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Print-sound regularities are more important than print-meaning regularities in the initial stages of

learning to read: Response to Bowers & Bowers (2018)

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RUNNING HEAD: PRINT-SOUND AND PRINT-MEANING REGULARITIES

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Abstract

Taylor, Davis and Rastle (2017) reported an artificial language learning study designed to compare methods of reading instruction that emphasise learning the relationship between spelling and sound versus learning the relationship between spelling and meaning. Behavioural and neural data supported emphasis on spelling-sound knowledge, and the authors therefore advocated use of phonics in the initial stages of learning to read. Bowers and Bowers (2018) argue that these conclusions are not justified because the authors (a) mischaracterised the English writing system; and (b) mischaracterised the meaning-based instruction used in schools. We respond to the first point by showing that the novel words used by Taylor et al. (2017) were a good approximation to the types of written words that children are exposed to in the first year of reading instruction. We respond to the second point by showing that while enhancements to meaning-based instruction can assist pupils to infer the meaning of unfamiliar words, these methods actually disadvantage long-term learning of those words. We conclude by suggesting that reading instruction should be based on an understanding of the writing system, properly characterised across the trajectory of learning. This means emphasis on spelling-sound regularities in the initial stage of learning to read, and increasing emphasis on spelling-meaning regularities as children gain greater experience with text.

Print-sound regularities are more important than print-meaning regularities in the initial stages of learning to read: Response to Bowers & Bowers (2018)

We recently reported a laboratory study designed to investigate the behavioural and neural consequences of different forms of reading instruction, as skilled adult readers learned the sounds and meanings of new words printed in artificial scripts (Taylor, Davis, & Rastle, 2017). Adults were pre-trained on two spoken language vocabularies comprising novel spoken forms that mapped onto familiar (noun) meanings (e.g. /vuz/ means 'bear'). Over 13 subsequent days of training and testing, participants learned how the written forms of these novel words, which were printed in a different artificial script for each language, mapped onto these sounds and meanings. For one language, training emphasised learning the relationship between the printed words and their sounds; for the other language, training emphasised learning the relationship between the printed words and their meanings. Behavioural results showed that accuracy in reading trained words aloud was enhanced by print-sound training relative to print-meaning training, while accuracy in retrieving the meanings of trained words was similar for the two training regimes. Functional neuroimaging data were consistent with the behavioural findings. They revealed increased neural effort during reading aloud when training had emphasised meanings of the novel words, but no impact of the training manipulation during meaning retrieval. We argued that these findings suggest that instruction in the initial stages of learning to read should focus on print-sound regularities (i.e. phonics) as opposed to teaching the meanings of whole words, as in "whole language" or "balanced literacy" programmes.

Bowers and Bowers (2018) argue that this conclusion is not justified because (a) our artificial orthographies mischaracterised the English writing system in fundamental ways; and (b) our method of meaning-based instruction did not capture important features of meaning-based approaches used in schools. In respect of their concerns about the writing system, Bowers and Bowers (2018) argue that our artificial orthographies were constructed in a way that biased the results in favour of print-sound training: they overstated print-sound regularity and understated print-meaning regularity.

Indeed, our novel words were completely systematic in terms of the relationship between letters and sounds, and completely arbitrary in terms of the relationship between letters and meanings. In respect of their concerns about the nature of instruction, Bowers and Bowers (2018) argue that meaning-based approaches typically assume that "children learn best when words are embedded in meaningful text designed to be enjoyable", as opposed to our protocol, which involved systematic and explicit instruction across several semantic tasks (e.g. definitions, word-picture matching, categorisation). Bowers and Bowers (2018) claim that these limitations are widespread in the literature around reading instruction, and that meaning-based approaches should not be rejected until further research is conducted that properly exploits print-meaning regularities in the English writing system.

