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Brief article

The role of orthography in speech production revisited

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Abstract

The language production system of literate adults comprises an orthographic system (used during written language production) and a phonological system (used during spoken language production). Recent psycholinguistic research has investigated possible influences of the orthographic system on the phonological system. This research has produced contrastive results, with some studies showing effects of orthography in the course of normal speech production while others failing to show such effects. In this article, we review the available evidence and consider possible explanations for the discrepancy. We then report two form-preparation experiments which aimed at testing for the effects of orthography in spoken word-production. Our results provide clear evidence that the orthographic properties of the words do not influence their spoken production in picture naming. We discuss this finding in relation to psycholinguistic and neuropsychological investigations of the relationship between written and spoken word-production.

Keywords: Language production; Speech; Phonology; Orthography; Writing; Picture naming

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1. Introduction

Language processing can be characterized by the joint activation of orthography, phonology and semantics (e.g., Seidenberg & McClelland, 1989). According to the strong interactive view, the activation of these various types of linguistic information can mutually influence one another (e.g., Van Orden & Goldinger, 1994; Van Orden, Pennington, & Stone, 1990). Such co-activation of linguistic codes seems to occur even if it is not strictly necessary for the task at hand. When people make lexical decisions or orthographic judgments about *written* words, performance is influenced by the phonology of the letter string (Ziegler, Jacobs, & Klueppel, 2001; Ziegler, Van Orden, & Jacobs, 1997). Similarly, when people are asked to make lexical decisions or rhyme judgments about *spoken words*, their performance is affected by the spelling of the spoken words (e.g., Seidenberg & Tanenhaus, 1979; Ventura, Morais, Pattamadilok, & Kolinsky, 2004; Ziegler & Ferrand, 1998; Ziegler, Ferrand, & Montant, 2004). These findings can be taken as strong evidence in favor of interactive models of language processing (but see Norris, McQueen, & Cutler, 2000; Van Orden et al., 1990).

Until recently, the investigation of orthographic effects on spoken language has been limited to perception tasks with auditory input. By comparison, the role of orthographic information in spoken language *production* has received little attention. Worse yet, the few psycholinguistic studies addressing this issue have provided contrastive results (Damian & Bowers, 2003; Franck, Bowers, Frauenfelder, & Vigliocco, 2003; Roelofs, in press). In this article, we briefly discuss these conflicting results. We then report two word-production experiments aimed at resolving this indeterminacy.

To test for effects of orthography on speech production, Damian and Bowers (2003) used the form-preparation paradigm (Meyer, 1990). In this paradigm, speakers participate in two experimental phases. In the first *learning* phase, participants are asked to memorize word pairs (e.g., sugar-COFFEE). In the subsequent *test* phase, they produce the second word in response to the first one, in blocks where three to five word-pairs are repeated. The phonological homogeneity of the target words produced in a block is manipulated, and naming latencies are measured. When phonological information is shared at the beginning of words (e.g., same first syllable), responses are faster than when no information is shared. It is argued that participants are able to encode and keep ready the shared onset of the words for the duration of the block (Meyer, 1990).

With this paradigm, Damian and Bowers (2003) compared the three experimental conditions summarized in Table 1. They found that the homogeneous condition

Table 1
A sample of the English materials used by Damian and Bowers, 2003

Type of block	Target words		
Homogeneous	COFFEE	CUSHION	CAMEL
Inconsistent	COFFEE	CUSHION	KENNEL
Heterogeneous	COFFEE	CUSHION	GYPSY

Our French materials were organized similarly (see Appendix A).

produced faster naming latencies than the heterogeneous condition. Remarkably, in the inconsistent condition – where the phonological onset is equally shared but not the orthographic onset – the facilitation effect disappeared. The orthographic disruption of the phonological effect was observed in three experiments.[1] This consistent pattern of results was cautiously interpreted by Damian and Bowers (2003) as showing influences of spelling on spoken word-production.

