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Effects of sound-to-spelling friends and enemies in children's auditory rhyme decisions

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Abstract
An experiment is reported, conducted on children of 9 and 11 years of age, that examined the possible effect of the relative number of sound-to-spelling friends and enemies the first word of a rhyming pair has on performance in the auditory rhyme judgment task. Friends are rhyming words with the same spelling of the rime (e.g., stream-dream and scheme-theme) and enemies are rhyming words with dissimilar spellings of the rimes (e.g., stream-theme and scheme-dream). It was predicted, following the Loosemore, Brown & Watson (1991) connectionist model of spelling, that the first word presented should activate the representations of its friends and inhibit the representations of its enemies and so the orthographic facilitation effect should be larger for those cases where the first word a rhyming pair has more friends than more enemies. The experiment reported in this paper found precisely the opposite pattern of results: the orthographic facilitation effect was only reliable for those cases when the first word had more enemies than friends. So it would appear to be the case that the degree of the activation of friends and the inhibition of enemies varies according to how many words are friends and how many words are enemies.

Keywords: rhyme judgment task; friends and enemies; orthographic facilitation effect; children.

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1. Introduction

Spelling-to-sound relationships may be described in different ways. Traditional symbolic rule-based methods have stressed the concept of regularity and have partitioned words into those with 'regular' correspondences (i.e., whose pronunciations are correctly determined by a set of spelling-to-sound translation rules) and those with 'irregular' or 'exception' correspondences (i.e., whose pronunciations are different from those given by the rules). The spelling-to-sound correspondence 'rules' have been derived from statistical analyses of how spelling patterns are pronounced in words, with the 'regular' correspondence being the most common phonological realization of a particular spelling pattern (or what Venezky, 1970, called its 'major' correspondence), and the 'exceptions' being minority correspondences of the spelling pattern. The division into 'regular' and 'exception' words for reading has been complicated by a number of issues, including: (i) what is the effective size of the units for which correspondence rules should operate (e.g., is it grapheme-to-phoneme or the phonological correspondences of larger units, such as orthographic 'bodies', see Patterson & Morton, 1985); (ii) whether regularity should be determined by the number of words or the absolute frequency of the words (i.e., should spelling-to-sound rules be determined by type or token correspondence rules); and (iii) how flexible should rules be in terms of allowing the operation of context-sensitivity constraints (e.g., A is usually pronounced as /*a*/, except when it follows W, when it is often pronounced as /*o*/, as in was, wasp and wash).

The value of the regular / irregular dichotomy has been questioned by some connectionist models of spelling-to-sound conversion. In Brown's (1987) connectionist model of reading, words were classified in terms of number of their spelling-to-sound "friends" and "enemies" rather than their regularity (and Brown focuses his analysis upon the phonological correspondences of orthographic bodies). A word's friends are those words with the same pronunciation of its spelling pattern; for example, the friends of the word HEAD would be all words where EAD is pronounced /ed/ (as in dead, bread, etc.). A word's enemies are those words with different pronunciations of the spelling pattern; for example, the enemies of HEAD are all those words with different pronunciations of EAD (as in bead). Note that regularity is irrelevant for this analysis; although there will be a clear tendency for most friends to be regular and most enemies to be irregular, simply as a result of the statistical distribution of sound-to-spelling correspondences of words in the language, it is possible for irregular words to also have friends (i.e., words sharing the same correspondence).

It is possible, within Brown's (1987) model of reading, to distinguish a number of different classes of words. First, some words have many friends but no enemies. The word lock, for example, has no enemies, as all words ending in OCK are pronounced to rhyme with "lock" (as in clock, dock, mock, block, etc.). In Patterson & Morton's (1985) classification, such words are referred to as being "consistent". Second, some words have no friends but many enemies; pint, for example, has only enemies as all other words ending in INT are pronounced as in mint, flint, lint, etc. (In Patterson & Morton's terms, pint is the "heretic" of the "consensus" family of words ending in INT.) Third, some words have both friends and enemies, but have more friends than enemies; for example, meat has the friends beat, feat, heat, etc., but great is an enemy. Fourth, some words have both friends and enemies, but have more enemies than friends (e.g., the enemies of love and dove include cove, stove and move). Finally, there are some words with neither friends nor enemies, such as bulb and yacht (which Patterson & Morton would call "hermits"). (Note that it is likely that most of these words will be irregular, but some may be regular, e.g., bulb.) In Brown's experimental work, in which he compared words with friends but no enemies, words with no friends but many enemies, and words with neither friends nor enemies, he found independent effects of the number of friends and enemies on word reading times.