Unsurprisingly, we disagree with Bowers and Bowers' (2018) assessment of our conclusions. We recognize that there are limitations of artificial language learning paradigms; for example, the training sets used in these paradigms cannot approach the complexity or size of natural languages. We discussed these limitations at length in Taylor et al. (2017). However, with that caveat in mind, we remain of the view that the laboratory simulation of Taylor et al. (2017) provides a reasonable approximation to the challenge that children face in the initial stages of learning to read in English, and therefore that our conclusions regarding reading instruction are well founded.

Regularities Encountered in the First Year of Reading Instruction

Bowers and Bowers (2018) argue that in contrast to our stimuli (a) a substantial percentage of words in children's books are "irregular"; and (b) English is characterised by well-known regularities between spelling and meaning (i.e. morphological regularities; e.g. act, actor, active, action, react, actively, reactivate, reactively, inaction). We agree with this general assessment of the English writing system. However, the important question with regard to our study concerns the nature of words that children encounter i*n the initial stages of reading instruction*. In order to quantify this, we used the Children's Printed Word Database (CPWD; Masterson, Stuart, Dixon & Lovejoy, 2010) to identify the words that children are exposed to in Reception (the first year of

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reading instruction in the United Kingdom). The CPWD is based on an analysis of words in 1,011 books (from structured reading schemes, book series, and other books), which teachers reported using in the first four years of reading instruction in the United Kingdom at the time that the database was constructed. We then cross-referenced this word list with the CELEX database (Baayen, Piepenbrock, & Gulikers, 1995) and the grapheme-to-phoneme correspondence rules of the DRC model (Coltheart et al., 2001) to determine regularity, and with the English Lexicon Project (Balota et al., 2007) to obtain syllabic and morphemic information.

The CPWD identifies 2,381 monosyllabic words and 3,184 polysyllabic words to which children in Reception are exposed. However, once frequency is considered, monosyllabic items represent 78% of tokens that children encounter in the initial year of reading instruction. Our analysis of the spelling-sound regularity of these words (based on the 2301 items for which there was an entry in the CELEX database) agrees broadly with that reported by Bowers and Bowers (2018); approximately 19% cannot be read aloud accurately using the rules of the DRC model (Coltheart et al., 2001). However, within these 19% of irregular words, which have a mean length of 3.7 phonemes, the mean number of phonemes pronounced differently than that predicted by rule is only 1.22 (based on Levenshtein distance). Thus, the vast majority of spelling-sound correspondences that children encounter in the first year of reading instruction are predictable based on a simple set of rules relating graphemes to phonemes.

In respect of morphemic information, 42% (2341/5565) of the words that children experience in Reception consist of a single morpheme. However, this rises to 80% when token frequency is considered. Thus, the majority of tokens that children encounter in the first year of reading instruction consist of a single morpheme, with a wholly arbitrary relationship between spelling and meaning. Of those 20% of tokens that comprise more than one morpheme, most contain the simple inflectional suffixes '-ed' or '-s' that attach to single-morpheme stems (Masterson et al., 2010). From this it follows that the spelling-meaning regularities of interest to Bowers and Bowers (2018) are of little relevance to the beginning reader. To summarize, the words that children

encounter in the initial year of reading instruction are overwhelmingly characterised by spelling-sound regularity and spelling-meaning arbitrariness, just as reflected in the stimuli constructed by Taylor et al. (2017).

Based on these analyses, we reject the assertion by Bowers and Bowers (2018) that we mischaracterised the English writing system in a fundamental way. The principal regularity in children's texts in the initial year of reading instruction reflects the relationship between spelling and sound and, based on the data reported by Taylor et al. (2017), we remain of the view that teaching methods that emphasise this relationship are most appropriate during that time period. Though children will encounter some spelling-sound instances that cannot be predicted by rule, these are frequently addressed through judicious sight-word training (e.g. McArthur et al., 2015; Shapiro & Solity, 2016), or through instruction on context sensitivities in the spelling-sound relationship (e.g. 'oo' is usually pronounced /u/, unless followed by /k/, as in *look*, *cook*, *book;* Department for Education, 2007). Further, though we agree that limited teaching of the high-frequency suffixes (e.g. -ed, -s) would be beneficial in this period, we argue that the types of morphological relationships illustrated in Figure 1 of Bowers and Bowers (2018) are at a level of complexity beyond the initial year of children's reading experiences, which our study was designed to simulate.

