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Running head: ORTHOGRAPHY AND RHYME JUDGEMENT

The Interplay Between Phonology and Orthography on Rhyme Judgement

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English: **The interplay between phonology and orthography on rhyme judgement**

Abstract

A Word Rhyme Judgements task for neuropsychological assessment in European Portuguese is presented. The task was modeled from Kay, Lesser & Coltheart (1992). It requires a yes/no decision on whether word pairs rhyme or not. Half of the pairs rhyme; half of these have the same final spelling (CEDO/DEDO), half have different final spellings (POÇO/FOSSO). Control pairs, half of which share the final spelling, do not rhyme (MEDO/CREDO; MOÇO/NOSSO). Thirty-two college students performed this task in the spoken and written modalities (order counterbalanced). Clear effects of modality, in favor of the spoken presentation, and of orthography, in favor of same spelling rimes, even in the spoken presentation, were observed. The findings are consistent with the assumption that orthography interacts with phonology even when the task does not require explicit attention to orthography. The usefulness of the materials and task for the assessment of language is upraised.

Key words: Rhyme Judgement, Orthography, European Portuguese, Language, Neuropsychological Assessment

Português: **Ouve, rima ou não? Ortografia e fonologia no julgamento de rima**

Resumo

Apresentamos aqui uma tarefa de Julgamento de Rimas em Palavras para avaliação neuropsicológica em português. A tarefa foi elaborada a partir da sua homónima de Kay, Lesser & Coltheart (1992), e consiste em decidir se um par de palavras rima ou não. Metade dos pares de palavras rimam; metade das rimas escrevem-se da mesma maneira (CEDO/DEDO), outra metade de maneira diferente (POÇO/FOSSO). Pares de controlo, metade dos quais têm a mesma sequência ortográfica no final, não rimam (MEDO/CREDO; MOÇO/NOSSO). Trinta e dois estudantes universitários realizaram esta tarefa na modalidade falada e na modalidade escrita (ordem contrabalanceada). Observaram-se efeitos claros de modalidade, em favor da apresentação falada, e de ortografia, em favor das rimas escritas da mesma maneira. Estes resultados são consistentes com a noção de que a ortografia interage com a fonologia mesmo quando a tarefa não requer atenção explícita dirigida à ortografia. A utilidade destes materiais e desta tarefa para a avaliação da linguagem é enfatizada.

Palavras chave: Julgamento de Rima, Ortografia, Português Europeu, Linguagem, Avaliação Neuropsicológica

Français: **Phonologie et orthographie déterminent le jugement de rime**

Résumé

Nous présentons ici une tâche de Jugement de Rime des Mots pour l'évaluation neuropsychologique en portugais. La tâche a été préparée d'après Kay, Lesser & Coltheart (1992), et consiste à décider si une paire de mots rime ou pas. La moitié des paires rime; la moitié de ces rimes a la même séquence orthographique (CEDO/DEDO), l'autre moitié a une séquence orthographique différente (POÇO/FOSSO). Les paires de contrôle, la moitié desquels a la même séquence orthographique finale, ne riment pas (MEDO/CREDO; MOÇO/NOSSO). Trente-deux étudiants universitaires ont réalisé cette tâche dans la modalité auditive et dans la modalité écrite. Des effets clairs de modalité, en faveur de la présentation parlée, et de l'orthographie, en faveur des rimes de séquence orthographique identique, ont été observés. Ces résultats sont consistants avec la notion théorique d'après laquelle l'orthographie interagit avec la phonologie même quand la tâche ne demande pas l'attention explicite dirigée vers l'orthographie. L'utilité de cette tâche pour l'évaluation neuropsychologique du langage est soulignée.

Mots clés: Jugement de Rime, Orthographie, Portugais Européen, Langage, Évaluation Neuropsychologique

Introduction

The neuropsychological assessment of language poses special problems because language is highly abstract and, at the same time, highly specific. In Portuguese, for example, there are two words for language, *linguagem*, the general mental faculty, and *língua*, the concrete form it takes when it is spoken or written. Because languages, *línguas*, differ markedly in the forms they take (phonemes, words, and sentences), assessment has to address the fundamental aspects that are known to be relevant across languages, but it must also be tailored to the specific phonological, orthographic, and morphosyntactic aspects, among others, of the language system being assessed.