Despite the clear evidence reported in this study, a number of observations are inconsistent with the observation of orthographic effects in oral naming performance. First of all, as discussed by Damian and Bowers (2003, p. 129) themselves, there are various experiments conducted in Dutch (Meyer, 1990, 1991) in which a post hoc analysis revealed that the phonological facilitation effect was observed independently of orthographic inconsistencies (see also Chen, Chen, & Dell, 2002, Experiments 1a and 1b). More recently, Roelofs (in press) reported 3 word-production experiments in which the experimental design was identical to that used by Damian and Bowers (2003). In this study, different participants either generated words from associates (as in the original experiments), named pictures, or named words. By contrast to Damian and Bowers' (2003) observations, no orthographic effect was found in the picture naming and word generation experiments. The only task for which orthographic effects were found was word reading.[2]

There are several possible interpretations for the apparent inconsistencies between Damian and Bowers' (2003) and Roelofs' (in press) results. One is that the effect of orthography stems from a Type 1 error. Notice however that the effect was replicated in three experiments. Another explanation has to do with the transparency of the language in which the experiment was conducted. The mapping between orthography and phonology is more consistent (transparent) in Dutch than in English (Seymour, Aro, & Erskine, 2003). As Roelofs pointed out "*cross-linguistic differences in the degree to which orthography and phonology interact in speech production (are) perhaps related to differences in orthographic depth between languages*". Such plausible assumption is consistent with previous findings in reading (e.g., Frost, Katz, & Bentin, 1987), although there is one data point that argues against it in speaking: No orthographic effects were found by Chen et al. (2002) in the form-preparation experiments they conducted in Mandarin Chinese, a language with a non-transparent and non-alphabetic orthography.

Finally, an alternative interpretation for the discrepant results is related to the experimental paradigm. The word-association paradigm contains not only a speech production component but also a memory component. In the initial learning phase of the experiment, participants have to memorize cue-target associations. It is entire-

[1] In only one of these three experiments the instructions (training phase) and response cues (experimental phase) were presented orally. In that case, participants received absolutely no orthographic input.

[2] The effect in this last task crucially shows that, despite massive repetition, the form-preparation paradigm is sensitive enough to find subtle effects in areas such as reading, in which researchers have previously found orthographic feedback effects (Stone, Vanhoy, & Van Orden, 1997; Ziegler, Montant, & Jacobs, 1997).

ly possible that the orthographic consistency effect has its locus in word-pair learning rather than in word-production, if participants use an orthographic code to improve memorization.[3] This is a plausible hypothesis given that orthographic codes can be implicitly activated even when words are presented only in their spoken form (see references in the first paragraph). The role of this activation in memorization has been recently demonstrated in a slightly different context (Johnston, McKague, & Pratt, 2004). These authors show that, when participants have to learn novel spoken words, orthographic feedback is used in order to improve their learning.[4]

The goal of the present study was twofold. First, we wanted to investigate whether orthographic effects on spoken word-production can be obtained in a production experiment that did not involve an added-on word-association learning phase. We conducted an experiment using the same methodology than Damian and Bowers (2003), except that we used picture naming instead of word-association to elicit participants' responses. This task should provide information on speech production per se while excluding the role of learning arbitrary word-associations. Second, we wanted to address the possibility that the orthographic effects are modulated by the transparency of the language. We conducted our experiments in French, a language that is less consistent than Dutch and at least as inconsistent as English (Ziegler, Jacobs, & Stone, 1996). If spelling inconsistencies are required for the orthographic effect to occur, our experiment should replicate Damian and Bowers' (2003) results.

2. Experiment 1

2.1. Participants

A total of 18 students (ages between 18 and 30), native speakers of French, volunteered for this experiment. They reported no history of language disturbance.

2.2. Materials

We selected six quintuplets of high name-agreement pictures (from the databases Alario & Ferrand, 1999; Bonin, Peereman, Malardier, Meot, & Chalard, 2003, or constructed in the same fashion). The picture names of a quintuplet had the same number of syllables. They were semantically unrelated. Three of them shared their first phoneme and their first letter, but not their second phoneme (see Appendix A). These three pictures were used in *homogeneous* blocks. The fourth picture name shared its first segment but not its first letter with the previous items. The *inconsis-*

[3] Note that Roelofs (in press) did not find orthography effects in his word-association experiment.

