The DRC1.2 model can be downloaded from http://www.maccs.mq.edu.au/~ssaunder/DRC, at which site there is also a document describing the differences between DRC1.0 (the first version of the DRC model, published by Coltheart, Rastle, Perry, Ziegler and Langdon, 2001) and the DRC1.2 model (the current version of the DRC model). In all the simulations with the DRC1.2 model summarized here, the parameters used were the default parameters installed in the downloadable model, except where otherwise noted. These parameters are listed in the Appendix.

Perry, Ziegler and Zorzi (2007) compiled a list of benchmark effects against which computational models of reading can be evaluated, and we can use this list to compare the current version of the DRC model, DRC1.2, to DRC1.0. In adherence to the principle of incremental (nested) modeling, we want those benchmark effects in the list provided by Perry et al. (2007) which DRC1.0 could simulate (there were 8 such effects in that list) to be also simulable by the DRC1.2 model.

Testing of any version of the DRC model must begin by measuring the accuracy with which it reads the set of words making up its vocabulary and the accuracy with which it reads nonwords. With the default parameters, except that the parameter MinReadingPhonology was set to .9 to simulate reading at leisure so as to measure the asymptotic accuracy of the model, DRC1.2 scores 100% correct on reading the 8021 words in its vocabulary, and also 100% on reading the 7000 nonwords originally used to test DRC1.0.

In the remaining simulations MinReadingPhonology was set to .4 to simulate speeded reading.

Another general way of testing any computational model of reading aloud is to assess the proportion of variance of human reading-aloud RTs from large-scale databases of word-reading that the model can account for: such as the large-scale database of Spieler and Balota (1997). The DRC1.0 model’s word-reading RTs accounted for 3.49% of the variance of the human RTs from that database. The DRC 1.2 model did slightly better: for the Spieler-Balota data from young subjects, the correlation between human and DRC1.2 RTs was .190 (p < .001; 3.61% of variance accounted for) and for the Spieler-Balota data from older subjects, the correlation between human and DRC1.2 RTs was .218 (p < .001; 4.75% of variance accounted for). Under these speeded-reading conditions, DRC1.2 misread 3 words (ache, gibe, gyp). Given this, we can now consider the 8 benchmark effects identified by Perry et al. (2007) as simulable by DRC1.0, and consider how DRC1.2 fares with these.

The frequency effect
Reading aloud RTs by human readers are faster for high frequency words than low frequency words (Weekes, 1997). With the words used by Weekes, the DRC1.2 mean latencies were: High Frequency 68.76 cycles, Low Frequency 71.92 cycles, t (1,194) = 4.00 p <.001. The correlation for the entire DRC1.2 vocabulary (7970 words) between log written CELEX frequency and DRC1.2’s RTs using the standard parameters (including MinReadingPhonology = .4 to simulate speeded reading aloud)
was -.235 (p <.001). Here DRC made 22 errors, all regularizations of irregular words. Human readers also make regularization errors with irregular words when asked to read rapidly.

The lexicality effect
Reading aloud RTs by human readers are faster for words than for nonwords (Weekes, 1997). With the words used by Weekes, the DRC1.2 mean latencies were: Words 70.34 cycles, Nonwords 138.37 cycles, t (1, 293) = 90.93, p<.001. The correlations between human and model RTs was .530 (p <.001) for nonwords and .163 (p = .023) for words.

Frequency by regularity
Irregular words are read more slowly than regular words, and in Experiment 2 of Jared (2002) the size of this regularity effect was independent of word frequency. Table 1 shows the DRC1.2 latencies for the words from that experiment.

<table>
<thead>
<tr>
<th></th>
<th>Low frequency</th>
<th>High frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>irregular</td>
<td>94.98</td>
<td>89.30</td>
</tr>
<tr>
<td>regular</td>
<td>71.72</td>
<td>67.95</td>
</tr>
</tbody>
</table>

Table 1: DRC1.2 RTs for the items from Jared (2002, Experiment 2)

The effect of regularity was significant (F (1,154) = 470.91, p<.001) as was the frequency effect (F (1,154) = 21.11, p<.001). The interaction was not significant (F (1,154) = .859, p = .355). The correlation between human and DRC RTs was .289 (p <.001). No errors were made.

Length by lexicality
Weekes (1997) reported that for nonwords reading-aloud RTs increased as a function of number of letters in the nonwords for strings of length from 3 to 6 letters, whereas reading-aloud latencies for words were independent of length when the confounding factor of neighbourhood size was eliminated by analysis of covariance. Table 2 shows the DRC1.2 latencies for the nonwords and words from that experiment.