Some years ago, Kay, Lesser and Coltheart (1992) developed an interesting tool for the assessment of language. The Psycholinguistic Assessments of Language Processing in Aphasia, or PALPA, consist of 60 tests designed to address specific aspects of language, from the auditory processing of nonword minimal pairs to the comprehension of written sentences. Language is viewed as a complex system composed by partly autonomous components or modules, and each task is designed to provide information about the integrity of these modules. Assessment is based on a hypothesis testing model in which the neuropsychologist probes the deficits and their causes by using individually tailored groups of tests, according to the observed pattern of impaired and preserved functioning of the various language components. Because it is modular and finely tuned, the PALPA battery is a useful resource for clinical assessments as well as for research on language. Originally developed in English, it was then adapted for the Spanish language (Valle & Cuetos, 1995). Some of its tests have also been adapted for Portuguese, and were used to monitor changes in, for example, letter knowledge and sentence comprehension in early through middle childhood, as well as differences between highly schooled and less schooled adults (Gomes & Castro,

1996, 1998, 1999, in press).

In this paper, we present materials and results for a rhyme judgement task in Portuguese (European variant), that was developed on the basis on the Word Rhyme Judgements task from the PALPA battery (Test 15 from Kay et al., ibd., pp. 1-6). The Word Rhyme Judgements task is designed to test phonological short-term storage, input processing abilities and segmentation skills (ibd., p. 1). It uses pairs of rhyming words that are spelled either differently, like BEAR/CHAIR, or in the same way, BONE/CONE (phonological vs. orthographic rhyme, respectively). Each rhyming pair has a corresponding control that does not rhyme and that is spelled either differently, e.g., FLAIR/YEAR, or the same, e.g., TONE/GONE (phonological vs. orthographic controls, respectively). The word pairs may be presented in written (the Written Version of the task) or auditorily (the Auditory Version).

An effect of orthography is quite likely in the written version, since the visual similarity or dissimilarity of the words in each pair may help, or interfere with, the rhyme judgement. In the spoken modality, a naive expectation would be that the incongruity in spelling would not play a role, since the task requires attention to the sounds of the words and these are heard instead of being seen as letter sequences. Kay et al. (ibd.) do not give results for this task (for most of the other PALPA tests, means and standard deviations for small groups of healthy participants are presented). However, other studies in English have shown that orthographic knowledge influences auditory word recognition. For example, it is easier to detect that two words rhyme when they have the same orthographic endings, even if the task is performed in the spoken modality (Seidenberg & Tannenhaus, 1979). In auditory lexical decision tasks, words whose endings that can be written in more than one way produce slower responses, and more errors, than words whose endings can be written in only one way

(Ziegler & Ferrand, 1998). Thus, one would expect to find an effect of orthography on the auditory version of the rhyme judgment task even if the phonological short-term storage systems are intact. If, however, these systems are damaged, judgements on rhyme would probably rely more on the visual representation of the words, and the effect of orthography would be stronger. Thus, the size of the orthography effect can be an index of the integrity of the phonological short-term storage systems and/or of the robustness of phonological representations.

In the Spanish version of the PALPA battery, the rhyme jugdment task (Juicios de Rima de Palabras: Version Auditiva y Escrita, Valle & Cuetos, 1995, p. 177) comprises only three conditions because all of the non-rhyming pairs are spelled differently (e.g., LOSA/LISA). Furthermore, of the 20 rhyming word pairs, only 5 differ in spelling (e.g., UVA/TUBA; an example of the remaining pairs is CHAL/REAL). The distinction between orthographic and phonological rhymes is lost because Spanish is a shallow orthography: if two words rhyme, they are also spelled in the same way. Though both are Romance languages, Portuguese and Spanish have important differences on phonology and orthography. The Portuguese vowel system has more vowel types, for example, and the Portuguese orthography is classified as intermediate in the opaque vs. transparent dimension (Castro & Gomes, 2000, p.133; Pinheiro, 1994; Seymour, Aro, & Erskine, 2003). Print to sound matching is typically predictable on the basis of contextual rules and fixed correspondences, but matching in the reverse direction - from sound to print - is less straightforward (for a fuller account, see Gomes, 2001; Castro & Gomes, in preparation). In Portuguese, thus, the link between phonology and orthography is less consistent than in Spanish, though more consistent than in English. Does this difference have an impact on rhyme judgement, and on the effect of orthography? The following experiment was carried out with the purpose of examining whether there is an effect of