[4] There have been a number of arguments considering and rejecting the possibility that the *phonological* facilitation effect found in the word-association paradigm could be due to memorization rather than speech production processes (e.g., Meyer, 1990, 1991). However, these arguments have not considered the possible role of orthography in the memorization component of the task (because this linguistic information had not been tested previously).

tent blocks were created by replacing one of the three homogeneous pictures with this one. The fifth picture of the quintuplet shared no phonology or orthography with the first three pictures. The *heterogeneous* blocks were created by replacing the same picture with this one.

The two pictures that were common to all three blocks were considered as targets. The three other pictures were fillers used in the different blocks to create the context defining the experimental conditions.

Three extra filler pictures were selected for the training block.

2.3. Design

We manipulated one factor – block type – with three levels – *homogeneous*, *inconsistent*, and *heterogeneous* – in a between-participants and between-items design. For each of the 6 quintuplets there were 3 runs (one per condition) totaling 18 runs. The runs comprised 6 repetitions of 3 pictures, totaling 18 trials per run. The order of the runs was counterbalanced across participants such that each combination of picture quintuplet and experimental condition appeared in a different order position for each subject (Damian & Bowers, 2003). Within these runs, the order of the trials was quasi-random (two successive pictures were never identical).

2.4. Procedure

The experiment was controlled by DmDX (Forster & Forster, 2003). Participants were tested individually. Before the experiment proper they were familiarized with the materials. They were presented the pictures once and asked to provide the most appropriate name. They were corrected *orally* in the rare cases where they did not produce the expected name. Participants were then tested on the training block, and then on the 18 experimental blocks.

Experimental trials started with a fixation point followed by the target picture, which remained on the screen until the participants responded or a deadline of 2000 milliseconds was met. We identified erroneous responses on-line and recorded response latencies with the software voice-key.

2.5. Results

We excluded technical recording errors (112 trials, 2.9% of the data) and outliers (below 300 ms or more than 3 standard-deviations away from the participant's mean; 15 outliers, 0.4% of the data). We counted as errors trials in which participants produced the expected name incorrectly, a different word or other verbal responses (112 errors, 2.9% of the data). Summaries of the data and the statistical analysis for naming latencies are shown on Tables 2 and 3.

The pattern of data was identical when outliers were identified with a stricter criterion (2 standard-deviations away) or when no outliers were excluded. We tested post hoc for an effect of the experimental conditions on the variability of the distributions, rather than their central tendency (mean). We computed the first

Table 2
Naming latencies (M), standard deviations (SD), and error rates (Err) per condition in the experiments

	Experiment 1			Experiment 2		
	M	SD	Err	M	SD	Err
Homogeneous	569	48	2.6	565	70	3.0
Inconsistent	568	53	2.8	565	73	3.4
Heterogeneous	581	51	3.3	587	75	3.4
Hom. effect	12			22		
Incon. effect	13			22		

[Hom. effect, Homogeneous – Heterogeneous; Incon. effect, Inconsistent – Heterogeneous].

Table 3
Analysis of variance and bilateral Student *t*-tests of the naming latencies in Experiments 1 and 2

		Experiment 1		Experiment 2	
		Participants	Items	Participants	Items
Main effect	df	2–34	2–22	2–34	2–22
	F	11.8	4.55	12.92	11.7
	MSE	1148	677	2926	2085
	p	<.001	=.02	<.01	<.001
Hom. Effect	df	17	11	17	11
	t	4.86	2.01	4.26	4.49
	p	<.001	=.07	<.001	<.001
Incon. effect	df	17	11	17	11
	t	4.28	2.76	4.19	3.68
	p	<.001	=.02	<.001	<.01
Orth. Effect	df	17	11	17	11
	t	.54	.50	.06	.31
	p	=.60	=.63	=.95	=.76

[df, degrees of freedom; *F*, Fischer ratio; MSE, mean squared error; *p*, significance level; *t*, Student's *t* statistic; Hom. effect, Homogeneous vs. Heterogeneous; Incon. effect, Inconsistent vs. Heterogeneous; Orth. effect, Homogeneous vs. Inconsistent].

and the third quartile of the distributions across conditions and tested whether these measures showed differential effects of the experimental factor (Holden, 2002). The interaction between the experimental factor and the quartile measure was not significant ($P_1 = .24$; $P_2 = .10$), suggesting similar variability across conditions.