Extracting Regularities through Text Experiences

Bowers and Bowers (2018) argue that our meaning training was unlike that practiced in classrooms that subscribe to "whole language" or "balanced literacy" approaches and therefore, that our results should not be used to reject those approaches.

> "Taylor et al. have mischaracterized the various meaning-based forms of instruction practiced in the classroom. … Participants were repeatedly presented with random orders of the novel written words and asked to perform various semantic tasks (define them, match them to a picture, and categorize them). This is very different from "whole language" and "balanced literacy" forms of instruction ... [that] claim that children learn best when words are embedded in meaningful texts designed to be enjoyable."

We agree that these approaches place high value on the discovery of meaning through positive experiences with text (Smith, 1971/2004), and on the importance of graphic, semantic and syntactic contexts to assist the reader to *guess* the meanings of words (Goodman, 1967). Might our meaning training have been more effective if we had presented our novel words in meaningful contexts? The evidence suggests not.

It is well established that contextual information supports word identification in good and poor readers (e.g. Nation & Snowling, 1998). However, in cases in which the representations of printed words are not yet established, the effects of context are more circumscribed. In studies in which young children learn to read novel or unfamiliar words, presentation in sentence contexts normally facilitates reading performance during training (e.g. Landi et al., 2006; Martin-Chang et al., 2017). However, these positive impacts are absent when children are tested one week later. In fact, Landi et al. (2006) reported that initial learning in sentence contexts *hurt* retention one week later, as compared with learning words in isolation. Martin-Chang et al. (2017) observed a similar pattern when they tested the extent to which children's new knowledge transferred to spelling performance: initial learning in sentence contexts *disadvantaged* spelling performance one week later. These authors suggest that sentence context information during learning can help to identify an unfamiliar word, but results in a 'good enough' strategy, whereby learners fail to attend to the features of the word necessary for the development of well-specified orthographic representations. Based on this evidence, we reject the claim that our meaning instruction may have been more effective if novel words had been embedded in meaningful texts.

Widespread Biases in Research on Reading Acquisition

Bowers and Bowers (2018) argue that the biased treatment of spelling-sound and spelling-meaning knowledge apparent in our study is characteristic of the wider literature on reading acquisition and reading instruction. We certainly agree that morphology is a major organising principle of English writing and that its impact on reading and reading acquisition has been neglected – this is a point that one of us has been making for the past decade (Rastle & Davis, 2008; Rastle,

2018). However, that does not mean that *initial* reading instruction should focus on the interactions between phonology, morphology, and etymology, as recently advocated by Bowers and Bowers (2017). Instead, we argue that decisions about how particular regularities should be conveyed in reading instruction need to be considered in the context of a wider theory of reading acquisition, and in light of the text experiences of children at different stages of learning.

We have already presented evidence that there is limited morphological information present in the text experiences of young children just starting to read. This is an important point because research shows that print exposure is an important aspect of orthographic learning (Cunningham & Stanovich, 1991, 1993). Instruction on its own does not yield long-term knowledge. Instead, this is likely to arise over time through repeated experiences with a particular structure (e.g. suffix -er occurring repeatedly in the context of agentive nouns such as *teacher*, *builder*, *banker;* see e.g. Nation, 2017; Tamminen, Davis & Rastle, 2015). Further, some theories of reading acquisition suggest that prior knowledge of stems may be a critical factor in the acquisition of morphological (affix) representations (Davis, 1999). Based on this evidence, we would argue that devoting time in the initial periods of reading instruction to interactions between phonology, morphology, and etymology may be ineffective, since it will be unsupported by the text experiences of the child. It is also likely to decrease the time available for instruction relevant to spelling-sound knowledge (Taylor et al., 2017). Such instruction is critical for learning the single-morpheme stems at the foundation of morphological families (e.g. the 'act' in action, activate, react).