<table>
<thead>
<tr>
<th></th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>nonwords</td>
<td>130.40</td>
<td>135.9</td>
<td>140.7</td>
<td>146.6</td>
</tr>
<tr>
<td>words</td>
<td>68.92</td>
<td>71.49</td>
<td>70.12</td>
<td>70.80</td>
</tr>
</tbody>
</table>

Table 2: DRC1.2 RTs for the items from Weekes (1997)

With N as a covariate in analysis of covariance, there was a significant effect of length for nonwords (F (3,94) = 86.43, p <.001), but not for words (F (3,191) = 1.39, p = .247). No errors were made.

Position of regularity
Rastle and Coltheart (1999) reported that the size of the regularity effect in reading aloud was smaller the later in the irregular word was the irregular grapheme-phoneme correspondence. Table 3 shows the DRC1.2 latencies for the words from that experiment.
Table 3: DRC1.2 RTs for the items from Rastle and Coltheart (1999).

The effect of regularity was significant (F (1,170) = 701.3 p < .001) as was its interaction with position of regularity (F (2,170) = 22.05 p < .001). The correlation between human and DRC RTs was .39 (p < .001). No reading errors occurred.

**Masked onset priming**

When a target letter-string is preceded by a briefly presented masked prime letter-string and the prime and target share their initial letter/phoneme, targets are read aloud faster than when the primes are unrelated to them. This occurs when the primes and targets are both nonwords (Kinoshita, 2000) and also when both are words (Forster and Davis, 1991; Mousikou, Coltheart, Saunders & Yen, in press).

We presented to DRC1.2 the CVC nonword primes and targets from Kinoshita (2000), using a prime duration of 26 cycles. When simulating masked priming with DRC1.2, we simulate the backward masking of the prime by the target by turning off the activation of the prime letters at target onset, since that is effectively what interruption masking by a backward mask does.

In the experiment by Kinoshita (2000), the nonword primes shared the initial letter/phoneme, the initial two letters/phonemes, or no letter/phoneme with the nonword targets. The mean DRC1.2 RTs in these conditions are shown in Table 4.

<table>
<thead>
<tr>
<th>Priming condition</th>
<th>Initial letter/phoneme</th>
<th>Initial two letters/phonemes</th>
<th>No letters/phonemes</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRC RT</td>
<td>128.67</td>
<td>128.67</td>
<td>129.57</td>
</tr>
</tbody>
</table>

Table 4: DRC1.2 RTs for the nonword items from Kinoshita (2000).

DRC RTs were significantly faster in both priming conditions than in the control conditions (t(53) = 22.79, p < .001), but there was no difference between the 1-letter and 2-letter overlap condition. That is the pattern of results observed by Kinoshita (2000) with her human subjects.

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1 27 of the CVC nonword primes in this experiment, and 8 of the CVC nonword targets, are actually real words and are in the DRC vocabulary (bop, dam, dib, dim, fab, gad, gat, gen, gob, hep, hod, hub, hun, kip, map, nub, pug, rep, ret, rig, set, sib, sop, sot, ted, teg, tic, tig, tod, vac, wop). These are generally of such low frequency that few if any of them would have been familiar to the subjects of Kinoshita (2000). So they would be words in a DRC simulation, but nonwords to the human subjects. To make the simulation data comparable to the human data, we therefore, for this simulation, deleted all these items from the DRC vocabulary, thus making all of them nonwords for DRC.
In Experiment 2a of Mousikou et al. (In Press), the primes and targets were four-letter words which either shared the initial letter/phoneme or no letter/phoneme with the word targets. We presented to DRC1.2 the 60 word primes and targets from this experiment, using a prime duration of 26 cycles.

<table>
<thead>
<tr>
<th>Priming condition</th>
<th>Same initial letter/phoneme</th>
<th>No letters/phonemes in common</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT</td>
<td>68.03</td>
<td>69.52</td>
</tr>
</tbody>
</table>

Table 5: DRC1.2 RTs for the word items from Experiment 2a of Mousikou et al. (In Press).

DRC1.2 RTs were significantly faster in the initial overlap condition than in the no-overlap condition ($t(59) = 5.12$, $p < .001$). Thus DRC1.2 also shows a masked onset priming effect when primes and targets are words.