orthography on auditory rhyme judgement in Portuguese, an orthography where the mapping between phonology and orthography is only partly consistent. An additional goal was to provide descriptive statistics on a Portuguese version of the Rhyme Judgments Task from the PALPA battery.

Method

Participants

Thirty two right-handed college students (18 female and 14 male) from 20 to 30 years of age (M = 23.6, SD = 2.6) volunteered to take part in the experiment. All were native speakers of European Portuguese with normal or corrected-to-normal vision, and normal hearing according to self-report. The participants were observed during July 2003.

Materials

The Word Rhyme Judgements task from the PALPA battery (Kay et al., 1992) uses 60 pairs of monosyllabic words, half of which rhyme (the other half does not). Half of the rhyming and of the non-rhyming pairs share the spelling of the rime (say, -OSE in the rhyming POSE/PROSE pair and in the non-rhyming ROSE/LOSE pair). The Portuguese materials were based on the same principle. We selected word quadruplets that share the final orthographic segment such that two of them rhyme and two do not, and such that four groups of word pairs could be built: same spelling rhyming and non-rhyming word pairs (e.g., respectively, C**EDO**/D**EDO** and M**EDO**/CR**EDO**, the latter /-edu/ vs. /-Edu/), and different spelling rhyming and non-rhyming word pairs (e.g., P**OÇO**/F**OSSO**, and M**OÇO**/N**OSSO**, the latter /-osu/ vs. /-Osu/). Bdisyllabic C(C)VCV words were chosen because monosyllables are relatively rare in Portuguese. The number of word pairs was 40 (10 by condition) because Portuguese is more regular than English and thus presents fewer candidate words. The words were selected from the Porlex database (Gomes,

2001; Gomes & Castro, 2003), and were roughly equated in length, frequency and neighborhood density across the four groups (see Table 1). The complete list of the word pairs is reported in the Appendix.

Table 1 about here

These materials were prepared for a computer controlled presentation, which allowed us to measure reaction times in milliseconds as well as accuracy. For the spoken version of the task, the stimuli were digitized, edited and saved in individual Wave files. Words were spoken by a female native speaker of Portuguese (SC) and recorded from a soundproof booth using ProTools LE, version 6.0 (1991 - 2002) at a sampling rate of 48 KHz and 16-bit resolution. The perceptual quality of the recordings was checked by the authors and by a third listener blind to the objectives of the experiment (LC). If rated positively, words were selected for further edition. This involved creating individual files for each word starting with 20 ms of silence before the onset and after the offset of the word.

Two lists containing the 40 word pairs in pseudorandom order were prepared, one for the written presentation, and another for the auditory one. The constraints were that no more than three consecutive pairs belonged to the same condition, and that a rhyming pair and its corresponding control were in different halves of the lists.

Procedure

The presentation of the stimuli and recording of the responses were controlled by Superlab Pro, version 2.0 (2001), run on a Toshiba Satellite 1800-400 portable computer attached to a Cedrus RB610 response box. Participants were tested individually in a quiet, dimly lit, room. They were explained that they would be

presented with sequences of two words, and their task would be to respond as quickly and accurately as possible whether the second word rhymed or not with the first one; if the words rhymed, the green key should be pressed, if not the red key should. They would perform the task by reading the words on the computer screen and also by hearing them through headphones. Instructions emphasized, in the written version, that the words should not be read aloud, and, in the spoken version, that the response should be given only after the end of the second word.