We believe that a focus on these morphological regularities is likely to be more appropriate in the later years of primary schooling (Rastle, 2018). During this period, children experience diverse texts that reflect their taught knowledge of spelling-meaning regularities, thus allowing them to engage in the self-teaching thought to be vital to building reading fluency (Share, 1995). This recommendation is consistent with research on the trajectory of children's understanding and use of morphology in reading acquisition (e.g. Beyersmann et al., 2012; Dawson et al., 2017), and our understanding of the development of the ventral reading pathway in the brain that underpins

knowledge of orthographic forms and their links to meaning (Ben-Shachar et al., 2011; see Rastle, 2018 for discussion). This recommendation is broadly consistent with the English National Curriculum (Department for Education, 2014), in which there is an emphasis on spelling-sound knowledge in the initial years of reading instruction, together with instruction on the most common inflectional suffixes (e.g. -ed, -s, -ing). In the subsequent years of primary school, once phonic knowledge is secure, children receive instruction on a range of prefixes and suffixes, their meanings, and the more complex spelling patterns that characterise their use.

Conclusions

We have argued that the laboratory-learning study reported by Taylor et al. (2017) provides a useful simulation of children's initial reading experiences. Based on that work, and our analyses of children's text experiences, we remain of the view that emphasis on spelling-sound regularities is of primary importance during this period. Emphasis on spelling-sound knowledge permits children to begin to learn the stems at the foundation of English morphological families, and text experiences during this period allow children to self-teach as they generalise their spelling-sound knowledge (Share, 1995). We share Bowers and Bowers' (2018) view that an understanding of morphology simplifies the English lexicon, and that emphasis on these spelling-meaning regularities is likely to be an important part of reading instruction. However, we believe that such instruction is likely to be most fruitful later in reading acquisition, when children's text experiences allow self-teaching through generalisation of this knowledge. In sum, we believe that reading instruction should be based on an understanding of the writing system, properly characterised across the trajectory of learning. Of course, these proposals require empirical evidence. Much more work is needed to discover how best to communicate morphological regularities in the writing system, and to understand how text experience supports this instruction to yield the abstract stored knowledge vital for fluent reading.

References

Baayen, R.H., Piepenbrock, R., & Gulikers L. (1995). The CELEX Lexical Database (CD-ROM). Linguistic data consortium, University of Pennsylvania, Philadelphia.

Balota, D.A., Yap, M.J., Cortese, M.J., Hutchison, K.A., Kessler, B., Loftis, B., Neely, J.H., Nelson, D.L., Simpson, G.B., & Treiman, R. (2007). The English Lexicon Project. Behavior Research Methods, 39, 445-459.

Ben-Shachar, M., Dougherty, R. F., Deutsch, G. K., & Wandell, B. A. (2011). The development of cortical sensitivity to visual word forms. *Journal of Cognitive Neuroscience, 23*(9), 2387-2399.

Beyersmann, E., Castles, A., & Coltheart, M. (2012). Morphological processing during visual word recognition in developing readers: Evidence from masked priming. *The Quarterly Journal of Experimental Psychology, 65*(7), 1306-1326.

Bowers, J. S., & Bowers, P. N. (2017). Beyond phonics: The case for teaching children the logic of the English spelling system. *Educational Psychologist, 52*(2), 124-141.

Bowers, J.S. & Bowers, P.N. (2018). The importance of correctly characterizing the English spelling system when devising and evaluating methods of reading instruction. Comment on Taylor, Davis, and Rastle (2017). *Quarterly Journal of Experimental Psychology*.