English sound-to-spelling relationships are even more inconsistent than spelling-to-sound relationships (see Barry, 1994). Spelling is even less consistent than reading. There are very many words that have both friends and enemies when these are defined in terms of orthographic similarity of rhyming words; indeed, it is this very feature of English that permits the ready construction of pairs of words that rhyme and have dissimilar spellings and of pairs of words that do not rhyme but have similar spellings. For this reason, Barry & Seymour (1988) recommended that the concept of 'regularity' of sound-to-spelling correspondences should be replaced by sound-to-spelling contingencies, as for many vowel phonemes there exist a range of spellings. For example, the vowel /i:/ is spelled in 12 different ways; the most common (EA, as in eat, clean, tea) occurs in 40% of words and the second most common (EE, as in eel, green, tee) occurs in 39% of words. In their experimental work, Barry & Seymour distinguished between "high-contingency" and "low-contingency" spellings of vowels, but this distinction is one of degree rather than of kind. English sound-to-spelling correspondences are very widely distributed.

Recent accounts of spelling production have been expressed in terms of connectionist models. Loosemore, Brown & Watson (1991) and Brown & Loosemore (1994) have developed a connectionist model of spelling in which words are classified in terms of how many sound-to-spelling friends and enemies they have. Friends are defined as rhyming words with the same spelling pattern (e.g., stream-dream and scheme-theme), and enemies as rhyming words with different spelling of the rimes (e.g., stream-theme and scheme-dream). The word kill has many friends (e.g., hill, pill, mill, etc.) but no enemies, whereas the word soap has no friends but many enemies (e.g., hope, cope, mope, etc.). Some words, such as bulb, wasp and desk have neither friends nor enemies (as these words have no rhyming words). Loosemore et al.'s network learned words like kill and lock (with many friends) more readily than words like bulb (with no friends or enemies); i.e., the number of friends facilitated acquisition. There was also a smaller effect of the number of enemies, in that the model learned words like soap (with many enemies) less readily than words like bulb (with no enemies); i.e., the number of enemies tended to interfere with acquisition. When Loosemore et al. tested 7- to 12-year-old children's spelling of these three sets of words, they found a very similar pattern of results: words with friends but no enemies were spelled more accurately than those with neither friends nor enemies which were, in turn, spelled more accurately than words with enemies but no friends.

The experiment in the present paper was designed to investigate the possible effects of friends and enemies in the auditory rhyme decision task. A prediction that follows from the Loosemore et al. model (although it was not explicitly made by the authors) is that, in the auditory rhyme decision task, the first word presented should activate the representations of its friends and inhibit the representations of its enemies. If so, then it should be possible to monitor the relative contribution of friends and enemies in the rhyme decision task, which of course does not require any selection for explicit production from a set of activated spellings. Consider the words that end in the rime -/i:m/. There are 16 such words, 11 of which are spelled with the pattern EAM (as in beam, dream, steam, etc.), 3 are spelled as EEM (teem, deem and seem) and only 2 are spelled as EME (scheme and theme). If the word "steam" was presented first, it should be expected to activate its many friends (all of which, by definition, have a similar spelling). If it was then followed, in the auditory rhyme decision task, with one of these friends, then it is quite reasonable to expect a large orthographic facilitation effect, compared to when one of its fewer enemies (i.e., a word with a different spelling pattern) is presented. In contrast, if the word "scheme" was presented first, it should be expected to activate its fewer friends which might result in a smaller orthographic facilitation effect, as its many more enemies should have some detrimental influence. Therefore, the difference between "steam-dream" and "steam-theme" (or "steam-deem") should be larger than the difference between "scheme-theme" and "scheme-dream" (or "scheme-deem").

Experiments comparing words with either more friends or more enemies in the auditory rhyme decision task should produce important empirical constraints upon the development of connectionist accounts of the mechanisms of spelling activation. If the Loosemore et al. model of spelling activation can be applied to performance in the auditory rhyme decision task, then it is predicted that the orthographic facilitation effect should be larger for those rhyming word pairs where the first word has more friends than where it has more enemies. This prediction will be tested in both 9- and 11-year-old children. The experiment will focus on the orthographic facilitation effects in positive responses to rhymes (as only these speak directly to the issue of friends and enemies in the Loosemore et al. model). If it is the case that the first word of any pair activates all its friends (i.e., similarly spelled rhyming words) and also actually inhibits its enemies (i.e., dissimilarly spelled rhyming words), then the orthographic facilitation effect (the difference between responses to similarly and dissimilarly spelled rhyming words) should be larger when the first word has more friends than enemies. The experiment therefore manipulated two variables: the first word of each rhyming pair either had more friends (e.g., "steam") or more enemies (e.g., "scheme"), and was followed by either a similarly spelled word (i.e., a friend of the first word) or a dissimilarly spelled word (i.e., an enemy of the first word).

2. Method

Participants. Forty-nine children participated in the experiment. There were twenty-five 9-year-olds (fifteen male and ten female) and twenty-four 11-year-olds (ten male and fourteen female).