The analysis of the error rates showed no effects (F's < 1.01; t's < 1.28).

2.6. Discussion

Experiment 1 yielded two results. First, we replicated the phonological onset facilitation effect. Second, we found exactly the same facilitation effect

in the inconsistent condition, where orthography is not shared (contra Damian & Bowers, 2003). This result suggests that, even in a language where the mapping between phonology and spelling is at least as inconsistent as English, orthography does not affect production. The absence of orthographic effect in picture naming suggests that Damian and Bowers' (2003) results might be due to the word-association learning phase they employed to elicit word-production.

Before reaching such a conclusion, another factor characterizing the relationship between orthography and phonology has to be taken into account: the grain size of psycholinguistic units (Goswami, Ziegler, & Richardson, 2005; Ziegler & Goswami, 2005). In languages like French, the syllable might be a more important phonological unit than the phoneme (Cutler, Mehler, Norris, & Segui, 1986, 1992). To obtain stable consistency effects in a syllable-based language like French, it might be necessary to manipulate orthographic consistency at the syllable rather than the phoneme level (Chen et al., 2002; Costa & Sebastián, 1996). This was done in Experiment 2.

3. Experiment 2

3.1. Participants

A total of 18 new participants from the same population as before volunteered for the experiment.

3.2. Materials, design, and procedure

The materials were selected exactly as for Experiment 1, except that now the phonological overlap between items was a whole syllable. The design and procedure were identical to those of Experiment 1.

3.3. Results and discussion

Recording errors (205 data points, 5.3%), outliers (149 data points, 3.8%), and errors (127 data points, 3.3%) were identified and excluded as previously. The data and the statistical analysis for naming latencies are summarized in Tables 2 and 3. As in the previous Experiment, the pattern of data was independent of the criteria used to identify outliers. A post hoc analysis (see Experiment 1) revealed no effect of the experimental factor on distribution variability ($P_1 = .62$; $P_2 = .28$). The analysis of the error rates showed no effects (F's and t's < 1).

The results of this experiment were identical to those of Experiment 1. A phonological facilitation effect was found, and this effect was not modulated by the orthographic properties of the words being produced.

4. General discussion

The experiments we report clarify the role of orthographic information in normal speech production. Experiment 1 showed a single-segment phonological facilitation effect. The effect was not affected by the orthographic properties of the words produced in the experimental blocks. Experiment 2 replicated this finding with a new set of materials and a syllable-sized manipulation.

One caveat regarding our findings is that the absence of orthographic effect is a null effect. Null effects are scientifically weak ground (e.g., Van Orden, Pennington, & Stone, 2001). However, one should keep in mind that the paradigm used in this research is based on an *ideal strategy manipulation* (see Stone & Van Orden, 1993). The critical words are identical across the different conditions – only the list composition changes. Such designs reduce the most common reason for failures to replicate, namely uncontrolled differences between different groups of items. This reduces considerably the likelihood that Damian and Bowers' (2003) robust effect is due to a type 1 error, or that our results stem from a type 2 error.

Roelofs (in press) hypothesized that the occurrence of orthographic effects might be tied to a language's overall degree of spelling-to-sound consistency. The absence of an orthographic effect in French, a language whose spelling is at least as inconsistent as that of English, runs against this hypothesis.

We suggest that the orthographic effect might not be due to speech production processes per se, but rather to the memorization processes recruited by the word-association procedure (the major difference between Damian & Bowers', 2003, and our study). Under certain conditions, orthography could be recruited to memorize word pairs. Recent evidence suggests that such orthographic feedback might occur in novel word learning when words are presented in their spoken form (Johnston et al., 2004). Importantly, when the cue-word memorization component of the task is removed, the speech production process is no longer affected by the orthographic properties of the items.