Coltheart, M., Rastle, K., Perry, C., Langdon, R., & Ziegler, J. (2001). DRC: A dual route cascaded model of visual word recognition and reading aloud. *Psychological Review, 108*(1), 204-256.

Cunningham, A. E., & Stanovich, K. E. (1991). Tracking the unique effects of print exposure in children: Associations with vocabulary, general knowledge, and spelling. *Journal of Educational Psychology*, *83*, 264–274.

Cunningham, A. E., & Stanovich, K. E. (1993). Children's literacy environments and early word recognition skills. *Reading and Writing: An Interdisciplinary Journal*, *5*, 193–204.

Dawson, N., Rastle, K., & Ricketts, J. (2017). Morphological effects in visual word recognition: Children, adolescents and adults. To appear in *Journal of Experimental Psychology: Learning, Memory and Cognition.* Epub ahead of print.

Davis, C. J. (1999). *The self-organising lexical acquisition and recognition (SOLAR) model of visual word recognition* (Doctoral dissertation). Uni- versity of New South Wales, Sydney, Australia.

Department for Education (2007). Letters and sounds: Principles and practice for high quality phonics. Reference 00281-2007BKT-EN. Retrieved from

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/190599/Letters_and_Sounds_-_DFES-00281-2007.pdf on January 24, 2018.

Department for Education (2014). National curriculum in England: English programmes of study. Retrieved from https://www.gov.uk/government/publications/national-curriculum-in-england-english-programmes-of-study on January 24, 2018.

Goodman, K. S. (1967). Reading: A psycholinguistic guessing game. *Journal of the Reading Specialist, 6*(4), 126-135.

Landi, N., Perfetti, C. A., Bolger, D. J., Dunlap, S., & Foorman, B. R. (2006). The role of discourse context in developing word representations: A paradoxical relation between reading and learning. *Journal of Experimental Child Psychology, 94*(2), 114-133.

Martin-Chang, S. (2017). Learning to read with and without feedback, in and out of context. *Journal of Educational Psychology, 109*(2), 233-244.

Masterson, J., Stuart, M., Dixon, M., & Lovejoy, S. (2010). Children's printed word database: Continuities and changes over time in children's early reading vocabulary. *British Journal of Psychology, 101*(2), 221-242.

McArthur, G.M., Castles, A., Kohnen, S., Larsen, L., Jones, K., Anandakumar, T., & Banales, E. (2015). Sight word and phonics training in children with dyslexia. *Journal of Learning Disabilities*, 48(4), 391-407.

Nation, K. (2017). Nurturing a lexical legacy: Reading experience is critical for the development of word reading skill. *Npj Science of Learning, 2*(1), 3.

Nation, K. & Snowling, M.J. (1998). Individual differences in contextual facilitation: Evidence from dyslexia and poor reading comprehension. *Child Development, 69*, 996-1101.

Rastle, K. (2018). The place of morphology in learning to read in English. To appear in *Cortex*.

Rastle, K., & Davis, M. H. (2008). Morphological decomposition based on the analysis of orthography. *Language and Cognitive Processes, 23*(7-8), 942-971.

Shapiro, L.R. & Solity, J. (2016). Differing effects of two synthetic phonics programmes on early reading development. *British Journal of Educational Psychology, 86*, 182-203.

Share, D. L. (1995). Phonological recoding and self-teaching: *Sine qua non* of reading acquisition. *Cognition, 55*(2), 151-218.

Smith, F. (1971/2004). Understanding Reading (6th Edition). Lawrence Erlbaum Associates: New Jersey

Tamminen, J., Davis, M. H., & Rastle, K. (2015). From specific examples to general knowledge in language learning. *Cognitive Psychology, 79,* 1-39.

Taylor, J. S. H., Davis, M. H., & Rastle, K. (2017). Comparing and validating methods of reading instruction using behavioural and neural findings in an artificial orthography. *Journal of Experimental Psychology: General, 146*(6), 826-858.

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