Half the participants pressed the green key with the right index finger and the red key with the left, and half the reverse; within each of these subgroups, half started with the auditory version of the task, the other half with the written version. Experimental trials were preceded by 6 practice trials where analogous word pairs were presented (see Appendix).

In the written version of the task, the stimuli appeared in black lower-case letters, Courier 150, at the centre of the computer screen. Each trial began with a fixation point for 750 ms, followed by the first word of the pair for 1000 s, and then the target word. This disappeared as soon as a response was initiated, or after a 3 s interval. From this, or from the response, a 250 ms inter-trial interval was started. Participants were seated at approximately 60 cm from the computer screen. For the spoken version, there was a 250 ms interval between the offset of the first word and the beginning of the second word. Time limit was also 3 s. Stimuli were presented through stereo headphones Sony - MDR-7509.

Results

Figure 1a shows the average number of correct responses for rhyming word pairs as a function of orthography and modality of presentation. It can be seen that there are on average more correct responses for word pairs with the same spelling than for

those with different spellings, in the written as well as in the spoken condition. Repeated measures ANOVAS with Orthography (Same vs. Different) and Modality (Spoken vs. Written) computed on the number of correct responses with participants (F1) and items (F2) as random factors showed a significant main effect of orthography, $F1(1, 31) = 10.29$, $p < .01$; $F2(1, 18) = 26.56$, $p < .001$. The decrease in performance associated with different spellings is more pronounced in the written condition than in the spoken one, but the Orthography X Modality interaction was significant in the analysis by participant only, $F1(1, 31) = 6.15$, $p = .01$ ($F2(1, 18) = 3.03$, *ns*). There is no significant difference in correct responses between the spoken and the written conditions (for Modality, $F1(1, 31) = 2.4$, and $F2(1, 18) = 1.77$, both *ns*).

Insert Figure 1a and 1b about here

Figure 1b shows mean reaction times for the same conditions. Reaction times shorter than 200 ms or more than 3 standard deviations above the individual overall means were excluded from the analysis (and of course only reaction times from correct responses were included). Again, the advantage of word pairs with the same spelling can be observed: latencies are ca. 70 ms shorter for these pairs than for those with different spellings. The effect of orthography is significant in the analysis by participant, $F1(1, 31) = 5.43$, $p = .02$, and close to significance in the analysis by item, $F2(1, 18) = 2.95$, $p = .10$. Responses are ca. 300 ms faster in the spoken condition than in the written one (for Modality, $F1(1, 31) = 12.63$, $p < .001$; $F2(1, 18) = 100.25$, $p < .001$). The effect of orthography does not interact with modality (both $F1$ and $F2 < 1$).

Insert Figure 2a and 2b about here

The results for the non-rhyming word pairs can be observed in Figure 2a and 2b. Accuracy is higher in the spoken condition, 79%, than in the written one, 66%, and response latencies are almost 500 ms shorter for spoken than for written word pairs. In fact, the only significant factor revealed by statistical analyses was Modality: for correct responses, $F1(1, 31) = 17.85$, $p < .001$; $F2(1, 18) = 8.56$, $p < .01$; for RTs, $F1(1, 31) = 41.62$, $p < .001$; $F2(1, 18) = 286.39$, $p < .001$. Neither orthography nor the two-way interaction reached significance in the F1 and F2 analyses. Comparing the performance obtained for the non-rhyming pairs with that for the rhyming pairs (cf. Figure 2 and 1, respectively), it is apparent that accuracy was lower for the non-rhyming pairs, especially in the written condition with the same spelling (only 69% correct; the corresponding value for the rhyming pairs is 92%). Response latencies were similar for both types of pairs in the spoken condition (ca. 600 ms), but they were ca. 100 ms slower for the non-rhyming word pairs in the written condition.

