσ∀Aδ]

34. We always like to eat **pudding** (pronounced: rhyme with budding) [βςδ∀IN]

35. The cat chased the **pigeon** (pronounced: pig-eon) [πIγ∀ιΘν]

36. He cut up the **onion** (pronounced: own-eon) [≅Yν∀ιΘν]

37. Mum paid the **chemist** (pronounced: tchem-ist) [τΣEμ∀Iστ]

38. For lunch we had some **soup** (pronounced: sow-p rhyme with cow-p) [σ≅Yπ]

39. Sam has big **muscles** (pronounced: musk-les) [μςσκ∀λEσ]

40. He ran away from the **wasp** (pronounced: to rhyme with rasp) [ω{σπ]

Variable (maximum score)	Time 1				Time 2				Marginal mean difference in improvement between groups [95% CI]
	Intervention		Control		Intervention		Control		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
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.

ENROLMENT – January 2015 (T1)

Children in Year 1 (all children) and 2 (those below reading level 3) in a mainstream school assessed at baseline on vocabulary, word recognition, phoneme awareness and mispronunciation correction measures (n=84)

Consent for participation gained from school head teacher. Opt-out consent forms sent home. No parent declined the use of data.

RANDOMISATION

Each child allocated randomly to intervention (n= 42) or control group (n=42)

ALLOCATION TO INTERVENTION

Allocated to intervention (n=42)

Received intervention for four weeks (two times per week) January 2015 – March 2015

Allocated to control (n=42)

Excluded from trial: limited English (n=2); severe autism (n=1)

Received "business as usual" teaching January 2015 - March 2015

FOLLOW-UP – March 2015 (T2)

All children retested using identical measures to T1.
Lost to follow-up: left school or absent on day of testing (n=4)

ANALYSIS

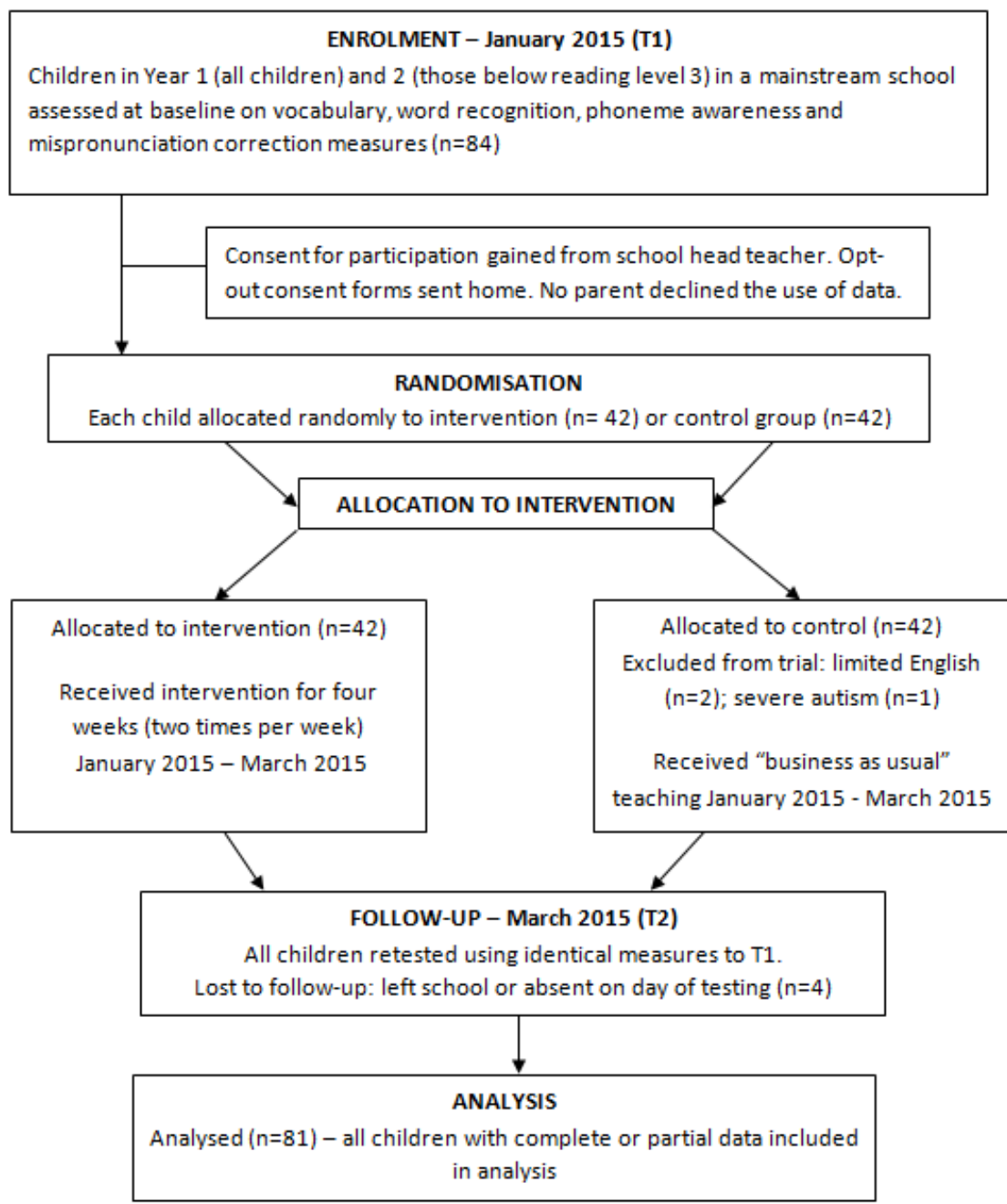Analysed (n=81) – all children with complete or partial data included in analysis