Design. Three independent variables were manipulated in this experiment. Age (9-year-olds vs. 11-year-olds) was a between subjects variable and the two within subject variables were whether the first word of each pair had more friends or more enemies, and whether the second word was a friend (i.e., spelled similarly) or an enemy (i.e., spelled dissimilarly). The dependent variables measured were the accuracy and time taken for each child to decide if the two words of every pair rhymed or not.

Stimulus materials. Eighteen sets of four rhyming words were selected (e.g., steam, dream, scheme, theme and boil, spoil, loyal, royal). Two words of each set (steam and dream, and boil and spoil for these examples) have more friends than enemies, and two words (scheme and theme, and loyal and royal) have more enemies than friends. From each set of four words, pairs of rhyming words were constructed for the four main conditions of the experiment, which were: (i) the first word has more friends than enemies and the second word is a friend (i.e., has a similar spelling), e.g., steam-dream and boil-spoil; (ii) the first word has more friends than enemies and the second word is an enemy (i.e., has a dissimilar spelling), e.g., steam-theme and boil-loyal); (iii) the first word has more enemies than friends but the second word is a friend (i.e., has a similar spelling), e.g., scheme-theme and loyal-royal; and (iv) the first word has more enemies than friends and the second word is an enemy (i.e., has a dissimilar spelling), e.g., scheme-dream and loyal-spoil.

There were two sub-groups within each age, in order to counterbalance the assignment of stimulus words to the conditions of the experiment. All the non-rhyming pairs had dissimilar spelling patterns.

Procedure. All the words were recorded by the authors using a MacRecorder. The recordings were then edited and saved digitally, using SoundEdit on a Macintosh computer, to exclude the silence before and after each word. Dr Alan Milne's program was used for presenting randomly the stimuli and for timing subjects' responses after the second word of every pair had ended.

Each participant was tested individually on the rhyme judgement task. They were given headphones in order to listen better to the stimuli and were instructed to press the 'yes' button if the two words of a pair rhymed or the 'no' button if the two words did not rhyme. After the first word of every pair and before the second one there was an inter-stimulus interval of 250 msec. Then the participant responded and an inter-trial interval of 1 second followed before the next pair of words was presented.

The durations of the second words were added to participants' reactions, before any analysis was conducted, in order to have a better measure of people's reaction times from the onset of the second word of each pair.

Each child was tested individually and all stimuli were presented randomly in a testing session, which took approximately ten minutes. Prior to the main seventy-two experimental trials, there were a series of twelve practice trials (consisting of stimuli not used in the main experiment).

3. Results

Harmonic means of reaction times of correct responses (which were measured from the onset of the target word) were calculated for each condition for each child, and for each stimulus pair. Very short reaction times (below 500 msec from the word's onset) and very long ones (above 3 sec) were excluded from the analysis. The reaction times of three children (one 9-year-old and two 11-year-olds) who made a lot of errors were excluded and so the data from 46 children (twenty four 9-year-olds and twenty two 11-year-olds) were used in the analyses that follow.

Only the data from responses to rhyming words were analysed. (There were no contrasts to make for responses to non-rhymes as all had different spellings.) The analyses of variance contained three variables: age (9- vs. 11-year-olds), whether the first word had more friends or more enemies, and the spelling similarity of the second word (i.e., whether it was a friend or an enemy). In the analysis by subjects, age was a between subject variable and the other two were within subject variables, whereas in the analysis by items whether the first word had more friends or more enemies was a between item variable and both age and spelling similarity were within item variables. Table 1 shows the results of responses to rhymes in the experiment.

Table 1. Mean correct reaction times (in msec) in the auditory rhyme decision task and facilitation effect for the two groups of children

	First word has more friends			First word has more enemies		
9-YEAR-OLDS	Similar Friend	Dissimilar Enemy	Facilitation	Similar Friend	Dissimilar Enemy	Facilitation
By subjects	1227	1234	7	1249	1297	48
By items	1192	1186	-6	1221	1226	5
% of errors	7.9%	10.2%		8.8%	11.6%	
11-YEAR-OLDS	Similar Friend	Dissimilar Enemy	Facilitation	Similar Friend	Dissimilar Enemy	Facilitation
By subjects	1302	1280	-22	1281	1374	93
By items	1258	1230	-28	1239	1337	98
% of errors	8.6%	7.1%		9.1%	8.1%	