An incorrect response for the non-rhyming word pairs is a false positive error; it amounts to report that two words rhyme when in fact they do not. A few participants had almost as many false positives as correct detections of the rhyme. Therefore, a signal detection analysis of these responses provides a more accurate measure of the ability to discriminate rhyming from non-rhyming word pairs than correct responses alone. Correct responses for the rhyming pairs were considered as hits, and false positives in the corresponding non-rhyming pairs as false alarms. Sensitivity, or d', scores were computed for each participant separately for same vs. different spelling pairs in the written and in the spoken modalities, thus resulting in four estimates of rhyme sensitivity. Average d' by condition ranged from 1.6 (SD = 1.0) for written word pairs with different spellings to 2.9 (SD = 1.8) for spoken word pairs with the same

spelling. An ANOVA with Orthography and Modality as within participants factors showed a significant effect of Modality, $F(1, 31) = 15.67$, $p < .001$, and no interaction. The detection of rhyme is better for spoken word pairs, average $d' = 2.8$ (SD = 1.7), than for written ones, average $d' = 1.9$ (SD = 1.4). The effect of orthography is close to significance, $F(1, 31) = 3.17$, $p < .08$, with an advantage of same spelling pairs. Inspection of the individual scores showed that seven participants had in at least one condition d' scores of zero or below. They were thus unable to discriminate rhyming from non-rhyming pairs. Excluding these participants from the analysis, the effect of orthography emerged significantly, $F(1, 24) = 14.54$, $p < .001$ (the effect of modality and the absence of interaction were replicated in this reanalysis).

Discussion

The results of this study provide clear evidence for the effect of orthography and for the effect of modality on rhyme judgement. Let us consider orthography first.

Analyses of correct responses and latencies consistently showed that it is faster and more accurate to detect that two words rhyme when the rimes of these words have the same spelling than when the spelling of the rimes differs. This is true not only for written presentation, but also for spoken presentation of the word pairs, thus showing that the effect of orthography does not depend on modality. In the control word pairs, which do not rhyme, the analogous effect failed to occur significantly: it was not reliably faster or more accurate to decide that word pairs with differently spelled rimes did not rhyme (though the differences between conditions are in this direction, cf. Figure 2). Note, however, that using d' scores, which combine responses to positive and to negative trials in a single sensitivity measure, the effect of orthography was again observed: sensitivity was higher in the same spelling condition than in the different spelling one.

The demonstration of the effect of orthography on rhyme judgement is, of course, not new (cf. Seidenberg & Tannenhaus, 1979). The new finding here is that this effect occurs even when the differences in the spelling of the rimes are minimal, as is the case with the Portuguese language. Because the mapping from print to speech is fairly consistent -- a rough estimate of the ratio of consistent to inconsistent mappings is 88% to 12% (Gomes, 2001; Castro & Gomes, in preparation) -- there are only a few cases that can be used to establish the incongruity between phonological and orthographic rimes. The differences in spelling occur in one letter only, and do not involve reordering of the remaining letters. Examples used in our word pairs are ATO/ACTO, ETO/ECTO, ESA/EZA, IOR/EOR, UPOR/OPOR. For comparison, here are a few examples from the PALPA Word Rhyme Judgements test (Kay et al, 1992) that involve reordering and/or changes in more than one letter: OWL/OLE, AIT/ATE, OUR/AW, OOT/UTE, OE/EW. The fact that minimal differences in the spelling of the rimes are sufficient to influence rhyme judgement is in good agreement with findings from a variety of paradigms showing that orthography and phonology interact more than was previously acknowledged in determining the time course and accuracy of responses in a variety of language tasks (Damian & Bowers, 2003; Stone, Vanhoy, & Orden, 1997; Ziegler, Tan, Perry, & Montant, 2000).