Figure 1: Outline of the flow of participants through study according to the CONSORT (2010) guidelines
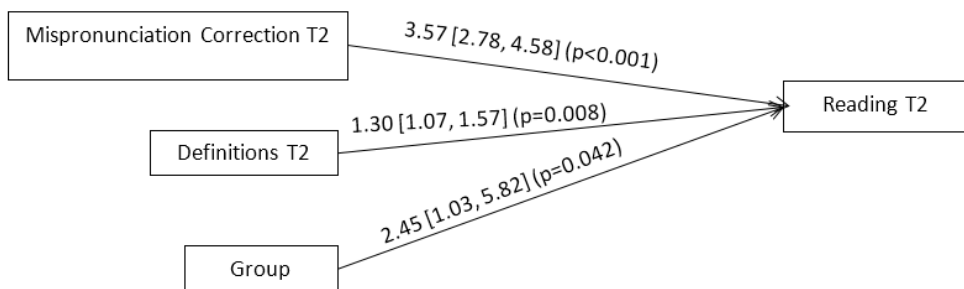
Figure 2a. All words

Mispronunciation Correction T2 — 3.57 [2.78, 4.58] (p<0.001) → Reading T2

Definitions T2 — 1.30 [1.07, 1.57] (p=0.008) → Reading T2

Group — 2.45 [1.03, 5.82] (p=0.042) → Reading T2

Figure 2b. Taught words only

Mispronunciation Correction T2 — 4.20 [2.77, 6.36] (p<0.001) → Reading T2

Definitions T2 — 1.53 [1.10, 2.13] (p=0.011) → Reading T2

Group — 5.91 [2.05, 17.07] (p=0.001) → Reading T2

Figure 2c. Untaught words only

Mispronunciation Correction T2 — 3.01 [2.17, 4.18] (p<0.001) → Reading T2

Definitions T2 — 1.26 [0.98, 1.61] (p=0.068) → Reading T2

Group — 1.35 [0.61, 2.99] (p=0.456) → Reading T2
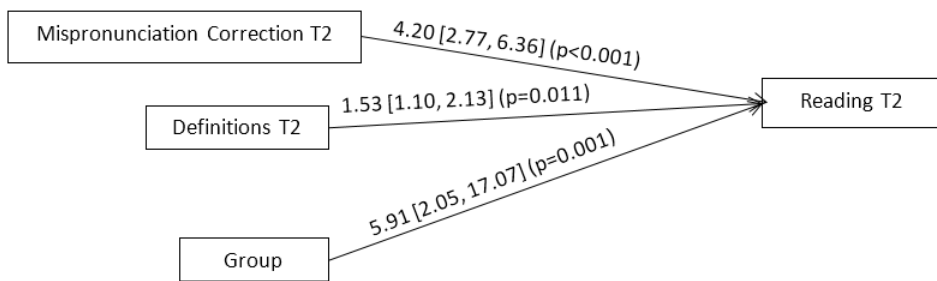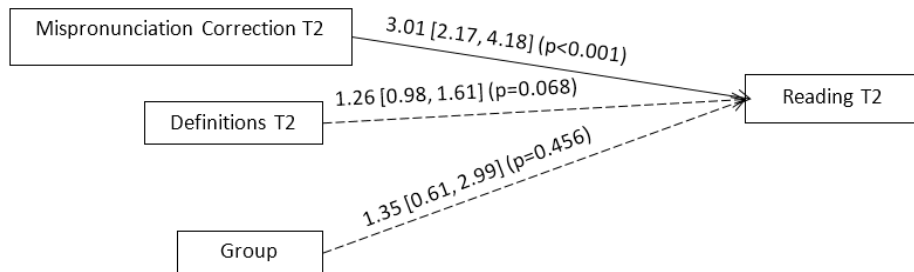
Appendix 2: Sample Teaching Materials (Week 3)

Note: all pictures shown in this appendix are taken from www.openclipart.org and are therefore free from copyright restrictions.