The main effect of age was not significant in the analysis by subjects [Fs < 1], but was significant in the analysis by items [Fi(1,34) = 15.52, MSe = 8096.627, p < 0.001], where the variable was a within-item contrast. Overall, the 9-year-olds were faster (1252 msec) than the 11-year-olds (1309 msec). The main effect of spelling was absent [Fs <1, Fi = 1.46]. The main effect of whether the first word had more friends or enemies approached, but did not reach significance [Fs(1,44) = 3.66, MSe = 19673.848, p = 0.065; Fi(1,34) = 2.53, MSe = 21736.054, p = 0.12], which reflected the fact that the children responded faster to pairs where the first word had more friends (1259 msec) than more enemies (1299 msec). However, the critical interaction between whether the first word had more friends or more

enemies and spelling similarity was significant in the analysis by subjects [Fs(1,44) = 6.13, Mse = 11485.281, $p < 0.025$] and approached significance in the analysis by items [Fi(1,34) = 2.73, MSe = 21736.054, $p = 0.108$]. The orthographic facilitation effect was larger when the first word had more enemies than when it had more friends. This was confirmed by analyses of simple main effects, which showed that the effect of spelling similarity was significant when the first word had more enemies [F(1,88) = 5.23, MSe = 2134.153, $p < 0.035$; Fi(1,34) = 3.09, MSe = 15681.034, $p = 0.087$] but absent when the first word had more friends [Fs < 0.1, Fi < 1]. The three way interaction between age, whether the first word had more friends or more enemies and spelling similarity did not reach significance in the analysis by subjects [Fs(1,44) = 1.38] but approached significance in the analysis by items [Fi(1,34) = 3.14, MSe = 9549.721, $p = 0.085$], which reflected the trend for the orthographic facilitation effect for pairs where the first word had more enemies to be larger for the 11-year-olds than the 9-year-olds.

The analyses of the error-rates produced no significant effects. An unrelated t-test was conducted on the means of the non-rhymes. The mean reaction time of all the twenty-four 9-year-olds was 1322 msec and the mean reaction time of all the twenty-two 11-year-olds was 1325 msec, and this difference was not significant [t(44) = 0.05].

4. Discussion

This experiment was designed to see if children of 9 and 11 years of age would show effects of sound-to-spelling friends and enemies in the auditory rhyme judgment task. The results found show that the 11-year-old children demonstrate a reliable orthographic facilitation effect only for those cases when the first word has more enemies than friends. A similar pattern of results was found for the 9-year-olds, although the effects were somewhat smaller. These results are very similar to those found with adults (Lipourli, 1999), and a similar interpretation can be offered in terms of the distribution of the pattern of activation produced by the first word in each rhyming pair for its orthographically similar friends and its orthographically dissimilar enemies. It is proposed that the degree of the activation of a word's friends and the degree of inhibition of a word's enemies will vary according to how many friends and enemies there are. If it is assumed that the amount of activation and inhibition will need to be distributed over the entire set of friends and enemies, then the more words there are, the smaller each word's 'share' of activation or inhibition will be (and so there will be smaller changes of activation levels when there are more words). On this assumption, when the first word heard in the auditory rhyme decision task has more enemies than friends, its fewer friends will be activated more strongly than its more enemies will be inhibited. So if the second rhyming word heard was a friend, it would be responded to faster as it would have enjoyed the large advantage of having been activated quite strongly; but if the second word was an enemy, it would not be responded to particularly slowly as it would have suffered only a relatively small disadvantage (as it was only one of many words that shared the inhibition). Therefore, when the first word of a rhyming pair had more enemies than friends, there was an overall orthographic facilitation effect. However, when the first word has more friends than enemies, each of its many friends would be activated only a little and its few enemies would be inhibited relatively strongly, which would have the effect of effectively cancelling any orthographic facilitation effect. This account provides an explanation for the finding that, for children as for adults (Lipourli, 1999), the orthographic facilitation effects found were larger (and only reliable) for those cases when the first word has more enemies than friends than for when the first word has more friends than enemies. As such, the results confirm those found for adults and so suggest that similar processes are used. It would appear that children are also sensitive to the number of friends and enemies a word has. This suggests that, not only do they activate the spellings of words they hear, but they also

activate the spellings of other words that rhyme with the first word (in the manner suggested by the Loosemore et al. model). If they did not, then there would have been no effects of friends and enemies in their performance.

It is possible that the orthographic facilitation effects for responses to rhymes that are larger for irregular than for regular words (Lipourli, 2014), could also be due to the effects of friends and enemies rather than to sound-to-spelling irregularity. This is because similarly spelled rhyming irregular words will have more enemies than friends. Therefore, all these results with children are likely to be due to the same process of spelling activation.

The results suggest that people not only activate the spelling of a heard word, but that they also activate the orthographic representations of the friends of the word (and inhibit the representations of its enemies). This would suggest that, on hearing a spoken word in this task, people activate all words that rhyme with it (i.e., all words that share the same phonological rime) and their orthographic representations, although the manner in which these become activated is influenced by the spelling similarity of the first word (i.e., there are effects of sound-to-spelling friends and enemies). It would appear that there exists a complex set of intricate and interconnected relationships between the phonological and orthographic representations of words.

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