The other main result of this study is the effect of modality. It is faster, and less prone to false positive errors, to judge rhyme for spoken words than for written ones (cf. Figures 1b and 2). The superiority of the spoken modality was also clear in the results with the *d′* scores. Why are there more false positives errors (that is, reporting that two words rhyme when they do not) in the written condition than in the spoken one? It is important to keep in mind that even for word pairs that do not rhyme there is a residual phonological and orthographic similarity. In our stimuli, for example, the last syllable

could be identical even though the words did not rhyme (e.g., /da/ in RODA/BODA, or /lu/ in GRELO/BELO). Notice however that on spoken presentation only the last phonological syllable is identical, whereas on written presentation the preceding vowel is identical too and this accounts for all but one segment of the word: there is more visual similarity than there is phonological similarity in these word pairs. Furthermore, because most of the words were stressed on the first syllable, and in European Portuguese the unstressed syllables are strongly reduced, it is possible that the acoustical realization of the identical unstressed syllable was not very salient perceptually. This type of prosodic information, which is explicitly present in the spoken words, is probably used as a source of information for rhyme judgment, thus contributing to faster and more accurate responses.

Finally, a comment on individual differences and on the usefulness of this task for neuropsychological assessment. With these materials and this task, we were able to observe participants over a wide range of sensitivity to rhyme (from negative *d'*s to more than 5). If only correct responses to rhyming word pairs had been considered, ceiling effects would hinder the interpretation of results (e.g., in the spoken modality 16 out of 32 participants reached 100% correct). However, by taking also into account the number of incorrect responses for the non-rhyming word pairs (false positive errors) it becomes possible to get a more discriminative picture of the individual differences in rhyme judgment, and to use this task as a resource for finely tuned neuropsychological assessment of language.

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Appendix

List of Word Pairs, WP, by Condition

#	Same spelling rhyming WP	#	Same spelling non-rhyming WP
1	cedo - dedo	1	medo - credo
2	cego - prego	2	lego - grego
3	selo - gelo	3	grelo - belo
4	fera - bera	4	hera - cera
5	festa - sesta	5	testa - cesta
6	foca - toca	6	doca - boca
7	bloco - foco	7	floco - coco
8	moda - soda	8	roda - boda
9	tolo - golo	9	bolo - colo
10	mota - cota	10	lota - gota
	Different spelling rhyming WP		Different spelling non-rhyming WP
1	fato - cacto	1	mato - pacto
2	neto - tecto	2	recto - preto
3	mesa - proeza	3	presa - reza
4	nicho - lixo	4	bicho - fixo
5	prior - teor	5	motor - pior
6	rocha - broxa	6	tocha - coxa
7	poço - fosso	7	moço - nosso
8	coze - dose	8	gnose - doze
9	bruxo - bucho	9	caucho - fluxo
10	supor - propor	10	furor - bolor

Note. Practice trials: rhyming *fada - nada, globo - lobo, lilás - cartaz, face - classe*; non-rhyming *comboio - saloio, mulher - lazer*.

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Table 1.

Characteristics of the words averaged for each condition (standard deviation in parentheses)

Variables	Rhyming Pairs		Non-Rhyming Pairs	
	Same Spelling	Different Spelling	Same Spelling	Different Spelling
Number of letters	4.20 (0.41)	4.70 (0.66)	4.30 (0.46)	4.70 (0.57)
Number of phonemes	4.20 (0.41)	4.40 (0.68)	4.25 (0.54)	4.45 (0.69)
Word frequency	379.74 (509.18)	282.89 (495.36)	477.05 (322.50)	464.17 (1038.88)
Number of orthographic neighbours	11.25 (4.66)	4.30 (3.70)	9.85 (4.92)	5.0 (3.67)
Number of phonological neighbours	8.95 (4.88)	6.90 (7.5)	6.65 (3.70)	4.9 (5.28)
Position of uniqueness point (in number of letters)	4.15 (0.37)	4.45 (10.69)	4.25 (0.44)	4.50 (0.61)
Position of uniqueness point (in number of phonemes)	3.85 (0.59)	3.90 (0.72)	4.0 (0.56)	4.05 (0.76)
Auditory length (in ms)	800 (107)	800 (72)	716 (177)	787 (88)

Note. Auditory length in milliseconds measured using ProTools LE (version 6.0). Word frequency collected from the Corlex database (Nascimento, Casteleiro, Marques, Barreto, & Amaro, n.d.). The remaining measures collected from the Porlex database (Gomes, 2001; Gomes & Castro, 2003).