Lesson 1

Overall goals:

1. *Children to recap concepts of easy / tricky words, word reading toolkit and the roles of Donny / Splodge*

2. *Children to understand that occasionally consonants make words tricky (that vowels do not always obey the "letter laws")*

3. *Children to accurately correct mispronunciation of week 3 target words*

Activity	Further Details	Aim	Materials	Differentiation / Feedback
Recap easy / tricky words, word reading toolkit and roles of Donny and Splodge	Remind children of the difference between easy / tricky words (tricky words don't always obey the letter laws) Remind children of the word reading toolkit that they can use to read tricky words Remind children that Donny will say words correctly, but Splodge will say them incorrectly.	Children to remember the aim of the intervention (helping them to identify and read words which don't follow the letter laws); to remember the basic components of the word reading toolkit; to be reminded of the different roles of Donny and Splodge.	Pieces of green and red card with easy words / tricky words label. Word reading toolkit. Donny and Splodge puppets.	Ask more able children if they can remind the rest of the group of key points.

Irregular consonants explanation.	Explain to the children that occasionally consonants do not follow the letter laws. Emphasise that this happens much less often than with vowels (last week).	Children to understand that consonants occasionally cause words to be tricky, but that this happens much less often than with vowels.		Ask more able children if any of them know the difference between vowels and consonants (year 1s may struggle with this)
Irregular consonants activity	Give children the irregular consonants worksheet (each cluster of words has consonants common to all the words that are pronounced differently in each case). Read out the words on the worksheet and ask the children to underline the irregular consonants as you read them.	Children to practice identifying consonants in tricky words.	Irregular consonants worksheet.	Ensure that all children are underlining correct letters. Correct as necessary. Feed back to children throughout activity (go through answers and make sure all children have got the correct answer).
Practice with target words.	Splodge to read sentences from week 3: The man argued with the *referee* He pushed the door with his *shoulder* They could not solve the *mystery* The queen lived in a large *palace* She put her glass on top of the *piano* Children to correct Splodge.	Children to accurately correct Splodge's pronunciation of target words.	Splodge puppet, written sentence examples (with pictures).	Ask each child to correct Splodge in turn (using written sentences for support).

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Lesson 2

Overall goals:

1. *Children to be reminded of the concept of easy / tricky words and the word reading toolkit*

2. *Children to understand the link between the sounds of words and meaning and to understand that they can use the meaning of the word to support their reading of tricky words.*

3. *Children to be reminded of week 3 target words.*

4. *Children to complete worksheet to consolidate their understanding of week 3 target words (sound and meaning).*

Activity	Further Details	Aim	Materials	Differentiation / Feedback
Reintroduce puppets and "top secret" reading toolkit for reading tricky words.	Recap easy words and tricky words. Recap on reading toolkit. Remind children of each step and ask them to remember what each symbol means.	Children to be reminded of the process for reading tricky words.	Red / green cards to tricky words and easy words. Top secret toolkit poster. Donny and Splodge puppets.	Ask more able children to remember what each symbol means.
Recap week 3 words.	Splodge to read week 3 sentences incorrectly. Children to correct. The man argued with the *referee* He pushed the door with his *shoulder* They could not solve the *mystery* The queen lived in a large *palace* She put her glass on top of the *piano*	Children to consolidate knowledge of week 3 target sentences.	Splodge puppet, week 3 target sentences (without pictures).	
Talk about sound / meaning	Recap the concept that we can think about what words mean, and what	Children to explore links between target words	Written sentences of target words.	Ensure that children understand difference between the meaning task

	words sound like. For each target word, ask the children to think of: a word that means the same a word that sounds the same (rhymes)	and words they know in terms of sound and meaning		and the rhyme task.
Word worksheet.	Introduce worksheets. Go through worksheet with children explaining the two sections: Meaning – match the target word to a word that means the same / a picture that shows the word. Sound – match the target word to a word that sounds the same. Once the children have completed the worksheet, recap the correct answers to consolidate.	Children to complete worksheet for target words.	Relevant worksheets.	Support children in completing worksheets. Discuss their choices of rhyming words / word meanings.

Word Reading Toolkit for Tricky Words

5. **Check** to see if the word makes sense.

4. **Choose** a word you know that **sounds similar.**

1. Say the word out loud

2. Decide if you've read or heard the word before

?

3. Think of a word you know that **sounds like** the word you are reading.

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Week 3 Worksheet - Meaning

Match this week's words to the right meaning.

referee   a large house where the Queen lives

shoulder   a puzzle that you have to solve

mystery   an instrument you play – it has black and white keys

palace   a part of your body – at the top of your arm

piano   a person who is in charge of making sure everyone obeys the rules of a
                        sports game (like football)

Write this week's words under the right picture.

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Week 3 Worksheet - Sounds

Match this week's words to a word that **sounds the same** (rhymes):

referee	**Alice**
shoulder	**shallow**
mystery	**guarantee**
palace	**colder**
piano	**history**

Match this week's words to a word that **starts with the same sound:**

referee	**paint**
shoulder	**pin**
mystery	**shout**
palace	**red**
piano	**mix**

Can you write today's words yourself? You have been given the first letter to help you.

r_ _ _ _ _ _   s_ _ _ _ _ _ _ m_ _ _ _ _ _

p_ _ _ _ _   p _ _ _ _

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