Indirect but converging evidence for that conclusion comes from a study by Franck et al. (2003) showing no effect of orthography on speech production. The fragment-completion paradigm was used to elicit subject-verb agreement errors (see Bock & Miller, 1991, for rationale and procedural details). Previous research has shown that the occurrence of agreement errors in oral responses is modulated by the *phonological* marking of number (Vigliocco, Butterworth, & Semenza, 1995). Franck et al. (2003) did not observe such an effect across modalities. In other words, the *spoken* error rate was similar whether or not the plural was contrastively marked in the *orthographic* form of nouns (e.g., $carrelage_{\text{singular}}$ vs. $carrelages_{\text{plural}}$, [pavement(s)] as opposed to $croquis_{\text{singular \& plural}}$ [sketch(es)]). Hence no effect of orthography on speech production.

Complementary evidence on this issue comes from neuropsychological studies of aphasic speakers. Two kinds of performance are relevant.

First, there are cases where oral production is impaired while written production is preserved (e.g., Assal, Buttet, & Jolivet, 1981; Lhermitte & Derouesne,

1974). These cases have been used to argue for independent orthographic and phonological output lexicons (against the obligatory phonological mediation hypothesis: Miceli, Benvegnù, Capasso, & Caramazza, 1997). According to this view, orthographic retrieval does not require the previous retrieval of phonological information and, conversely, phonological retrieval does not require orthographic retrieval.

Second, there is evidence indicating that these phonological and orthographic modules can influence one another under certain circumstances. Consider individuals that produce lexical substitution errors in speaking and writing. When tested on double naming tasks (e.g., write down the name of a picture and speak it out-loud immediately after, or vice-versa) some of these patients often produce *lexically inconsistent* responses (i.e., different words in the two modalities) while others always produce *lexically consistent* responses (i.e., the same correct or incorrect word in the two modalities). The occurrence of lexically inconsistent responses is tied to the inability to read and/or write pseudo-words. Conversely, responses are lexically consistent when the ability to read and/or write pseudo-words is preserved (Beaton, Guest, & Ved, 1997; Miceli & Capasso, 1997; Miceli, Capasso, & Caramazza, 1999; Rapp, Benzing, & Caramazza, 1997). This finding was interpreted as showing that, when available, ortho-phonological conversion procedures can constrain lexical access. In this interpretation, the activation of orthographic information (by the production of the first response) percolates through the conversion procedures and influences the processes of speech production (for the production of the second response. See Alario, Schiller, Domoto-Reilly, & Caramazza, 2003, for two further cases and a review).

Interactive models were initially used to predict orthographic effects in speech production. Yet, the absence of these effects does not invalidate them. The issue of whether interactive or modular frameworks are more appropriate is orthogonal to the question of whether orthography influences speech production. One could as easily accommodate the absence of orthographic effect in the context of non-linear dynamic systems (e.g., Van Orden & Goldinger, 1994; Van Orden, 2002). In such a case, one would need to argue that orthography is not one of the main controlling variables that allow production dynamics to settle into stable states.

5. Conclusion

The experiments we report show that spoken word-production processes are insensitive to the orthographic properties of the words being produced, even in a language with a deep orthography. It is plausible to tie the original observation of this effect to memorization processes in the word-association paradigm. Pending further evidence, the only reliable influence of orthography on speech production seems to be that found for aphasic patients, under the specific circumstances of double naming.

Appendix A

Target pictures		Context pictures		
		Homogeneous	Inconsistent	Heterogeneous
Materials used in Experiment 1				
cible	cintre	cerf	selle	fouet
feuille	flèche	fraise	phare	clou
étoile	écharpe	église	aiguille	oreille
souris	soleil	sifflet	citron	vélo
koala	képi	kayak	cactus	bouilloire
genoux	gélule	girafe	jumelles	tortue
Materials used in Experiment 2				
Tonneau	Totem	Tomate	Taureau	Cuillère
Collier	Colonne	Colombe	Chorale	Landau
Faucille	Faucon	Fauteuil	Photo	Couteau
Cahier	Camion	Caddie	Kayak	Toupie
Cerceau	Cerveau	Cercueil	Serpent	Branche
Echelle	Eponge	Eclair	Aiguille	Usine

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