Figure Captions

Figure 1. Mean percentage of correct responses (a) and of response latencies (b) as a function of modality and orthography for rhyming word pairs.

Figure 2. Mean percentage of correct responses (a) and of response latencies (b) as a function of modality and orthography for non-rhyming word pairs.

Figure 1.

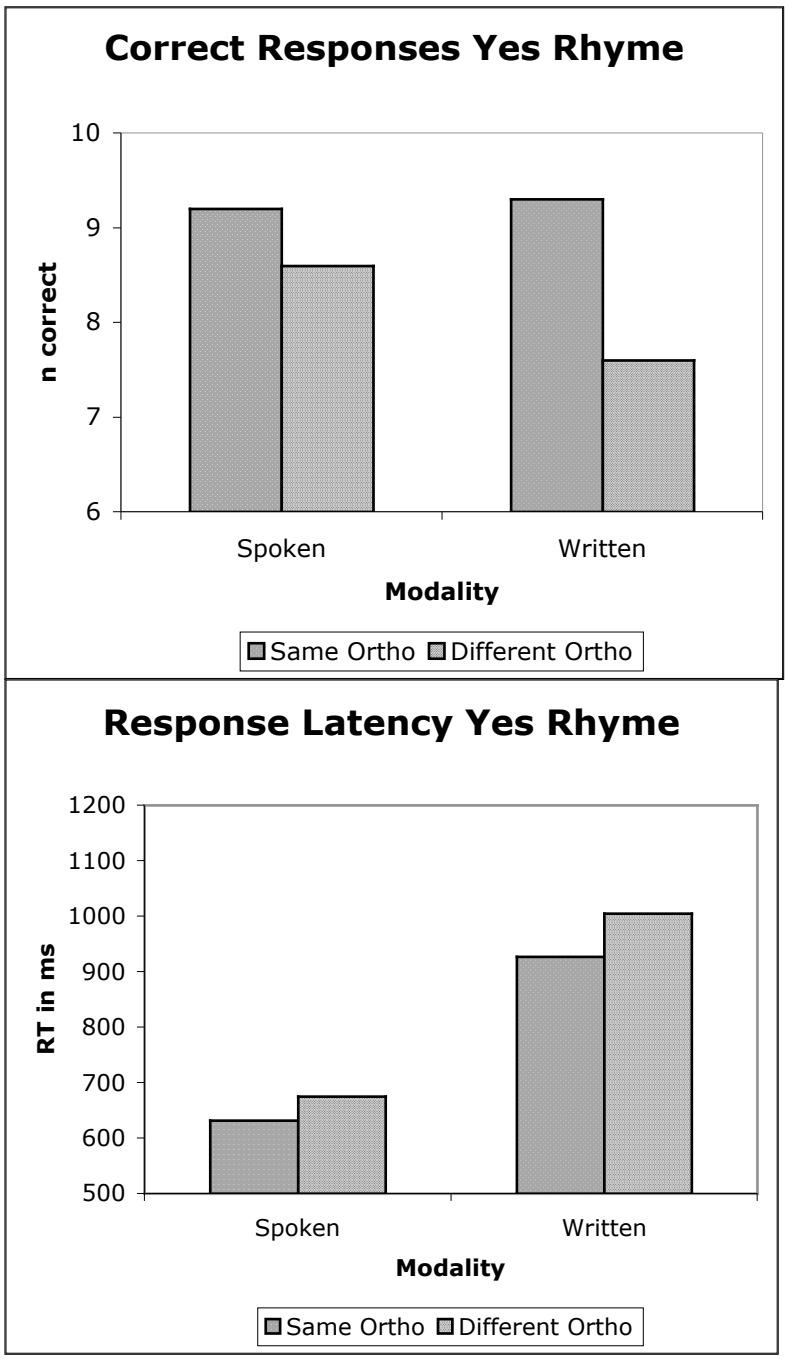
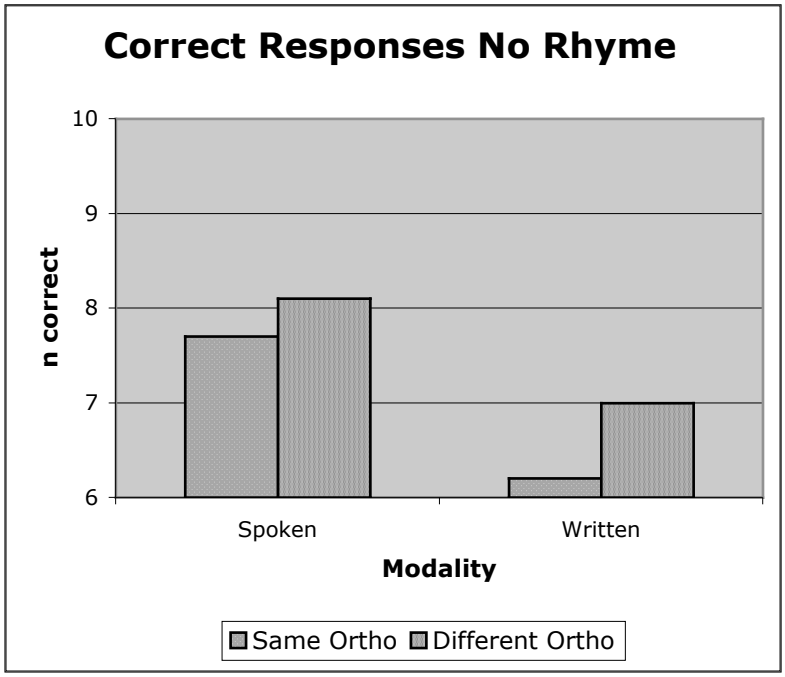
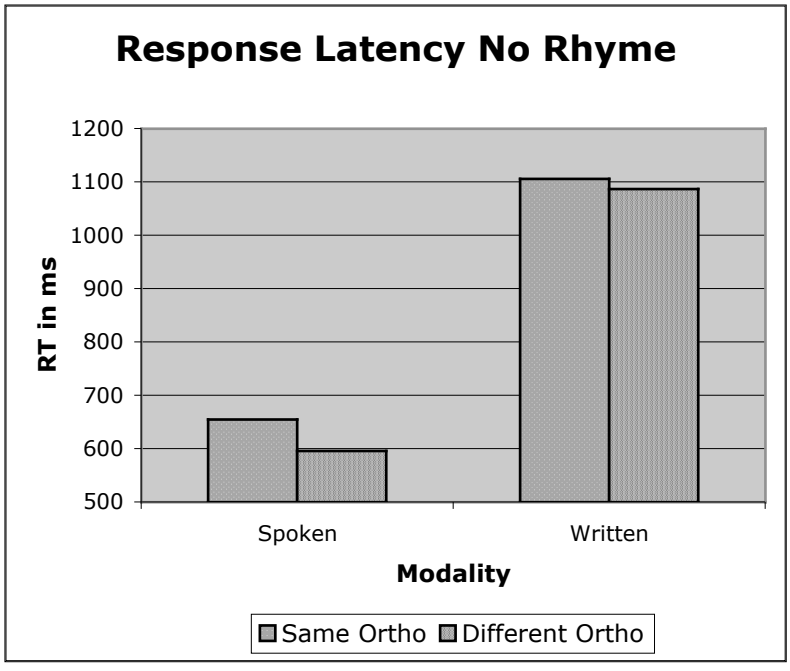

Correct Responses Yes Rhyme
n correct
10
9
8
7
6
Spoken
Written
Modality
Same Ortho
Different Ortho
Response Latency Yes Rhyme
RT in ms
1200
1100
1000
900
800
700
600
500
Spoken
Written
Modality
Same Ortho
Different Ortho

Figure 2.


Correct Responses No Rhyme
10
9
8
7
6
n correct
Spoken
Written
Modality
Same Ortho
Different Ortho


Response Latency No Rhyme
1200
1100
1000
900
800
700
600
500
RT in ms
Spoken
Written
Modality
Same Ortho
Different Ortho