The pseudohomophone effect
Pseudohomophones - nonwords that sound identical to real words - are read aloud faster than orthographic-control nonpseudohomophones (McCann & Besner 1987). The DRC1.2 mean latencies for the items from that experiment were: Pseudohomophones 134.29, Controls 138.86, $t (1,141) = 7.84$ $p < .001$. The correlation between human and DRC nonword reading latencies was $.249$, $p = .003$. No errors were made.

Phonological dyslexia
Patient LB (Beauvois and Derouesne, 1985), who suffered from an acquired impairment of nonword reading, was more accurate at reading pseudohomophones than orthographic-control nonwords provided that the pseudohomophones were orthographically similar to the words from which they were derived. This experiment was done in French, so new material was constructed by Coltheart et al. (2001) to explore the effect in English: pseudohomophones which were or were not orthographically similar to their basewords and orthographic-control nonwords.

It is important to note here that only some patients with phonological dyslexia show an influence of pseudohomophony on nonword reading. Others do not. So there are clearly two subtypes of the condition, with different impairments. To model the condition we need therefore to find two different ways of impairing the model’s nonword reading whilst not impairing its word reading: one way which shows the LB pattern, and another way which shows no effect of pseudohomophony.

Many but not all patients with phonological dyslexia have a rather general phonological impairment and these may be the patients who show no pseudohomophone advantage in nonword reading. We modeled this subtype by increasing the value of the phonological parameter $GPCCriticalPhonology$ from its

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2 Current attempts at simulating masked onset priming for words using the stimuli from Experiment 1 of Forster and Davis (1991) with the DRC 1.2 model have not succeeded; this issue is being pursued.
The resulting lesioned model produces the following results with the pseudohomophonic nonwords and their controls:

<table>
<thead>
<tr>
<th></th>
<th>Near</th>
<th>Far</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSH % correct</td>
<td>35.0%</td>
<td>32.5%</td>
</tr>
<tr>
<td>Control % correct</td>
<td>37.5%</td>
<td>45.0%</td>
</tr>
</tbody>
</table>

Table 6: Percent correct reading of pseudohomophones and orthographic control nonwords by a phonologically lesioned DRC1.2.

Here there is a general impairment of nonword reading with no significant influence of pseudohomophony or orthographic similarity.

Patients like LB, on the other hand, seem to have an orthographic rather than a phonological impairment, and we modelled this by reducing the value of the orthographic parameter `LetterOrthlexInhibition` from its default value of .48 to .30.

The results were:

<table>
<thead>
<tr>
<th></th>
<th>Near</th>
<th>Far</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSH % correct</td>
<td>87.5%</td>
<td>27.5%</td>
</tr>
<tr>
<td>Control % correct</td>
<td>30.0%</td>
<td>35.0%</td>
</tr>
</tbody>
</table>

Table 7: Percent correct reading of pseudohomophones and orthographic control nonwords by an orthographically lesioned DRC1.2.

There is a pseudohomophone advantage for the Near condition (chi squared 11.25, df = 1, p <.001) but not for the Far condition. That was the pattern shown by the patient LB.

**Conclusion**

There were 8 benchmark effects in the list provided by Perry et al. (2007) which DRC1.0 could simulate. DRC1.2 can simulate all eight of these effects.
References


DRC1.2 default parameters

# DRC Parameters File

# General Parameters
ActivationRate 0.2
FrequencyScale 0.05
MinReadingPhonology 0.4

# Feature Level Parameters
FeatureLetterExcitation 0.005
FeatureLetterInhibition 0.15

# Letter Level Parameters
LetterOrthlexExcitation 0.07
LetterOrthlexInhibition 0.48
LetterLateralInhibition 0

# Orthographic Lexicon (Orthlex) Parameters
OrthlexPhonlexExcitation 0.25
OrthlexPhonlexInhibition 0
OrthlexLetterExcitation 0.3
OrthlexLetterInhibition 0
OrthlexLateralInhibition 0.06

# Phonological Lexicon (Phonlex) Parameters
PhonlexPhonemeExcitation 0.09
PhonlexPhonemeInhibition 0
PhonlexOrthlexExcitation 0.25
PhonlexOrthlexInhibition 0
PhonlexLateralInhibition 0.07

# Phoneme Level Parameters
PhonemePhonlexExcitation 0.04
PhonemePhonlexInhibition 0.16
PhonemeLateralInhibition 0.147
PhonemeUnsupportedDecay 0.05

# GPC Route Parameters
GPCPhonemeExcitation 0.051
GPPCriticalPhonology 0.05
GPCOnset 26